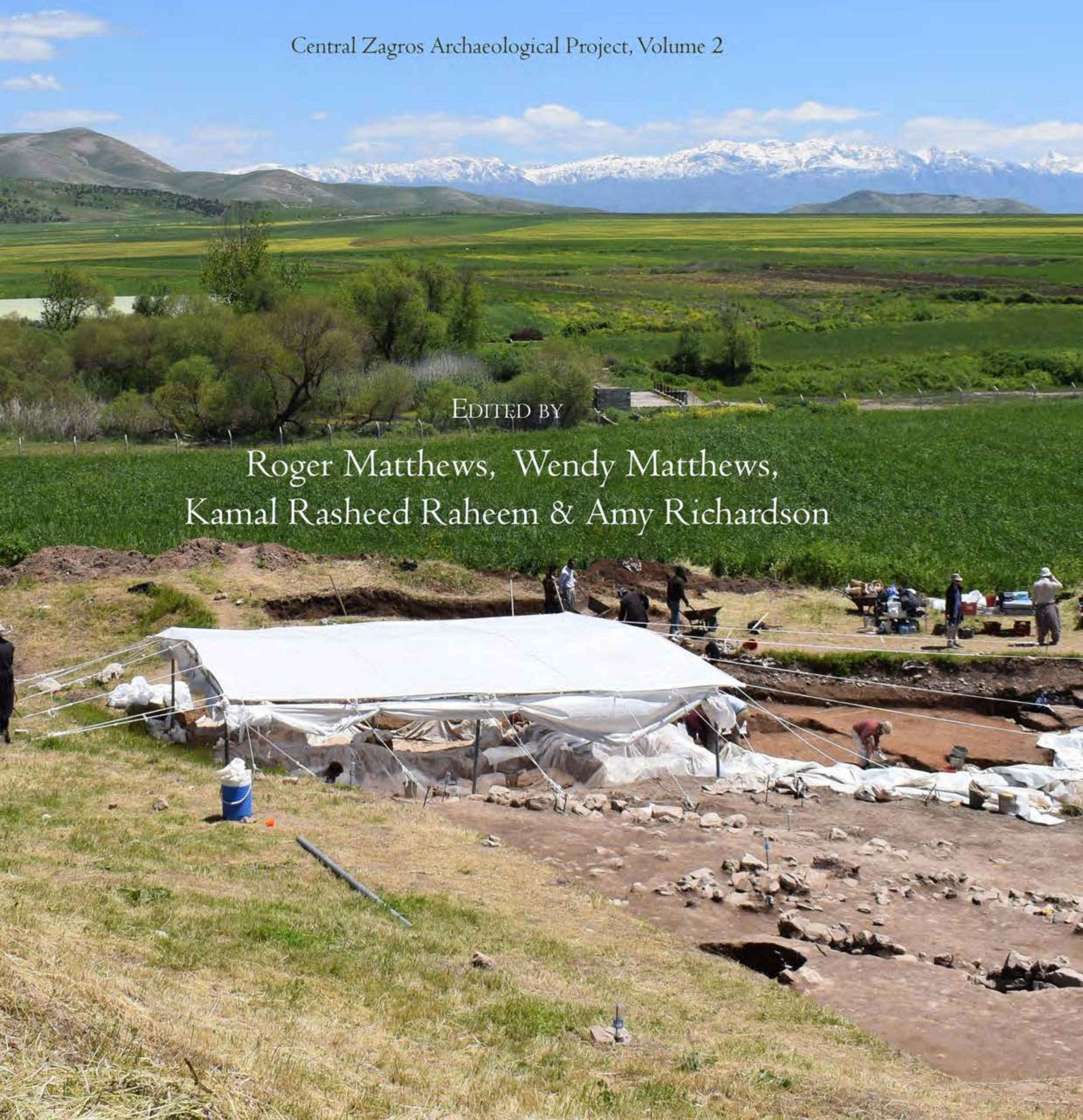
The Early Neolithic of the Eastern Fertile Crescent

Excavations at Bestansur and Shimshara, Iraqi Kurdistan

Central Zagros Archaeological Project, Volume 2



EDITED BY

Roger Matthews, Wendy Matthews,
Kamal Rasheed Raheem & Amy Richardson

THE EARLY NEOLITHIC OF THE EASTERN FERTILE CRESCENT: EXCAVATIONS AT BESTANSUR AND SHIMSHARA, IRAQI KURDISTAN

CENTRAL ZAGROS ARCHAEOLOGICAL PROJECT
CZAP REPORTS VOLUME 2

EDITED BY
ROGER MATTHEWS, WENDY MATTHEWS, KAMAL RASHEED RAHEEM AND AMY RICHARDSON

OXBOW | books
Oxford & Philadelphia

Published in the United Kingdom in 2020 by

OXBOW BOOKS
The Old Music Hall, 106–108 Cowley Road, Oxford, OX4 1JE

and in the United States by

OXBOW BOOKS
1950 Lawrence Road, Havertown, PA 19083

Hardcover Edition: ISBN 978-1-78925-526-3
Digital Edition: ISBN 978-1-78925-527-0 (epub)

A CIP record for this book is available from the British Library

Library of Congress Control Number: 2020934985

Printed in Malta by Melita Press
Typeset in the UK by Frabjous Books ~ www.frabjousbooks.com

For a complete list of Oxbow titles, please contact:

UNITED KINGDOM
Oxbow Books
Telephone (01865) 241249
Email: oxbow@oxbowbooks.com
www.oxbowbooks.com

UNITED STATES OF AMERICA
Oxbow Books
Telephone (610) 853-9131, Fax (610) 853-9146
Email: queries@casemateacademic.com
www.casemateacademic.com/oxbow

Oxbow Books is part of the Casemate Group

Front cover: Excavations at the Early Neolithic site of Bestansur, Shahrizor Plain, Sulaimani province, Kurdistan Region, Iraq
Photo: Roger Matthews, University of Reading

CONTENTS

CONTRIBUTORS

Georgia Allistone
Department of Archaeology
University of Reading

Matthew Almond
Department of Chemistry
University of Reading

Salvador Bailon
Muséum national d'Histoire naturelle
Sorbonne University, Paris

Rob Batchelor
Quaternary Scientific (QUEST)
University of Reading

Robin Bendrey
School of History, Classics and Archaeology
University of Edinburgh

Amy Bogaard
School of Archaeology
University of Oxford

Matt Bosomworth
Department of Archaeology
University of Reading

Mathew Britten
East Lancashire Railway
Manchester

Ian Bull
School of Chemistry
University of Bristol

Mike Charles
School of Archaeology
University of Oxford

Charlotte Diffey
Department of Archaeology
University of Reading

Sarah Elliott
Department of Archaeology and Anthropology
Bournemouth University

Othman Fattah
Department of Archaeology
Sulaimani University, Sulaimaniyah

Dominik Fleitmann
Department of Environmental Sciences
University of Basel

Pascal Flohr
EAMENA, School of Archaeology
University of Oxford

Aroa García-Suárez
School of Oriental Studies
University of Oxford

Jessica Godleman
Department of Chemistry
University of Reading

Chris Green
Quaternary Scientific (QUEST)
University of Reading

Alessandro Guaggenti
Department of Archaeology
University of Reading

Hawar Hawas
Department of Archaeology
Salahaddin University, Erbil

Jeremy Herman
Natural Sciences Department
National Museums of Scotland, Edinburgh

Ingrid Iversen
Department of Archaeology
University of Reading

Jessica S. Johnson
Museum Conservation Institute
Smithsonian Institution, Washington DC

Osamu Maeda
School of Humanities and Culture
University of Tsukuba

Roger Matthews
Department of Archaeology
University of Reading

Wendy Matthews
Department of Archaeology
University of Reading

Tom Moore
Independent
Stroud

Mel Morlin
School of History, Classics and Archaeology
University of Edinburgh

David Mudd
Department of Archaeology
University of Reading

Marta Portillo
Spanish National Research Council
Institución Milá y Fontanals, Barcelona

MARIA RABBANI
Department of Archaeology
University of Reading

KAMAL RASHEED RAHEEM
Sulaimaniyah Directorate of Antiquities and Heritage
Sulaimaniyah

AMY RICHARDSON
Department of Archaeology
University of Reading

JUAN ROFES
Department of Archaeological Studies
University of the Philippines

KAMAL RAEUF AZIZ
Sulaimaniyah Directorate of Antiquities and Heritage
Sulaimaniyah

HERO SALIH
Sulaimaniyah Directorate of Antiquities and Heritage
Sulaimaniyah

RHI SMITH
University Museums and Special Collections Services
University of Reading

CHRIS SPEED
Analytical Technical Services
University of Reading

ADAM STONE
Independent
London

DAVID THORNLEY
School of Archaeology, Geography and Environmental Science
University of Reading

WIM VAN NEER
Laboratory of Biodiversity and Evolutionary Genetics
Katholieke Universiteit Leuven

SAM WALSH
Department of Archaeology
University of Reading

JADE WHITLAM
School of Archaeology
University of Oxford

PREFACE AND ACKNOWLEDGEMENTS

This volume is the final report on excavations, survey and analyses undertaken within the Central Zagros Archaeological Project (CZAP) between autumn 2011 and summer 2017. The project's activities in this period were generously supported by a range of funding bodies, to all of whom we owe a huge debt of gratitude. Above all, from 2011 to 2014 investigations under the project title 'Sedentism and Resource Management in the Neolithic of the Central Zagros' were supported by a major research grant from the UK Arts and Humanities Research Council (Grant AH/H034315/2). Subsequent research was funded by the National Geographic Society (Grant HJ-R005-17), the British Institute for the Study of Iraq, and Gerald Averay Wainwright Fund at the University of Oxford. Additional support was received from the University of Reading's School of Archaeology, Geography and Environmental Science, and the University of Reading's Undergraduate Research Opportunities scheme to develop outreach and student involvement programmes, and to support borehole and phytolith analyses by Maria Rabbani and Georgia Allistone. A grant from the British Academy International Partnership and Mobility scheme (Grant IP090128) supported the project 'RADII: Recording Archaeological Data from Iraq and Iran' from 2010 to 2013, which provided specialist training for Iraqi and Iranian archaeologists in the use of integrated archaeological data-bases. Within this scheme three sessions of training, in London, Ankara and Sulaimaniyah, were provided by Mike Rains to a total of *c.* 50 archaeologists from Iran and Iraq. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 787264), 2018–2023, which has assisted considerably with completion of this volume.

The editors and authors wish to express deepest gratitude to our colleagues in Iraq who have made this project both possible and thoroughly rewarding, in particular: staff at Sulaimaniyah Directorate of Antiquities and Heritage, above all the Director Kamal Rasheed Raheem, and our government representatives who have been and remain integral members of the team: Kamal Raeuf Aziz, Sami Hama Rashid, Sabr Ahmed Sabr and Parween Yawar Manda; staff at Slemani Museum, directed by Hashim Hama Abdullah; staff at Erbil Directorate of Antiquities and Heritage, directed formerly by Abubakir Zainaddin (Mala Awat) and currently by Kaifi Mustafa Ali; staff at the Rania Office of Antiquities; and staff at the State Board of Antiquities and Heritage, Baghdad, directed formerly by Qais Hussein Rasheed. We owe a huge debt of gratitude to the villagers of Bestansur for hosting us and working with us in the field, laboratory and house through many months of fieldwork, in particular to Umaid Hama Rasheed, Nawruz Mohammed, Amir Mohammed, Raheem Mahmud and Khalid Rasheed, as well as all the men and women of Bestansur who have joined us on the project. We sincerely thank Simone Mühl for her support at the project's initiation, Jesper Eidem for help and support in working at Shimshara, Melinda Zeder for her invaluable academic input as Project Advisor through 2011-2014, and Mike Charles and Amy Bogaard for expert archaeobotanical support throughout the project. The editors wish to thank academic and support staff in the Department of Archaeology, School of Archaeology, Geography and Environmental Science, and in central support at the University of Reading. We also thank Steve Mithen and Tobias Richter for kindly reviewing this volume in draft and enhancing it through their critical insights and advice. All remaining errors are solely the fault of the editors.

The project teams in the field, 2011–2017, have included those listed in the Team Table (affiliation at time of participation). We thank them all for their hard work and dedication to the project.

Additionally, for Chapter 12 the author is very grateful to Sandy Harrison for comments on a draft of part of the text and to QUEST and Aroa García-Suárez for manufacture of the thin-sections. For Chapter 13, the fieldwork and research conducted by Marta Portillo was supported by EU Horizon 2020 MICROARCHEODUNG project (H2020-MSCA-IF-2015-702529). The authors of Chapters 13 and 16 thank the Natural Environment Research Council, UK, for supporting GC-MS analyses at the NERC Scientific

Support and Facilities, Bristol (Contract No. R8/H10/63; Application no. lsmsf_bristol_049). We are very grateful to Graham Luke, School of Biological Sciences for the training and support in the CLSM analyses. We are grateful to QUEST for conducting the pH, particle size, and XRD analyses, including G. P. Warren.

For Chapter 15, the authors thank Louise Martin (University College London) for kind support and digital resources/databases; Judith White and Jo Cooper (Natural History Museum, Tring) and; Andrew Kitchener and Zena Timmons (National Museums of Scotland) for access to the extensive comparative osteological reference collections held in these institutions. Wim Wouters (RBINS, Brussels) is acknowledged for his help with the identification of the fish remains. The contribution of Wim Van Neer to this chapter presents research results of the Interuniversity

Team table.

Roger Matthews	University of Reading	Project Co-Director, lithics, excavation
Wendy Matthews	University of Reading	Project Co-Director, micromorphology, excavation
Kamal Rasheed Raheem	Sulaimaniyah Directorate of Antiquities and Heritage	Co-Director
Amy Richardson	University of Reading	Project Assistant Director, data-base, excavation, pXRF, finds
Kamal Raeuf Aziz	Sulaimaniyah Directorate of Antiquities and Heritage	Chief Representative, excavation
Sami Hama Rashid	Sulaimaniyah Directorate of Antiquities and Heritage	Representative, excavation
Sabr Ahmed	Sulaimaniyah Directorate of Antiquities and Heritage	Representative, excavation
Parween Yawar Manda	Sulaimaniyah Directorate of Antiquities and Heritage	Representative, excavation
Hero Salih Ahmed	Sulaimaniyah Directorate of Antiquities and Heritage	Excavation
Halala Salih Ahmed	Sulaimaniyah Directorate of Antiquities and Heritage	Excavation
Sam Walsh	University of Reading	Human remains
Robin Bendrey	University of Reading	Zooarchaeology
Sarah Elliott	University of Reading	Micromorphology, excavation, pXRF analyses
Jade Whitlam	University of Reading	Archaeobotany
David Mudd	University of Reading	Groundstone
Ingrid Iversen	University of Reading	Microarchaeology
Dominik Fleitmann	University of Reading	Cave survey
Pascal Flohr	University of Reading	Excavation, 14C dating
David Thornley	University of Reading	Geophysics
Mike Charles	University of Sheffield	Archaeobotany
Gemma Martin	University of Sheffield	Archaeobotany
Chris Beckman	University of Reading	Photography, excavation
Zoe Robinson	Oxford Brookes University	Excavation, lithics
Adam Stone	University of Cambridge	Excavation
Jeroen de Reu	University of Ghent	3D recording
Aroa García-Suárez	University of Reading	Excavation
Nick Harper	University of Reading	Excavation
Will Owen	University of Reading	Excavation
Matt Bosomworth	University of Reading	Excavation
Alessandro Guaggenti	University of Reading	Excavation
Tom Moore	University of Reading	Excavation
Lisa Cooper	University of British Columbia	Director of Iron Age excavations
Zuhair Rijib	University of Baghdad	Ceramics
Chelsea Gardner	University of British Columbia	Excavation
Lynn Welton	University of British Columbia	Excavation, surveying, ceramics
Sheri Pak	University of British Columbia	Excavation, photogrammetry
Miles Tysoe	University of Reading	Excavation
Rory Williams-Burrell	University of Reading	Excavation
Agnieszka Trambowicz	University of Reading	Excavation
Nichirwan Khosravi	Bu Ali Sina University	Excavation
Golnaz Ahadi	University of Tehran	Archaeobotany
Rosie Everett	University of Reading	Excavation
Zoe Richardson	University of Reading	Excavation
Mathew Britten	University of Reading	Excavation, outreach
Rhi Smith	University of Reading	Outreach
Rob Batchelor	University of Reading	Coring
Alice Williams	University of Oxford	Archaeobotany
Hawar Najmadin Hawas	University of Cairo	Excavation
Jessica Johnson	IICAH Erbil	Conservation
Nyan Nasser	IICAH trainee Erbil	Conservation
Julie Unruh	Independent	Conservation
Nedal Haj Darwich	Independent	Excavation
Marta Portillo	University of Reading	Animal ethnoarchaeology
Kayce Herrick	University of Reading	Excavation
Samira Idriss	University of Reading	Excavation
Maria Rabbani	University of Reading	Excavation
Mubariz Rabbani	University of Reading	Excavation

Attraction Poles Programme – Belgian Science Policy. Karin K. Lindboe is thanked for discussion on marrow use from phalanges.

For Chapter 18, the authors acknowledge the support of a NERC/AHRC grant (NF/2016/2/5) for ^{14}C dates and a British Academy grant (pf170053) which supported some of the writing up. For Chapter 22, the author wishes to thank Wendy Matthews, Danny Rosenberg and Anna Stroulia for their helpful suggestions on comparanda and interpretation. For Chapter 23, Wendy Matthews and Amy Richardson wish to thank the Director and staff at the Slemani Museum for the opportunity to collaborate in the new Prehistory Gallery, including its Director Hashim Hama Abdullah, Shazad Jaseem Tofiq, Rebin Mohammed Rashid, and Dr Rozhen Mohammed-Amin, Sulaimani Polytechnic University.

Although in some fields it is common practice to round off radiocarbon dates to the nearest decade (Mook 1986), we adhere to the precise given date throughout the volume. As Millard (2014) advises, where higher precision is required precise dates should be adhered to, without decadal rounding off. Given the extremely tight stratigraphy and associated chronology of the human burials at Bestansur, Trench 10, Space 50, in particular, where individual burial events appear to be separated by very short timespans, we prefer to adhere to precise dates throughout the volume.

For assistance with production of this volume the editors express special thanks to David Mudd for his tireless support and generous input of time and expertise. At Oxbow Books we wish to thank the production team headed by Julie Gardiner, for their support, patience and understanding during the gestation and production of this volume.

Interim reports on all field seasons at Bestansur, Shimshara and Zarzi, along with much other relevant information, are available at: https://www.czap.org/. A new 5-year phase of the project, entitled MENTICA Middle East Neolithic Transition: Integrated Community Approaches, commenced in October 2018 supported by a European Research Council Advanced Grant (Grant ERC-AdG 787264: https://research.reading.ac.uk/mentica/).

The Editors

UKRI Arts and Humanities Research Council

erc European Research Council
Established by the European Commission

University of Reading

The British Academy

1. THE NEOLITHIC TRANSITION IN THE EASTERN FERTILE CRESCENT: PROJECT THEMES, AIMS AND OBJECTIVES

Roger Matthews, Wendy Matthews, Amy Richardson and Kamal Rasheed Raheem

Research context: global challenges, archaeology and the Neolithic transition in the Eastern Fertile Crescent (EFC)

Our planet is undergoing a catastrophic episode of disruption. Scientists have highlighted the fragility of the planet's future due to intensive exploitation by human societies of its finite resources in attempts to sustain ever-increasing population densities and differential wealth levels (Lewis and Maslin 2018). The 2019 report *Climate Change and Land* produced by the Intergovernmental Panel on Climate Change (Arneth *et al.* 2019) stresses the role of intensive agriculture and pasturage, necessary for provisioning the planet's almost eight billion people, in negatively impacting many aspects of Earth's environment. There is an urgent and critical role for archaeology in providing a deep-time perspective on these issues. As Carleton and Collard (2019: 12; see also Whitehouse and Kirleis 2014: 8) state "archaeologists are in a unique position to study long-term human-environment interaction and we should be helping to educate the public and inform policy discussions." Within the context of an increasing awareness of the contribution that the study of the past can make to approaching contemporary issues of global concern (Kintigh *et al.* 2014), a new agenda for archaeology comprises a wide range of issues with resonances for the past, present and future of our planet. Major concerns include human responses to, and causation of, abrupt climate change, the management and domestication of plants and animals, the sustainability and transformation of societies, and health and well-being, all of which fall within the scope of the research reported on in this volume.

The Neolithic transition from millennia of hunter-gatherer life to farmer-herder lifeways is universally regarded as one of the most important episodes of change in human history (Mithen 2003; Barker 2006; Zeder 2015; 2016; Asouti 2017; Watkins 2017), holding fundamental significance for global societal development in subsequent millennia. The Neolithic transition coincided with a time of abrupt global climate change as the warmer, wetter Holocene (Roberts 2013; Jones *et al.* 2019) succeeded the Last Glacial Maximum (Clark *et al.* 2009). Through the Neolithic period, the interrelationships between people, animals and plants, including goat, sheep, pig and cow, and cereal and legume crops, were significantly realigned. There is also considerable evidence for the development by human communities of networks, some ranging over hundreds of kilometres, to enable access to materials such as obsidian, carnelian and seashells used for implements, adornment and prestige. On the basis of farming, over time societies accumulated agricultural surpluses which underpinned the development, elaboration and eventual worldwide domination of complex, stratified societies, including cities, states and empires, capable of sustaining large numbers and classes of people – ruling elites, armies, craft-workers, bureaucrats, priesthoods – professionally detached from the practicalities of food production (Liverani 2014).

Many researchers see the Neolithic transition as representing a first stage in the formulation of a new relationship between humans and their environments whereby new modes of intensified human engagement with plants, animals and entire landscapes could be characterised as "the single most dramatic (and ultimately the most catastrophic) set of changes that human society has experienced since the mastery of fire" (Hillman and Davies 1999: 70; see also Larsen 2006; Hole 2007). Through the Neolithic, the nature of human relations with their surroundings changed fundamentally from one of long-term stable engagement to one of ultimately unsustainable exploitation by humans of the planet's rich but finite resources. At 10,000 BC, somewhere between 2-4 million humans walked the earth, all of them hunter-gatherers, while today more than 7.6 billion people inhabit the planet, largely concentrated in dense urban environments and all but a tiny minority reliant on intensive agriculture.

Across the same time-span, an eye-blink in the context of Earth's 4 billion-year existence, the planet's wild land biomass (the total mass of all living things on dry land) has plummeted from 100% to just 3%, with some 25 billion animals today forming the bulk of the domesticated biomass (Smil 2011; Lewis and Maslin 2018: 4). Cultivated or pasture land area across Earth has soared from 0% to 50% of habitable land, while agriculture today accounts for 70% of global freshwater use (Arneth *et al.* 2019: 2). Human-directed crop cultivation and animal herding have colonised the planet, converting biomes to 'anthromes', and have done so in an extravagant, excessive and iniquitous manner, with 25–30% of global food production going to waste, 2 billion adults now overweight or obese and more than 820 million people undernourished (Arneth *et al.* 2019: 3). As phrased by Williams *et al*. (2015: 206): "The modern biosphere is unique in that much of the animal and plant variation, and ecosystem structure is shaped by one species." These dramatic shifts in the constitution of life on earth have been enabled and advanced by scientific developments such as the artificial fixation of nitrogen and the production of nitrogen fertilisers, made possible since AD 1909 through the Haber-Bosch process, and producing over only the past 110 years "the largest disruption to the earth's nitrogen cycle in 2.5 billion years" (Brannen 2017: 236).

The scale of change to our planet over the past 10,000 years has encouraged some to see the Neolithic transition as a starting point of a new geological era, the Anthropocene, defined by the predominance of humans as environmental forces at a planetary scale. While often seen as starting with recent historical episodes such as the industrial revolution or the atomic age (Crutzen and Stoermer 2000; Zalasiewicz *et al*. 2015; Lewis and Maslin 2018), many studies situate the Anthropocene within the context of deep-time perspectives that reach back into human prehistory (McCorriston and Field 2020), with a focus on the Neolithic transition as a major step-change in the capacity of human niche construction to rearrange the planet's resources in ultimately deleterious ways, including loss of biodiversity, over-exploitation of finite resources, landscape modification, habitat destruction and increases in atmospheric carbon dioxide and methane (Ruddiman 2003; Smil 2011; Smith and Zeder 2013; McClure 2015; Ruddiman *et al*. 2015; Boivin *et al*. 2016): "Clearly, the change in how humans acquired food in a few centres 10,000 years ago has now engulfed much of the world in a profound way, arguably not for the better, either then or now" (Larsen 2006: 18).

In approaching the Neolithic transition in Southwest Asia, earlier notions of a 'Neolithic Revolution' (Childe 1936) have been superseded as research reveals the diversity of the transition across the region, now emphasising the long time-spans and mosaic, multi-centred, non-linear nature of change across the Fertile Crescent (Willcox 2005; Asouti 2006; 2017; Zeder *et al.* 2006; Fuller *et al.* 2011; Zeder 2011; Asouti and Fuller 2013; Finlayson 2013; Riehl *et al.* 2013; 2015; Ibáñez *et al*. 2018). The focus has shifted from overarching theories such as climatic determinism and Childe's 'oasis hypothesis' to approaches that investigate regions as case-studies of transition, and that integrate contextually robust evidence from interdisciplinary field and analytical methodologies (Zeder and Smith 2009).

In the mid-twentieth century, the importance in the Neolithic transition of the Eastern Fertile Crescent (EFC) region, principally comprising eastern Iraq and western Iran along the Zagros uplands, was established in formative research in the Zagros 'hilly flanks', identified as native habitats of plants and animals that were later domesticated. This early research included investigation of Epipalaeolithic occupation at Zarzi cave (Garrod 1930; Wahida 1981; Olszewski 2012), and of early settlements by a multi-disciplinary team at the Neolithic sites of Jarmo and Karim Shahir (Fig. 1.1 and 1.2; Braidwood *et al.* 1983), followed by investigations at Asiab and Sarab in the high Zagros (Braidwood 1960; 1961). While pioneering in their multi-disciplinary approach, the Braidwoods realised that future research would need to focus on the 2500-year period preceding occupation at Jarmo in order to investigate the formative Early Neolithic period, *c*. 10,000–7500 BC, which did not appear to be attested there.

The Braidwoods' fieldwork in the Zagros was followed by investigations at EFC Neolithic sites including Ganj Dareh (Smith 1976; 1990), Guran (Mortensen 1972; 2014) and Abdul Hosein (Pullar 1990), and in the south Zagros at Ali Kosh (Hole *et al*. 1969), Chogha Sefid (Hole 1977) and Chogha Bonut (Alizadeh *et al*. 2003). Since 1979 in Iran and 1990 in Iraq, political instabilities meant that field research was largely on hold, during which time there were major developments in archaeological theories, methods and techniques (Trigger 1989; Hodder 1999; 2012). No new excavations of EFC Early Neolithic sites were conducted until recently, in western Iran at

East Chia Sabz (Darabi *et al*. 2011) and Chogha Golan (Riehl *et al*. 2015), following surveys of the region (Mohammadifar and Motarjem 2008).

Since 2007, new investigations of the Early Neolithic of the Zagros uplands have been directed within the Central Zagros Archaeological Project (CZAP: https://www.czap.org). CZAP investigations 2007–2011 included excavation and interdisciplinary ecological and materials analysis at Sheikh-e Abad in the high Iranian Zagros, spanning levels dated to *c*. 10,000–7590 BC, and investigation of a large section through the mound at Jani, with levels dated to pre and post *c*. 8240–7730 BC (Matthews *et al*. 2010; 2013a; 2019b). This current volume focuses on major fieldwork campaigns and interdisciplinary analyses from 2011 to 2017 including: excavations at Bestansur, 66km southeast of Jarmo in Sulaimaniyah province in the Iraqi Zagros foothills, involving investigation of ecology and society in different sectors of a previously unexcavated Neolithic settlement with levels spanning at least *c*. 7700–7100 BC; rescue excavations in the early levels at Shimshara, *c*. 7320–7180 BC, and; survey in the vicinity of the Epipalaeolithic site of Zarzi cave (Matthews *et al.* 2016b; 2019a). These new case-studies and the project aims and objectives are outlined in more detail at the end of this chapter, in the context of the key research issues in the transformation to more sedentary agricultural communities and lifeways, discussed in the following sections.

The importance of the EFC within the Neolithic transition is well-established by archaeological and DNA analyses on Neolithic humans, animals and plants, which demonstrate intensifications of human-animal-plant interrelationships including the domestication of founder crops and animals, within the context of changing climate and environment (Sharifi *et al*. 2015; Jones *et al*. 2019). Recent and ongoing research on the Zagros high steppe, foothills and mountain plains of western Iran and eastern Iraq emphasises this region's role as a core zone of Neolithic transformation and the urgent need for further investigation (Matthews and Fazeli Nashli 2013; Matthews *et al*. 2013a; 2013b; 2016b; 2019a; Helwing 2014; Riehl *et al*. 2015; Roustaei and Mashkour 2016).

The archaeological and ancient DNA (aDNA) evidence indicates the independent domestication of goat in the Zagros-Taurus uplands (Luikart *et al*. 2001; Naderi *et al*. 2008; Pereira and Amorim 2010), and practices of stock-keeping were transmitted from the EFC eastwards (Daly *et al*. 2018). There is evidence for early barley domestication in the Zagros and further east in Iran, independently of its domestication in the Western Fertile Crescent (WFC: Morrell and Clegg 2007; Saisho and Purugganan 2007). Analysis of plant assemblages from Early Neolithic sites allows the possibility of an independent trajectory from gathering to cultivation of cereal crops in the Zagros foothills (Riehl 2012; Riehl *et al*. 2013; 2015) and high plains (Whitlam *et al*. 2013), underpinned by continuity in EFC stone tool assemblages through the early stages of the transition (Thomalsky 2016). Genetic analysis of human remains from the sites of Hotu, Abdul Hosein and Ganj Dareh in Iran has identified a Zagros population, unrelated to early farmers in Turkey to the north or in the WFC (Gallego-Llorente *et al*. 2016) and indicative of lengthy independent population development in western Iran (Lazaridis *et al*. 2016).

Most significantly, aDNA analysis of Neolithic EFC human remains identifies the Zagros as "the cradle of eastward expansion" into central and south Asia of "the SW-Asian domestic plant and animal economy" (Broushaki *et al*. 2016: 3). The origin of the Neolithic lifeways of Central and South Asia is a greatly under-researched issue (Harris 2010). The indication from new research is that the EFC, in particular the Zagros region, comprises a key formative zone for some of the earliest, most significant steps in the transition from mobile hunter-gatherer to settled farmer-herder lifeways, with special significance as a source region for new human-plant-animal interconnections, including animal herding and crop cultivation, spreading eastwards across Iran, into Central Asia and northwards into Transcaucasia, an issue about which we know extremely little (Barker 2006; Helwing 2014). Interpretations of the Neolithic transition proposing the spread of all new practices from a WFC Levantine core outwards, ultimately reaching Turkey and the Zagros (Bar-Yosef 2001; 2014), are untenable in view of the increasing evidence from the EFC for local origins and development of Neolithic settled communities, at least contemporary with early developments across Southwest Asia.

The chronology of the Neolithic transition in the EFC, as discussed in Chapter 11, needs much greater refinement from securely contextualised radiocarbon dates. Table 1.1 presents the basic outline of EFC prehistoric chronology including comparative chronology of the WFC, which is supported by greater numbers of radiocarbon dates and has much finer resolution than the EFC. Throughout the volume we adhere to a chronology local to the EFC to highlight the regional variability in cultural traditions in the EFC as against the WFC. The chronological divisions outlined in Table 1.1 are shaped partly by local factors, such as lithic typologies and absence/presence of pottery, for example, as well by broader factors such as the global climatic transition from the Younger Dryas into the Early Holocene at *c*. 9700 BC (all dates are given as calibrated BC throughout the volume, except where stated). The significance of the 8.2ky BP horizon is underlined by a proposal that it serves as the end point of the Early Holocene and the start point of the Middle Holocene, ending at 4.2ky BP

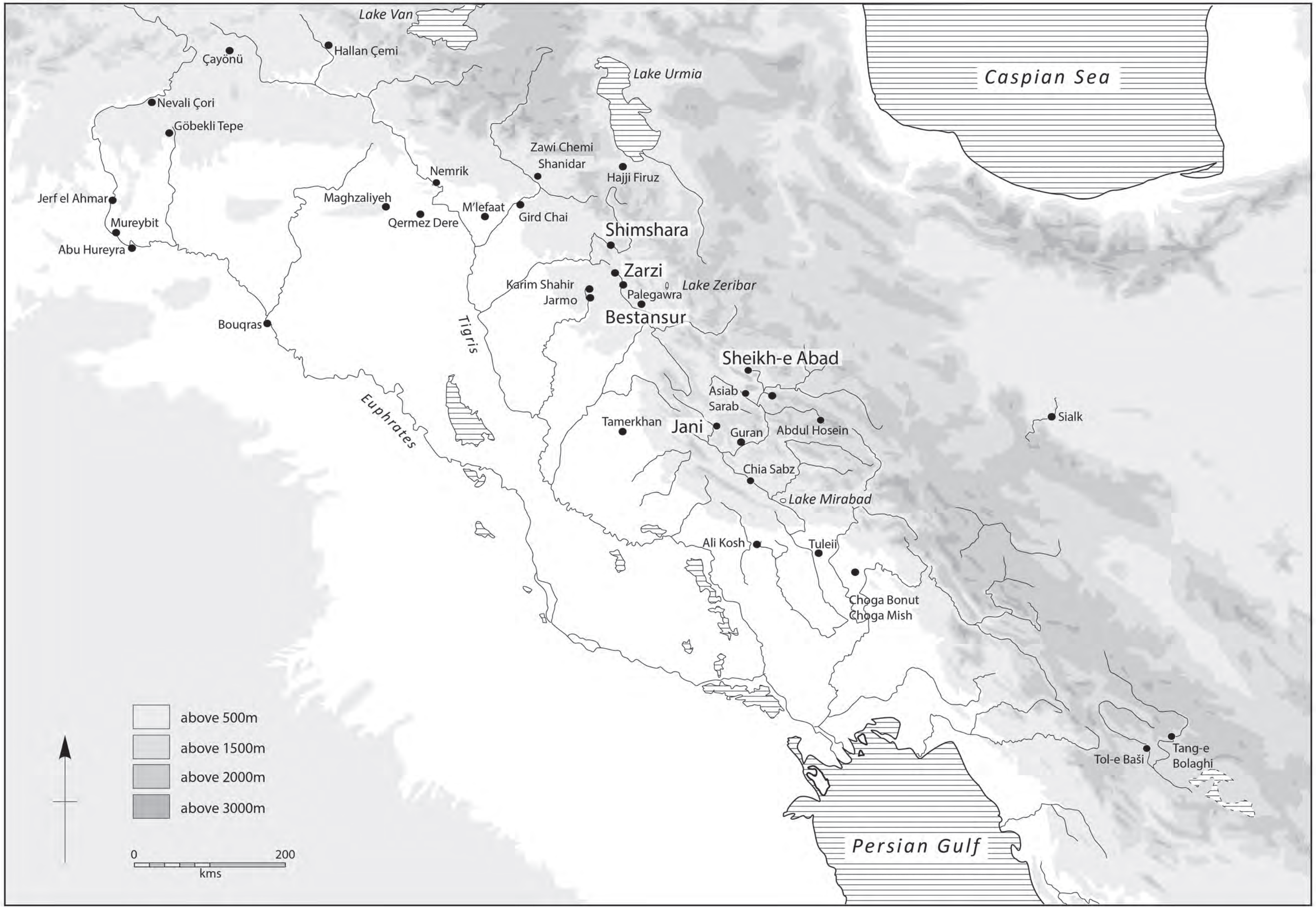


Figure 1.1. Map of Palaeolithic and Neolithic sites in the EFC region.

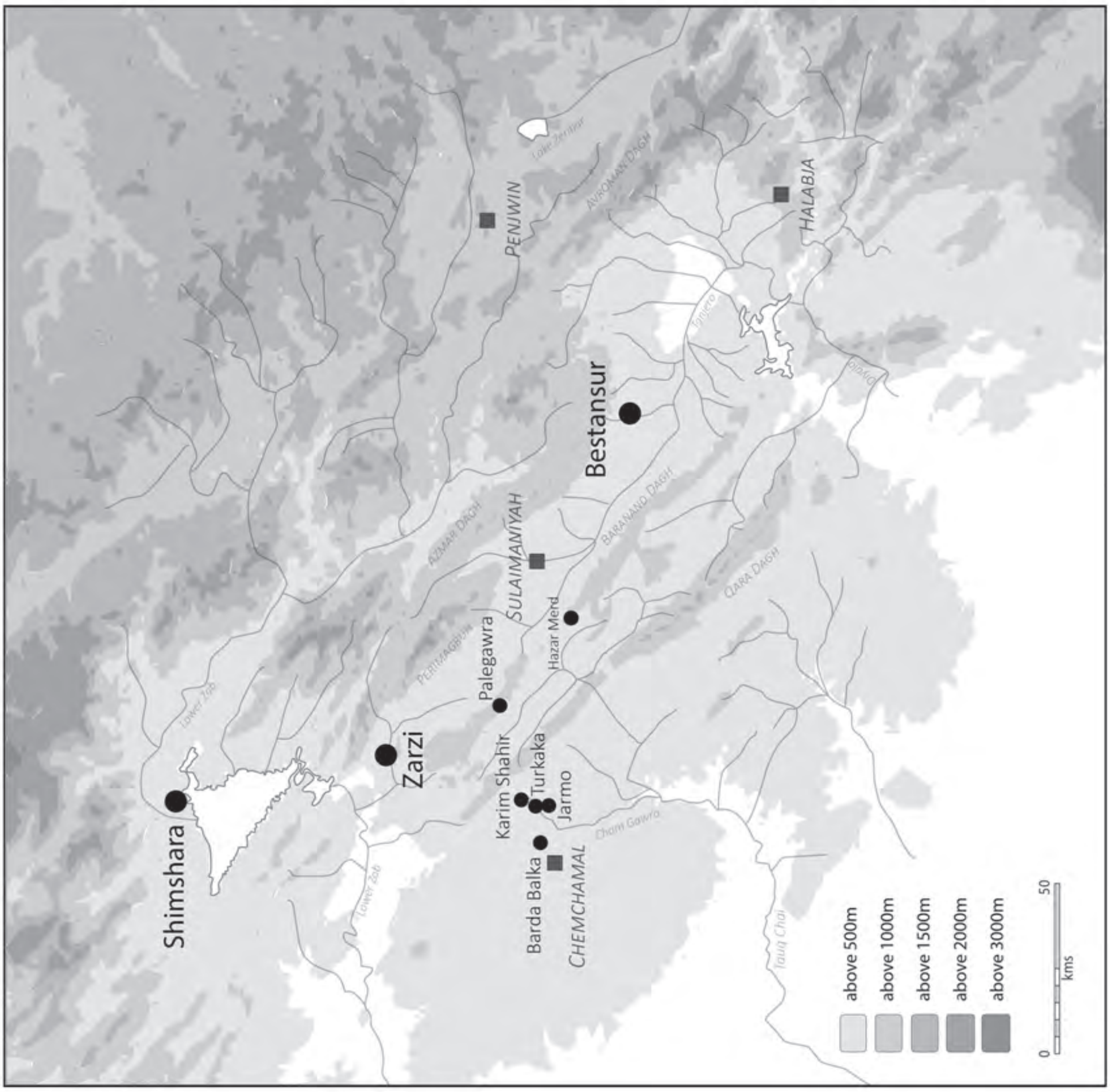


Figure 1.2. Location of the CZAP sites.

Table 1.1. Outline chronology of the WFC and EFC (calibrated BC).

WFC		*EFC*	
Late Epipalaeolithic	12,000–10,000	Late Epipalaeolithic	15,000–10,000
PPNA	10,000–8700	Early Neolithic	10,000–7000
Early PPNB	8700–8200		
Middle PPNB	8200–7500		
Late PPNB	7500–7000		
Pottery Neolithic	7000–6000	Pottery Neolithic	7000–5200
Chalcolithic	6000–4000	Chalcolithic	5200–3000

(Walker *et al*. 2012), since climatic events at both these dates are detectable in global climate proxy records.

Drawing from and building on the research summarised above, the following key themes and questions were articulated and investigated within the fieldwork and research scope of CZAP as reported on in this volume and examined in turn in this chapter:

1) Human-environment interactions and sustainable lifeways
How did the Early Holocene climate and environment of the EFC and beyond, including the 9.2 and 8.2ky BP events (Flohr *et al*. 2016), impact human settlement and activity, and how did humans begin to impact their environments through their changing food and fuel acquisition and production practices? How resilient were Early Neolithic communities of the EFC and how sustainable were their newly developing practices?

2) Sedentarisation, society and ritual
How can we best trace the development of sedentary Neolithic societies from seasonal and temporary to year-round and permanent? In what circumstances were Neolithic settlements and communities founded and sustained and how were they constructed and socialised? Within the architecture of Early Neolithic sites, how can the use of construction materials and the distribution of macro- and micro-archaeological evidence across internal and external spaces inform us on modes of behaviour and activity within early settlements? What role(s) did ritual and symbolic behaviour play in the transition from mobile hunter-gatherer to sedentary farmer-herder? In what ways did treatment of the human dead within EFC Neolithic settlements underpin the socialisation of early settled communities?

3) Resource management, diet and health
The Neolithic transition is characterised by major changes in practices of food acquisition and production. Across the spectrum of food practices ranging from exclusive reliance on hunting and gathering to full agriculture, through the course of the Neolithic we can trace considerable variability in the ways in which individual communities acquired and produced their food, including in terms of storage, diet diversity and seasonal access to food resources. Within the Early Neolithic EFC can we delineate processes of plant and animal management prior to full, morphologically attested domestication that might fit with the model of so-called 'protracted domestication' (Allaby *et al*. 2008; Heun *et al*. 2012)? What impacts were there on human health and demography of the transition to a more sedentary lifestyle, increasingly focused on a diet of cultivated crops and closely managed animals?

4) Material engagement and networks
The broadening horizons of Neolithic communities are richly attested by increases in import of exotic materials such as obsidian, carnelian and seashells to sites in the EFC. What networks of engagement and social relations underpinned the material evidence, and how did they intersect with the widespread sharing of food procurement strategies which in time enabled the spread of farming lifestyles across vast distances of Southwest Asia and beyond?

Human-environment interactions and sustainable lifeways

How resilient were past human societies in coping with environmental change, including changes that may have been human caused? Within the Late Pleistocene-Early Holocene transition, *c.* 15,000–9800 BC, a time of major environmental change, there is considerable scope for investigation of this question even if much work remains to be done. Key issues include the extent to which land management practices were sustainable, the degree to which such practices led directly to land degradation and the potential for such practices to ensure food security, all issues of major contemporary resonance (Arneth *et al*. 2019).

The urgent importance of applying integrated interdisciplinary approaches to the study of past human-environment interactions as a means of exploring current and future scenarios has been highlighted in a recent review of the most-cited papers published in 2005–2015 dealing with this field. Carleton and Collard (2019) stress the need for greatly refined chronologies in order to improve understanding of human-environment interactions, an aim that can more readily be achieved today with ever-improving accuracy of radiometric dating methods. They also call for increased awareness of non-linearity in past human–environment relationships (Freeman *et al*. 2015), an issue that can be addressed only through the generation, interpretation and synthesis of multi-component, highly contextualised and rigorously dated material evidence.

The Late Pleistocene–Early Holocene period constitutes the environmental and climatic context within which human communities undertook the Neolithic transition across Southwest Asia. During the Late Glacial Maximum, 25,000–15,000 BC, a severely cold and dry climate dominated the EFC region, with mean temperatures 6–7°C cooler than modern times enabling snow lines as low as 600m (Hole 1996). Lake core evidence from Mirabad and Zeribar attest a lack of tree pollen for the period 35,000–12,000 BC, suggestive of an environment of mountain tundra, steppe and scrub-steppe across the Zagros (van Zeist and Bottema 1982; van Zeist 2008). Occupation evidence from Zagros cave sites such as Shanidar suggests a long period of abandonment, up to 15,000 years (Solecki and Solecki 1983), matched by a lack of significant evidence for human occupation across all the EFC through much of these millennia (Matthews *et al.* 2013e).

During the later Epipalaeolithic period and the warmer, wetter climate of the Bølling–Allerød Interstadial from *c.* 15,000 BC, small-scale human communities re-established themselves across the Zagros, in cave and rock-shelter sites such as Shanidar, Zarzi, Palegawra and the Hulailan valley (Matthews 2000). By *c.* 10,500 BC open-air sites such as Karim Shahir and Zawi Chemi Shanidar were occupied, with the earliest evidence in the region for architecture in the form of a circular dry-stone structure 2m in diameter (Solecki 1981). From the same site there is some of the earliest evidence for ritual paraphernalia in the form of skulls of wild goat and sheep and wing-bones from at least 17 large birds (Solecki and McGovern 1980). The human occupants of these sites secured food through hunting and gathering of wild species, with evidence for specialisation in prey, which varied at different sites: gazelle and sheep/goat at Zarzi, onager at Palegawra, sheep at Zawi Chemi Shanidar, goat/sheep at Karim Shahir (Matthews *et al.* 2013e: 16–18). This micro-regional emphasis on individual species as prey enabled human communities to develop in-depth familiarity with their hunted species, serving as a pool of accumulated knowledge that underpinned the intensification of human-animal interrelations that characterise the Early Neolithic transition. Very small quantities of obsidian from these sites reveals their participation, however tenuously, in networks of transregional movement of cherished materials across considerable distances (Barge *et al.* 2018; Campbell and Healey 2018; Frahm and Tryon 2018). This new phase of CZAP research therefore seeks to investigate local micro-regional climate and environment and ecological strategies and how they may have enabled or constrained the development of increasing plant and animal management and domestication.

The Younger Dryas episode, *c.* 11,000–9700 BC (Roberts 1998: 70–71; Jones *et al*. 2019), was marked by a return to a cooler, drier, dustier climate, attested in the Zeribar and Neor lake cores which indicate a semi-desert environment of chenopod-*Artemisia* and dominance of pistachio forest across the Zagros (van Zeist 2008; Sharifi *et al.* 2015). An increase in charred grass awns and micro-charcoal in Zeribar sediments from *c.* 10,000 BC, along with an increase in grass pollen, suggests the spread of grasslands and the common occurrence of grass fires in the lands surrounding the lake (Wasylikowa *et al.* 2006; Turner *et al.* 2008), supported by archaeological evidence for an enhanced human presence in the Zagros from that time. A key issue is that of the spread of woodland in the warmer, wetter, less dusty climate of the Early Holocene. Following the spread of grasslands including cereal crop progenitor taxa (Asouti 2017) and associated grazing animals from *c.* 10,000 BC, the rate of oak spread in the Zagros region is much slower, not peaking till *c.* 4000 BC. Possible factors delaying the oak spread include continuing dryness in the Early Holocene, and human management of woodlands including controlled clearance for fuel, livestock grazing and early cultivation (Roberts 2002; Robinson *et al.* 2006; Jones and Roberts 2008; Asouti and Kabukcu 2014; Asouti 2017). Other inland areas of Southwest Asia, notably, underwent a similar rate of oak spread through the Early to Middle Holocene. Doubts have been expressed, however, concerning the capacity of the relatively small-scale, low-density levels of human settlement in the Early Holocene Zagros to have had significant impact on regional vegetation patterns as widespread and synchronous as the lake core pollen data appear to indicate (Jones *et al.* 2019).

Regarding the 9.2 and 8.2ky BP climatic events, global episodes of sudden, dramatic cooling caused by marine intrusions of segments of the Laurentine ice-sheets, detailed analysis (Flohr *et al.* 2016) indicates that Early Neolithic communities across Southwest Asia, including in the EFC, appear not to have been significantly impacted. This pattern of settlement continuity in the face of abrupt climate change is suggestive of resilient, flexible societies pursuing adaptable combinations of food procurement strategies, as also attested at the Early Holocene site of Star Carr in England through the 9.2 and 8.2ky

BP events (Blockley *et al.* 2018). Key to Neolithic communities' resilience in the face of changing environmental conditions, in particular regarding food security, would have been their ability to pursue a range of buffering strategies, which might include the exploitation of previously unexploited land, shifting the emphasis between agriculture and livestock herding, including variable seasonal occupation of sites, and between use of wild vs domesticated resources, increased multi-cropping, and storing and trading in foodstuffs (Hole 2007: 195). Evidence from across Southwest Asia suggests that all these buffering strategies were adopted at various times by resilient Neolithic communities.

In sum, research to date indicates that societies of the Epipalaeolithic–Early Neolithic transition experimented with food procurement and dietary practices within changing environmental and climatic contexts, providing new opportunities for human engagement with the plants, animals and landscapes with which they lived. Alongside established practices such as hunting of wild prey and gathering of plants, communities continued to use small-scale biodiverse resources such as fish, molluscs and birds (Stiner *et al.* 2000; Starkovich *et al.* 2016) as well as to experiment with greater management of animals and plants. The diversity of food procurement strategies in itself appears to have been an invaluable asset in enabling small-scale human communities to be resilient in terms of land use patterns and food security in the face of dramatic change, including abrupt climate events.

Human–environment interactions: research aims and objectives

Within the scope of this phase of the CZAP project, the aim for investigating human-environment interactions was to recover new contextually secure evidence from relevant archaeological sites and their environs with which to examine the nature and extent of transformations in resource availability, management and domestication and sedentism and ritual. Excavations at Bestansur and Shimshara in Iraqi Kurdistan were designed for retrieval, integration and analysis of richly contextualised evidence on human-environment interactions in order to investigate local and trans-regional variation from the lower Zagros for comparison to ongoing research in the highland Zagros. We aimed to develop an initial programme of sampling of speleothems from cave sites in the region (Chapter 3) leading directly to the recovery of palaeoclimate archive records and their ongoing study. In association we initiated a programme of study of lake cores from the high Zagros in Iran and the Zagros foothills in Iraq, research on which is underway (Chapter 3). From the excavated sites we designed an integrated programme for recovery of a wealth of zooarchaeological and archaeobotanical evidence with which to reconstruct aspects of the environments of these major settlements and of the interrelations between people, plants, animal and environments through this critical episode of transition.

Sedentarisation, society and ritual

One of the major attributes of the Neolithic transition is the fact that human communities across Southwest Asia became increasingly sedentary, with more people staying for longer periods in the same place. The implications of this trend are immense for the nature and development of human communities in subsequent millennia. A significant feature of recent studies of this process is the decoupling of sedentarisation from other components of the Neolithic transition. In a thoughtful discussion of this issue, Valla (2018) stresses the lack of linkage between sedentarisation and the early intensification of food production. Increasingly to the fore is the notion of 'sedentary hunter-gatherers' characterised by nascent complexity, communal buildings, complex modes of burial and developed symbolic practices, while reliant exclusively or almost so on hunting and gathering of wild plant and animal resources. This model has been proposed for the very Early Neolithic societies of the Upper Tigris region in south-eastern Turkey, attested at sites such as Hasankeyf Höyük, Hallan Çemi and Körtik Tepe (Özkaya 2009; Miyake *et al*. 2012; Zeder 2012a; Rössner *et al*. 2017; Rosenberg and Rocek 2019). Through the CZAP research we examine how applicable this model might be in the context of the Early Neolithic Zagros.

Traditional approaches of attempting to prove the practice of, rather than just the potential for, year-round settlement on the basis of the presence of season by season resources need to be complemented by theoretical frameworks and in-field approaches that move beyond the mobile vs settled dichotomy to consider instead "modalities of site occupation" (Valla 2018: 26) approached through a suite of integrated methods. Such methods should comprise microarchaeological and micromorphological analyses of floors and occupation deposits (W. Matthews *et al.* 2014), integrated phenological analysis of plant and animal remains as suggestive of possible seasons of occupation, plus analysis of commensal species such as house mouse, rat and dog as indicative of new ecological niches afforded by human sedentarisation (Weissbrod *et al.* 2017), all of which methods have been applied in this research and are recurrently addressed through this volume.

Connected to the issue of sedentarisation is the early development of mounded sites or *tells* in the Neolithic landscape of Southwest Asia. In the Epipalaeolithic of the EFC, human occupation was focused on caves, rock shelters and flat open-air sites, all indicative of episodic visits and seasonal stays by small-scale human communities. Through intensive field survey of the region of Zarzi cave (Chapter 4), we investigate the theory of Wahida (1981) that human societies in this period moved seasonally between sites according to climate and to availability of hunted and gathered resources. From the start of the Neolithic this pattern began to change with the development of mounded sites composed of accumulated debris and materials from a more intensive human presence, often commencing with evidence for repeated episodes of large-scale burning over significant but episodic time-frames prior to construction of substantial architecture (Matthews *et al.* 2013e; W. Matthews 2016). Such sites do not necessarily indicate year-round occupation, even when they become substantial mounds. They could have served as focal points for a wide range of social, cultural and economic activities by widely scattered communities including early agriculturalists, pastoralists and hunter-gatherers.

Steadman's (2005) analysis of tell formation articulated two major types of factor determining location and formation: functional considerations such as proximity to essential and desired resources including water, arable soil, flint and clay, plus symbolic-cognitive attachments to place through their sacred, cultic and/or ancestral associations. Combinations of both these factor types are the likeliest situation whereby, for example, a major fresh-water spring might both serve as an essential resource and constitute a highly charged cultic or sacred location. Similarly, a nearby mountain might host rich seams of stone for production of chipped and ground stone tools and timber for fuel and construction while also being revered as the home of a major deity.

Human societies created tells but tells were also instrumental in the socialisation of human communities. In this context the idea of them as abodes of the ancestors comes especially to the fore (Verhoeven 2006). A significant component of this attribute of sedentary community life was the burial of the human dead recurrently under house floors at Early Neolithic sites across Southwest Asia, including a frequent emphasis on the special treatment and deposition of human skulls (Croucher 2012). Burial practices became a means of connecting people to place through time and of binding the living to the dead through their co-presence, vertically separated above and below floors by a mere few dozens of centimetres. Within the settlement, and partly forming it, sequences of sub-floor burials accumulated within sequences of ancestral buildings, so that "the living did not just live with the dead and ancestors under their immediate floor or floors but with their ancestral houses beneath them as well, surely a powerful motivation for house continuity and a factor emphasizing the symbolic continuity of the house" (Baird *et al.* 2017: 764). The passage of time and the continuity of occupation of space by human societies would in time generate in each individual a sense of belonging to that place, that settlement and those landscapes, and the development of a sense of "sacrosanct ownership … linked in the minds of all inhabitants" (Steadman 2005: 296), leading in time to the establishment of "corporate land-holding descent groups" (Bellwood 2005: 56–57). A key aim in CZAP research, therefore, is to investigate burial practices and how the dead were connected to the living and the relationships that they represent.

Connected to this interpretation of social development is Chapman's (1997: 144) vision of Neolithic settlements as evidence of "commitment to a communal rather than a household ideology", with the repeated cycles of construction, occupation, abandonment and reconstruction of buildings critical both to the physical development of mounded sites and to the symbolic-cognitive connectivity of human communities to deep-time ancestral presences at the same place. The use of clay as a construction material is significant in this regard. Clay can be reused more or less indefinitely and is a more versatile and sustainable building material than stone, even where stone is available (Rosen 1996; Verhoeven 2006). Clay buildings can be readily constructed, either in pisé or mudbricks, modified, demolished, levelled, and new clay walls built atop the old ones or atop new clay packing. Repeated activities of this sort, whether conducted at the individual household level or as neighbourhoods or entire communities, would work to ground people's sense of identity firmly within the settlement of their home (Brami *et al.* 2016). Settlements are argued to have become sites of memory and identity "where the present and the past merged and directions towards the future were given shape" (Verhoeven 2006: 35).

In this project we investigate how people created, and lived within, Early Neolithic settlements. What was the relationship between physical architecture and social constitution? Were individual buildings occupied by well-defined social units that might be identified as 'families', nuclear or otherwise, and what was the relationship between living people occupying buildings and dead people buried under the floors of those same buildings? Through integrated application of recently developed scientific techniques we can begin to address questions such as these for the first time with meaningful evidence. Recent analysis of mitochondrial DNA of human burials at Çatalhöyük in Anatolia, for example, indicates a lack of maternal kinship between individuals buried together in a suite of rooms, leading to the proposal that "Such systems are characterized by ritual-based social organization, where biological kinship is secondary to alternative networks of affiliation" (Chyleński *et al.* 2019: 8–9), a social interpretation in agreement with that reached by another study of burials at Çatalhöyük based on micrometric analysis of human teeth (Pilloud *et al.* 2007). We need to adopt a complex, multi-stranded approach to understanding kin and social constitution in Neolithic communities, as advocated by Halperin (2017: 287; see also Johnson and Paul 2016; Torres-Rouff and Knudson 2017): "studies that consider the isotopic signature of individuals with an array of other data, such as burial treatments, morphometric data, body modifications, and other contextual information, underscore the fluidity of ethnic and cultural identities". The many human burials at Bestansur, in particular the large quantity of individuals in Space 50, Building 5 (Chapter 19), provide richly contextualised assemblages for exploration of these issues in the Early Neolithic of the EFC.

One major question which we examine is whether individual families were living in discrete buildings, which together we might define as 'households', as the basic building blocks of Early Neolithic societies in the EFC (Byrd 2000; 2005). In addition to the human burial analyses outlined above, an approach to this question is to apply integrated microarchaeological, microstratigraphic and micromorphological techniques in order to investigate patterns of activity and use of space within and across excavated buildings and internal and external spaces, as applied in this research, in order to investigate whether spaces were reserved for quite specific activities such as food preparation and cooking, or tool production and repair.

Across much of the Fertile Crescent in the Early Neolithic there is considerable evidence for 'special purpose buildings' as foci of early human settlement, further support for Chapman's (1997) theory of Neolithic commitment to a communal identity. Substantial 'communal' buildings have been excavated at many Early Neolithic sites in the WFC as at Wadi Faynan 16 (Mithen *et al.* 2018), Jerf el-Ahmar (Stordeur *et al.* 2001), Dj'ade al-Mughara (Coqueugniot 2000) and also at sedentary hunter-gatherer sites in the Northern Fertile Crescent such as Göbekli Tepe, Hasankeyf Höyük and Hallan Çemi (Miyake *et al.* 2012). Many of these buildings have a strong association with burial of the human dead. In CZAP research we aimed to explore whether such buildings existed at Early Neolithic sites of the EFC such as Bestansur or to consider what the lack of them might mean in terms of social complexity.

Evidence for the role of cultic practice and structured ritual behaviour is common in the Early Neolithic of Southwest Asia although doubts have been expressed regarding its significance within the EFC (Bernbeck 2004). Putative 'houses of the dead' have been excavated at several Early Neolithic sites in Southwest Asia, including the Skull Building at Çayönü, *c.* 8500 BC, with >450 individuals attested mainly by skulls and long bones (Özbek 1998; Özdoğan and Özdoğan 1998), a 'communal building' at Hasankeyf Höyük, *c.* 9500 BC, with >30 individuals (Miyake *et al.* 2012), a 'charnel house' at Abu Hureyra on the Syrian Euphrates, *c.* 9000 BC, with >50 individuals in pits, under floors and on floors (Moore and Molleson 2000), and a 'house of the dead' at Dj'ade al-Mughara, also on the Syrian Euphrates, *c.* 8000 BC, with >70 individuals in primary and secondary deposits (Coqueugniot 2000). While these special buildings, and the burial evidence from other Neolithic sites of the region (Croucher 2012), point to an elaboration of modes of treatment of the human dead through the Neolithic, research into Neolithic houses of the dead has yet to benefit from the full potential of interdisciplinary approaches of scientific archaeology, as applied in the integrated manner discussed in this volume.

Finally, why did Neolithic people stop living at Bestansur? The indications from chipped stone tool typology (Chapter 20) and radiocarbon dates (Chapter 11) are that the site was abandoned by its Early Neolithic inhabitants in the late eighth millennium BC. While this dating is at least approximately contemporary with the 9.2ky BP sudden climatic event (Flohr *et al.* 2016), we hesitate to associate the two occurrences without much richer evidence including more refined dating. More broadly, within the Early Holocene the period *c.* 9200–7000 BC witnessed a relatively stable climatic regime characterised by heightened seasonality: winters were cooler and wetter while summers were warmer and drier compared to today, especially in upland, inland zones such as the EFC (Brayshaw *et al.* 2011). From *c.* 7000 BC this regime steadily changed to a climate broadly similar to that of modern times, at least until very recently. If the human abandonment of Bestansur can be associated at all with climatic factors, it may relate to potential issues such as drying or translocation of springs, exhaustion of vital nearby resources such as grasslands or arable soil, or a major shift in food procurement strategies such as a decline in hunting and gathering at the expense of farming and herding that favoured relocation of the settlement elsewhere on the plains of Shahrizor or beyond.

Sedentarisation, society and ritual: research aims and objectives

In order to address the issue of sedentism, society and ritual, our aim was to plan and conduct a programme of excavations, above all at the formerly unexcavated site of Bestansur as surface material indicated that it was contemporary with, and potentially earlier than, Jarmo and would enable investigation of earlier stages in the transformations to sedentary agriculture, as highlighted by the

Braidwoods and colleagues (1983). The objectives were to detect, recover, record, integrate and analyse new evidence at scales ranging from the ultra-microscopic to the transregional to study local and interregional settlement, material culture and practices. This level of archaeological investigation was made possible only through the generous funding awarded to the project which enabled the involvement of appropriate specialist and other staff in the field, laboratory and across many universities internationally. Not without challenges, a programme of radiometric dating was planned in order to refine the chronology of the Early Neolithic in this under-researched region of Southwest Asia (Chapter 11). Our objectives included the excavation of stratified sequences of mudbrick buildings and their recoverable contents, employing high resolution excavation and recording techniques, including microarchaeology (Chapter 14), micromorphology (Chapter 12), and systematic sampling for flotation, sieving and laboratory analyses. We also planned for innovative and detailed analysis of recovered artefacts through systematic use of technologies such as portable x-ray fluorescence (pXRF), purchasing a dedicated machine for use in the field and laboratory, as exemplified in research discussed throughout this volume.

Resource management, diet and health

Current models of the processes of domestication of both plants and animals across Southwest Asia have developed significantly from initial formulations of unilinear, overarching theories that searched for single points of origin of domestication as unitary explanations of how farming came about and how it spread (Matthews 2003: 67–92; Barker 2006; Zeder 2011). It is now widely accepted that intensified human exploitation of plants and animals, leading to cultivation, management and full domestication, happened in many locations within the Early Holocene, and that in each regional case there is a need to investigate the trajectory from wild to domestic in its own context, articulating the courses of change and continuity in edible resource management specific to each region, even to each site. Millennia-long traditions of hunter-gatherer lifeways will also have made their contribution, as Fuller *et al.* (2012: 630) articulate with regard to plant cultivation: "the reasons domestication happened in parallel numerous times is that human groups drew upon a collective memory and deep cultural traditions of plant tending that developed in the later Palaeolithic/Pleistocene". It has long been argued that the Early Neolithic communities of the EFC differed in their food procurement and production practices and preferences from their contemporaries in the WFC, making, adapting and augmenting their own selection from a basic menu of so-called 'founder crops' and animal domesticates (Table 1.2; Zohary 1996; Hole 2007: 194; Fuller *et al.* 2012).

Table 1.2. 'Founder crops' and animal domesticates of Neolithic Southwest Asia.

Common name	*Latin name*
Einkorn	*Triticum monococcum*
Emmer	*Triticum dicoccum*
Barley	*Hordeum vulgare*
Lentil	*Lens culinaris*
Pea	*Pisum sativum*
Chickpea	*Cicer arietinum*
Bitter vetch	*Vicia ervilia*
Flax	*Linum usitatissimum*
Goat	*Capra aegagrus*
Sheep	*Ovis orientalis*
Pig	*Sus scrofa*
Cattle	*Bos primigenius*

Human–animal interrelations

Regarding animals, we firstly stress that the processes of intensified management and domestication of the four major species (Table 1.2) developed in highly variable ways and circumstances, animal by animal, region by region and possibly site by site (Zeder 2012b). This variability was determined by a range of factors, shaped by the natural distribution of wild progenitors but also including regional cultural traditions, taboos and preferences. In a stimulating review of animal domestication in the EFC Arbuckle *et al.* (2016: 7) lay down a bold challenge for archaeologists addressing these issues: "Untangling the myriad local environmental and cultural factors responsible for these regional patterns of change and continuity represents an important challenge for future work reconstructing the processes responsible for the origins and evolution of Neolithic animal economies in this important, yet under-explored, region of the Fertile Crescent."

There is no doubt that goat was an animal of major significance to communities of the Zagros range in the EFC, a relationship we can trace back into at least the Middle Palaeolithic (Matthews *et al.* 2013e). The aDNA evidence (Luikart *et al.* 2001; Naderi *et al.* 2008; Pereira and Amorim 2010; Daly *et al.* 2018) indicates that goat were independently domesticated in the Zagros-Taurus uplands within a mosaic pattern of intensified management and domestication by many human communities, thus generating "genetically and geographically distinct Neolithic goat populations, echoing contemporaneous human divergence across the region" (Daly *et al.* 2018). It is also now established that goats to the east of the EFC across Iran and into Central and South Asia derive directly from herds originating in the EFC (Daly *et al*. 2018: 86), a major development in our understanding of how the Neolithic arrived at these more eastern regions (Harris 2010).

Moreover, there are indications of the early appearance of genetic traits preferentially selected through human control over breeding patterns of goat, including pigmentation, a reduction in calving intervals, and resistance to a "toxic product of fungal strains that contaminate cereals and grains" (Daly *et al.* 2018: 86). This last trait is indicative of selection of breeds of goat able to thrive on the new foddering practices that accompanied their increasingly intensive entanglement with settled human societies of the Neolithic EFC. The fact that at the same time humans developed a genetic trait analogous to the goat trait of resistance to fungal toxins in foddering underlines the intimate entwinement of human, goat and crop in this single thread of the Early Neolithic tapestry. These inseparable developments in the biology and ecology of humans and goats highlight Zeder's (2015) characterisation of domestication as a process whereby the mutual evolutionary 'fitness' of both the domesticator and the partner organism are enhanced, "a strongly resilient style of human-animal relationship, which respects the autonomy of the domestic form" (Anderson *et al.* 2017: 399). Another thread in the human-goat-sedentary engagement is the development of zoonotic diseases, such as brucellosis, as discussed below.

Living in the natural habitat zone of wild goat, Early Neolithic communities of the high Zagros in Iran, including those at Ganj Dareh, Sheikh-e Abad and Jani, appear to have been the first to intensify their management of goat, as attested by kill-off patterns of goat at Ganj Dareh *c.* 8100–7800 BC (Zeder and Hesse 2000) and by stratified sequences of herbivore dung deposits at Jani and in animal pens at Sheikh-e Abad of approximately the same date along with zooarchaeological evidence for a strong reliance on goat as opposed to sheep (W. Matthews *et al*. 2013h: 99–101; Bendrey *et al.* 2013). The emphasis on goat at Sheikh-e Abad is underlined by the deliberate deposit of four wild goat skulls and one wild sheep skull within a dedicated small building dating *c.* 7600 BC (Bendrey *et al.* 2013: 152–156). By the mid-eighth millennium BC goat are attested at lowland Zagros sites such as Ali Kosh (Zeder 2008a; 2009) and we might therefore expect them to have reached the western Zagros foothills where Bestansur is situated at about the same time (Chapter 15).

Understanding of early management and domestication of sheep in the Early Neolithic EFC is less clear, but their appearance as domesticates in the region follows that of goat by up to 1000 years at *c.* 7000 BC (Zeder 2008a), after their initial domestication probably in southeast Anatolia in the ninth millennium BC (Peters *et al.* 2005; Arbuckle 2014; Stiner *et al*. 2014). As with the deep-time wild-domestic trajectory of human-goat engagement in the high Zagros, the human-sheep entanglement of southeast Anatolia was rooted in millennia of intensifying hunting prior to management, as attested at sites such as Körtik Tepe (Arbuckle and Özkaya 2006). In the Zagros foothills, wild sheep were hunted in the earlier levels of Jarmo at *c.* 7000 BC (Arbuckle 2014) while more intensive sheep herding and management are not attested across the Zagros until later in the seventh millennium BC at Sarab, Chogha Sefid and other sites (Zeder 2008a; 2008b).

Cattle and pigs feature less in the Early Neolithic domesticated animal economies of the EFC. As with sheep, cattle and pigs were probably first domesticated in the ninth millennium BC at sites in southeast Anatolia such as Çayönü (Hongo *et al.* 2009; Bollongino *et al.* 2012; Frantz *et al.* 2019), with initial domestication of cattle from a pool of only some 80 females (Scheu *et al.* 2015; Verdugo *et al.* 2019). But domesticated cattle and pigs are argued to have taken a very long time to travel south-eastwards into the EFC, not detectable in notable numbers till the sixth millennium BC, cattle as components of the distinctive Halaf culture of the Late Neolithic (Matthews 2000: 109; Arbuckle *et al.* 2016). Neolithic societies engaged fully in hunting wild *Bos* and boar over the centuries prior to the arrival of their domesticated cousins from the north. Arbuckle *et al.* (2016) suggest that Early Neolithic communities of the EFC may have deliberately avoided the incorporation of domesticated cattle into their daily lives, possibly because of the socio-cultural significance of hunting of wild *Bos*. Similar taboos may have operated with regard to pig. As Arbuckle (2014) proposes, the replacement of hunting by herding may have met with significant cultural resistance by communities heavily invested in hunting as a socially and ritually meaningful activity perhaps especially for males.

In sum, regarding animals in the Early Neolithic EFC, the trajectories of intensifying exploitation from hunting through management to full domestication involving control over breeding, feeding and culling were highly contingent and need to be investigated and articulated species by species, site by site and region by region (Arbuckle *et al.* 2016).

Human–plant interrelations

Turning to the role of plants within the context of Early Neolithic resource management, the patterns of intensifying human–plant engagement show considerable trans-regional diversity (Fuller 2007b; Fuller *et al.* 2012; Zeder 2008b; Arranz-Otaegui *et al.* 2016b). Human communities experimented with the practice of pre-domestication cultivation of morphologically wild crop progenitor species (Riehl *et al.* 2013; Willcox 2013; Asouti 2017) as an element of 'low-level food production' (Smith 2001; Zeder 2015), within a matrix of a continuing focus on hunting and gathering as the major sources of food acquisition as well as increasing animal management. These mixed hunting/herding, farming/gathering strategies endured for up to 2000 years across Southwest Asia, testament to their lasting success in providing resilient and flexible options with which to face changing environmental circumstances. Thus, in the WFC the earliest morphologically domesticated cereals are evident in the early PPNB, *c.* 8500 BC, but full agriculture with high reliance on domesticated plants did not develop till the mid-late PPNB at least half a millennium later (Arranz-Otaegui *et al.* 2016b).

Study of site by site food procurement practices across the Early Neolithic of Southwest Asia presents us with "a picture of rich, yet fragmentary and seasonally unstable resource environments and highly fluctuating resource ceilings", leading to the development of "locally distinctive resilience strategies" (Asouti 2017: 23). Asouti's analysis of Early Neolithic food procurement systems finds theoretical underpinning in the innovative study by Freeman *et al*. (2015) of non-linear transitions from gathering to farming, which applies ideas from human behavioural ecology, gathering theory and cultural niche construction, to generate an intriguing model whereby low-level farming (typically <40% dependence on domesticated plants) within a gathering system may lead to multiple stable subsistence states but is also prone to punctuated change over decades caused by rare events. In this context, such rare events might include massive landscape disruption by fire, changes in seasonal or annual rainfall and temperature patterns, and spread of disease or infection across populations of crops, herds or people, to cite a few possible scenarios.

As discussed above, significant changes in climate through the Pleistocene-Holocene transition formed the context for intensifying human–environment interactions with the worlds of plants and animals, including the Early Holocene spread of grasslands and crop progenitor species to their maximum extent across inland Southwest Asia (Asouti 2017). The highly varied topography of Southwest Asia generally and the EFC more specifically also played their part. Stable carbon isotope analysis of barley grains from Early-Mid Holocene Southwest Asia, 10,000–4000 BC (Riehl *et al.* 2014), indicates that regions situated between the 200m and 300mm isohyets received much greater precipitation during the cereal growing season than they do today, a boost to crop yields and potentially a major factor in the early adoption and spread of cereal farming regimes, precisely in regions where sites such as Bestansur and Shimshara are located.

Zeder's (2015) concept of 'mutual fitness' can be considered here in the sense that domesticated crops, protected by their human partners from a range of natural threats such as consumption by grazing animals, were able to thrive and spread across vast regions of Southwest Asia to an extent impossible without that human protection. On the human side, the ability to sow and reap ever-greater harvests from the modified crop species underpinned and shaped a sequence of socio-cultural developments that lie well beyond the scope of this research but which are fundamental to the subsequent prehistory and history of all agriculturally-based socio-political formations – towns, cities, states, empires – in Southwest Asia and beyond (Scott 2017).

A major as yet unresolved issue is the degree to which Early Neolithic communities of the EFC autonomously developed domestication of cereal crops or were in receipt of grain previously domesticated in another region, such as the WFC, and then transported to the EFC as argued by some (Bar-Yosef 1998). The evidence from Chogha Golan in the central Zagros foothills indicates a shifting emphasis through time from goat grass (*Aegilops* sp.) to cultivated wild barley (*Hordeum spontaneum*) followed by emmer and lentil cultivation (Riehl *et al.* 2012; 2013; 2015; Conard *et al.* 2013: 79). Bases of domesticated-type emmer wheat spikelets (*Triticum dicoccum*) are evident from *c.* 7800 BC and indicate early management of domesticated species (Riehl *et al.* 2013; 2015; Willcox 2013; Weide *et al.* 2015; 2017). This well-stratified evidence, although from a trench only 1m^2 in area, suggests that intensification of cereal exploitation, leading to morphologically visible domestication, could have occurred locally within the Early Neolithic communities of the Zagros, although more evidence is needed to make a convincing case and the sudden appearance of emmer grains with non-shattering rachises may suggest introduction from outside (Maeda *et al.* 2016). The genetic evidence, however, suggests that barley was independently domesticated in the EFC and travelled east from there across Iran reaching Mehrgarh in Pakistan after 7000 BC (Morrell and Clegg 2007).

In the highland Zagros zone, the development of early crop cultivation is as yet unclear. In the earliest levels at Sheikh-e Abad, of tenth millennium BC date, human communities appear to have been 'auditioning' wild grasses which ultimately were not domesticated (Whitlam *et al.* 2013; 2018). The appearance of domesticated crops at Sheikh-e Abad at *c.* 8000 BC, along with lack of evidence for their wild progenitors, has been interpreted as evidence of their probable import from "a distant lowland source" (Whitlam *et al.* 2018: 829) but we should bear in mind that there is a missing, unexcavated episode at Sheikh-e Abad of up to 1300 years between the securely dated deposits of Trenches 1 and 2 (Matthews *et al.* 2013c: fig. 6.1), during which time there may have been experimentation with local wild crop progenitors.

In any case, it appears that hunter-gatherer and early farmer mobility and/or networks were key in facilitating the spread of strains of grain in the earliest stages of pre-domestication cultivation. Genetic studies of emmer wheat (Civán *et al.* 2013; Asouti 2017) suggest that domesticated emmer has a reticulate rather than a phylogenetic evolutionary relationship with its wild progenitors, resulting from hybridisation between many lineages caused by cross-pollination of wild grain from diverse sources over long periods. This genetic pattern indicates persistent movement of emmer grain, at least, from region to region across Southwest Asia carried in the hands of mobile hunter-gatherers who were engaging in the cultivation of wild crop progenitors which they shared with contemporary communities near and far. This model of cereal domestication and distribution is also supported by genomic analysis of wild and domesticated barley, with sufficient gene flow between widely separated populations through intervening wild stands and human movement of seed grain (Fuller *et al.* 2014; Allaby 2015; Poets *et al.* 2015).

A key issue explored through CZAP research in the high and low Zagros is that of fuel and fertiliser. Excavations in the high Zagros at Sheikh-e Abad and Jani indicate a new emphasis on use of herbivore dung in association with possible animal penning from the mid–later ninth millennium BC onwards (W. Matthews *et al*. 2013h: 99–101; Shillito *et al.* 2013), while at Chogha Golan in the Zagros foothills dung is also attested from at least *c.* 8000 BC (Riehl *et al.* 2015). The use of animal dung as manure on cropped fields and gardens would have significantly improved soil quality, pushed the development of horticulture and enhanced crop yields, while providing a new buffer against seasonal risks (Bogaard 2005; Asouti 2017: 24). Evidence for Early Neolithic fuel and fertiliser practices in the low Zagros has not been forthcoming till now and is investigated in this research (Chapters 12 and 16).

An associated factor in changing plant use patterns may have been the increased occurrence of fire (W. Matthews *et al*. 2014; W. Matthews 2016). Early Holocene peaks in fire signals in lake sediments may principally attest natural fires caused by storms at the end of long, hot summers, and/or sparks from human occupation that is now attested in the region, rather than intentional human-caused clearance but the effect was to favour the spread of grasslands including crop progenitors as well as of legumes which benefit from arousal of seed dormancy by fire, removal of competing herbaceous growth and enjoy access to nitrogen-low soils because of their ability to fix nitrogen in the soil (Lajeunesse *et al.* 2006; Asouti 2017). Such factors, as well as cultural traditions including a commitment to goat foddering, may underlie the enhanced emphasis on goat grass, small-seeded wild grasses, legumes, pulses and nuts at the expense of cereals in the Early Neolithic EFC as compared to the WFC (Arranz-Otaegui *et al.* 2016b). As Riehl (2016) points out, the relative delay in Early Holocene increase in atmospheric moisture in the EFC compared to the WFC would significantly impact the suitability of the region for the cultivation of cereal crops, which are not common in the EFC until after 7000 BC some 1500 years after their major adoption in the WFC. Similarly, a diachronic study of the relationship between use of chert sickle blades and frequency of cereals in Neolithic archaeobotanical assemblages across Southwest Asia (Maeda *et al.* 2016: 234) demonstrates how the use of sickles for harvesting grain accelerates in the EFC much later than in the WFC according to "different technological trajectories."

In summary, previous research indicates that the food resource management strategies and practices of Early Neolithic communities of the EFC were flexible, adaptable and ultimately resilient over long timespans. As articulated most effectively by Asouti (2017: 39): "Early PPN communities responded to short-medium term ecological instability by engaging in flexible economic strategies that precluded substantial reliance on delayed-return practices such as seed crop cultivation. Their landscape practices likely included the residential and/or logistical mobility of different community segments, the management of spatially extensive and ecologically diverse territories, and sustained social and material investment in the maintenance of long-range community interaction networks."

Impacts of Early Neolithic life on human health and well-being

The transition to agriculture potentially resulted in increased fertility, life expectancy and age-at-death underpinning substantial population increases (Bocquet-Appel 2011; Eshed *et al.* 2004). A study by Eshed *et al.* (2010), however, revealed a higher prevalence of infectious lesions in Neolithic populations, attributed to increased exposure to disease agents, changes in diet, and denser populations. In fact, recent studies support an interpretation of increased morbidity and adverse health impacts in populations inhabiting the gatherer-farmer transition across the world (Larsen 1995; 2014; 2015; Bocquet-Appel 2008; Larsen *et al.* 2015; Pinhasi and Stock 2011). In a seminal article entitled 'The agricultural revolution as environmental catastrophe: implications for health and lifestyle in the Holocene', Larsen (2006) made the case for the shift to largely sedentary, agricultural life as severely inimical to human and even planetary health. Negative human impacts articulated by Larsen include an increase in tooth decay (caries) from cereal consumption, a decline in quality of drinking water, a decline in nutritional quality, especially iron, through reduced meat consumption, and a dramatic increase in the genesis and spread of infectious diseases including newly developing zoonotic diseases such as brucellosis (Pearce-Duvet 2006; Bar-Gal and Greenblat 2007; Chisholm *et al.* 2016). A recent modelling of the transmission of brucellosis within early goat populations suggests that goat herds of Neolithic sites in Southwest Asia could have hosted and sustained reservoirs of the pathogen *Brucella melitensis* in sufficient densities to render proximate human populations susceptible to regular exposure to the disease (Fournié *et al.* 2017; see also Wolfe *et al.* 2007; Quammen 2012; Moreno 2014).

Larson also pointed to new Neolithic cooking practices, involving the reduction of tough food to soft mush, as leading directly to a reduction in size of the human face and jaws in turn producing dental crowding and poor oral hygiene. More broadly and longer-term, Larson underlines the significance of the Neolithic transition in terms of both increasing inter-community competition and violence over control of land, and the enhanced capacity for large-scale negative impacts on entire landscapes. While there is some evidence for an increase in inter-community violence in the Neolithic, there was also a major role for cooperation across and between communities throughout the Neolithic transition (Halperin 2017). Cultural niche construction approaches stress the importance of cooperation for enabling and encouraging communities to invest present efforts in return for future benefits, a key attribute of the farming-herding lifestyle (Zeder 2016). Social and ritual activities, such as feasting and burial of the dead, can assist this process through the development of distinctive community identities and traditions.

Finally, who *were* those people? Advances in genetic studies in recent years, involving enhanced recovery and sequencing of ancient DNA, have revolutionised our ability to investigate the relatedness of human individuals and entire populations from the past, enabling new perspectives on human mobility and kinship through the ages (Reich 2018). Analysis of aDNA is increasingly significant in addressing the origins and early spread of Neolithic lifeways within Southwest Asia and well beyond. The aDNA evidence from high Zagros Early Neolithic sites, including Ganj Dareh and Abdul Hosein, reveals a distinctive genetic make-up of EFC early farmers differing from that of early farmers of the WFC to an extent "as great as the differentiation between Europeans and East Asians today", with both groups of farmers genetically derived from local hunter-gatherer populations (Reich 2018: 95; Broushaki *et al.* 2016; Lazaridis *et al.* 2016). The evidence suggests that Neolithic dispersals eastwards across Iran were effected by the movement of people as much as by cultural diffusion or acculturation, as supported by DNA studies of modern populations (Quintana-Murci *et al.* 2004). A genetic contribution from Neolithic Iranian/Caucasian humans to Early Holocene central Anatolian populations (Feldman *et al.* 2019) could attest mutual meetings and pair-bondings in the course of procurement of materials such as obsidian from Anatolian and Armenian sources.

Our most intimate insights into who the Early Neolithic people of the EFC were provided by Gallego-Llorente *et al.* (2016), whose analysis of the aDNA of an adult female from Ganj Dareh, dated to 8000–7700 BC. Her DNA is special to the region and, as with other examples of Neolithic aDNA from the EFC, makes little contribution to later DNA pools of the wider region of Southwest Asia and beyond "suggesting those of the Central Zagros were somewhat isolated from other populations of the Fertile Crescent" (Gallego-Llorente *et al.* 2016: 1). The sampled woman was aged 30–50 years, had dark or black hair, brown eyes and she lacked the common European variant of the gene associated with the ability to digest raw milk, consistent with the emergence of this adaptation at a later time. These personal attributes of a long-dead woman from an age we write so much about but truly know so little about bring sharply to mind that above all the Neolithic transition was lived through, created, shaped by real living people not so different from people living today.

Resource management, diet and health: research aims and objectives

Our aim within this research area was to integrate secure contextual archaeological evidence as recovered in the ways detailed above and in Chapters 2, 9 and 10. We aimed to locate and excavate human burials which could provide detailed information on issues relating to demography, diet and health through the Early Neolithic transition. We aimed to recover assemblages of plant and animal remains from deposits across the excavated sites with which to investigate modes of management of food and other resources.

Material engagement and networks

In our discussions regarding the cultivation of plants, the management of animals, and in the construction of the built environment, we have sought to investigate the interconnectedness of the Early Neolithic communities of the EFC and beyond. People were engaging with each other in a broad spectrum of ways, direct and indirect, across distances of hundreds of kilometres at least. These networks are evident in the emerging genetic structure of crops and managed animals, discussed above, which can only be accounted for by significant, recurrent movement of seeds and animals under human control through the Early Neolithic. Inter-community interaction is also indicated in the distribution of 'exotic' materials, in raw or manufactured form, and the spread of new technologies at sites across the region. In studies of Southwest Asia, interpretations of the increase in the intensity of these interactions and exchanges in the Early Neolithic have shifted away from core-periphery assumptions, such as Kozlowski and Aurenche's (2005) 'golden triangle' model, towards a more nuanced view of complex interactions conducted at multiple scales (Asouti 2006; Zeder 2009; Coward 2013).

Shared commonalities in material practice and direct evidence for contact through the movement of raw materials demonstrate widespread networks of connected communities distributed across Southwest Asia. Building on the work of Renfrew and colleagues (1966), obsidian remains a cornerstone in the interpretation of interactions across the region and is still subject to review and reanalysis. The established scientific basis for identifying obsidian to source deposits and the astonishing regularity of its occurrence at sites far from these sources affords an unparalleled, albeit narrow, insight into the connections between dispersed sedentarising communities. Even amongst the sparse evidence for Epipalaeolithic communities in this region, small quantities of obsidian tools are present at almost all sites, including Palegawra, Zarzi, Shanidar and Zawi Chemi Shanidar, representing an enduring tradition of long-distance movement and engagement with eastern Anatolia.

Evidence for the long-distance and likely indirect connections to far-flung communities is not limited to the obsidian sources to the north. Even in this land-locked region, seashells occur in Neolithic settlements at sites including Ganj Dareh and Ali Kosh (Hole 1969; Smith 1974). The seashells most commonly reaching inland sites were the distinctive *Dentalium* tusk shells and cowries, both of which appear to have been modified for use as adornments. The cultural phenomenon of *Dentalium* is not restricted to marine sources, and sites in the region include the use of fossilised shells that may have come from local fossiliferous limestone (Howe 1983). Both most frequently appear in association with the dead and the phenomenon of cowries in association with burials and skull curation has been well-documented, including at Tell Halula on the Syrian Euphrates (Alarashi *et al.* 2018).

Rare and 'exotic' minerals are not as common in the Early Neolithic as in later periods, but there are some examples of raw materials coming from far afield as Neolithic networks reached towards Central Asia. Carnelian, often presumed to have come from the Indus Valley, could have come from a range of sources, including Iran, Armenia, the Sinai Peninsula or the Arabian Peninsula, and reached as far west as the Levant and Cyprus (Moutsiou and Kassianidou 2019). 'Exotic' materials constitute only a small proportion of the material assemblage and yet have been studied far more intensely than locally available materials, which have shed light on the layers of complexity in intricate local and regional networks at Neolithic sites such as Çatalhöyük (Nazaroff *et al.* 2015). Chipped stone technologies and changing patterns of usage demonstrate the spread of ideas and technologies between communities, for example through the rise in the frequency of sickle blades used for gathering plant foods and fuel (Maeda *et al.* 2016).

Beyond tools and adornments, networks of shared practice are visible in the technology and iconography of clay figurines and 'tokens' recovered at so many sites across the region from the tenth millennium BC (Kozlowski and Aurenche 2005). Some of these objects likely served as early counting tools, although they may have performed multiple functions (Schmandt-Besserat 1992; Bennison-Chapman 2019). Local variants were developed at sites such as Ganj Dareh, where distinctive gashes were cut into clay cones or they were given anthropomorphised features (Broman Morales and Smith 1990). The trajectories in experimental clay practice varied from site to site, but strands of shared knowledge, innovation, and resistance can be identified across the region (Bernbeck 2017).

The movement of objects, materials and ideas points to the movement of people through the Zagros and beyond in the Early Neolithic. Some cultural traits span the Fertile Crescent, but the archaeological evidence suggests independent trajectories in the east and west (Kozlowski and Aurenche 2005), supported by the disparity in the intensity with which these regions have been investigated. Nonetheless, studies of the aDNA indicate that these divisions were more than cultural, with individuals from the highlands of Iran, Ganj Dareh and Abdul Hosein in particular, representing a Zagros population in the Early Neolithic who were genetically distinct from their western contemporaries (Gallego-Llorente *et al.* 2016; Lazaridis *et al.* 2016). It remains to be seen whether people at the intersection of these communities operated as the cultural and genetic conduit that united the populations in subsequent periods.

Networks: research aims and objectives

A key aim was to investigate how different communities and sectors of society in the Zagros and EFC engaged in local and cross-regional networks and what was their context and impact. The objectives were to study a wide range of ecological and artefactual evidence as different spheres of life and sectors of society are likely to vary in their openness, access to, and impact of contacts and networks (Chapters 20–22; Borrell and Molist 2014). We aimed to apply new pXRF analyses of materials to distinguish differences in the sources of materials through time and across different sites and sectors of communities.

CZAP and the scope of this volume

In order to address the issues discussed in detail above, since 2007 we have conducted field work and integrated analysis of recovered materials at key Early Neolithic sites in the Zagros region of the EFC. The present volume presents results, analysis, interpretation and synthesis from the second major phase of the Central Zagros Archaeological Project (CZAP) from 2011 to 2017. We conducted the first phase of CZAP in the high Zagros in Kermanshah province of western Iran, with investigations at the Early Neolithic sites of Sheikh-e Abad and Jani coupled with palaeoenvironmental investigations (Matthews *et al*. 2010; 2013a; W. Matthews *et al*. 2019b). In the second phase of CZAP, covered by this volume, research in Sulaimaniyah province in the Kurdistan region of Iraq has focused above all on excavations at the Early Neolithic site of Bestansur on the Shahrizor Plain (Matthews *et al*. 2019a) and, to a lesser extent, at Shimshara on the Rania Plain, alongside intensive regional survey in the environs of Zarzi cave and associated palaeoenvironmental research. This strategy was designed to couple investigation of an unexcavated Neolithic site at Bestansur, whose nature and preservation was unknown, with investigation of two known sites in the region: the newly exposed early levels at Shimshara, excavated by a Danish team in the 1950s (Mortensen 1970), following recession of dam waters, and survey in the vicinity of Zarzi cave, previously excavated by Garrod (1930) and Wahida (1981), both to investigate whether there were open-air sites in the vicinity of Zarzi cave as predicted by Wahida and to survey for formerly undetected Early Holocene sites.

Taken together, the two major phases of CZAP research, outlined at the beginning of this introduction, enable detailed and multi-level comparison between Early Neolithic developments in the high Zagros of western Iran and those in the low Zagros of eastern Iraq, as we explore throughout this volume. These two zones differ significantly in character, in terms of topography, hydrology, climate and environment, and the habitats they provide for flora and fauna and the prehistoric human communities living in their midst. While there is significant evidence for trans-regional connectivity between Early Neolithic inhabitants of the high and low Zagros, we are also able to investigate and delineate distinctive socio-cultural trajectories for each region through the course of the transition from hunter-gatherer to farmer-herder. As the research in this and the first CZAP volume aims to examine and highlight, these trajectories were shaped partly by geographical circumstance – the availability of critical resources such as wild precursors of plant and animal species later to be domesticated, or the intensity of seasonality, for example – but also by cultural choices and preferences that human communities decided to make and follow, individually and collectively. Such cultural preferences and traditions are manifest in the material culture of each region, even each site within regions, including in their choices of material resources such as cherts, obsidians, semi-precious stones, and architectural materials, their ways of making and using tools, their strategies for securing reliable, sustainable food resources from plants and animals from near and far, the modes of burial of their human dead, and many other cultural attributes which archaeology may reconstruct from the remains they left behind for us, some 10,000 years later, to unearth, record, analyse, discuss and interpret.

Structure of the volume

In order to investigate the issues and questions discussed above, in this volume we examine the results from new fieldwork and interdisciplinary analyses conducted by CZAP 2011–2017. Chapter 2 reviews the integrated excavation, recording and sampling methodologies applied. Chapter 3 highlights the new palaeoclimate and environment research initiated by CZAP and currently known evidence for Early Holocene climate as a context for understanding settlement, ecology and material networks. The methodology and results of the survey in the vicinity of the Epipalaeolithic site of Zarzi are examined in Chapter 4. This survey was undertaken to provide new insights into the nature and extent of Epipalaeolithic activity and networks in this region and to compare Late Pleistocene and Early Holocene developments in this locale and the wider region.

The following five chapters focus on the fieldwork conducted to investigate the nature and extent of settlement at the previously unexcavated site of Bestansur. Chapters 5 and 6 review the results from geophysical survey and coring that were conducted prior to and during excavation to inform on the nature and depth of occupation and areas for further investigation. Ethnoarchaeological research, Chapter 7, was conducted to provide insights into vegetation, land-use and animal management and uses and traces of dung that could be used to inform the interdisciplinary bioarchaeological analyses. We discuss conservation issues and challenges in Chapter 8, separately from the methods chapter in Chapter 2, as conservation of heritage is an important priority which informs excavation practice and analysis and storage of bioarchaeological and artefactual remains.

To investigate the nature and diversity of settlement, ecology and society at Bestansur, we excavated and analysed materials from thirteen trenches in different sectors of the flat and mounded settlement. The excavation strategies and results from each of these trenches are discussed and critically evaluated in Chapter 9, by trench number for ease of cross-referencing throughout the volume. Intact Neolithic levels were encountered in 11 of these thirteen trenches, eight of which included architectural remains, one with a succession of elaborate buildings and intra-mural burials (Trench 10). Chapter 10 discusses brief campaigns of fieldwork at the site of Shimshara.

A wide range of interdisciplinary analyses were conducted and are providing exciting new insights into the chronology of developments in the EFC (Chapter 11), and into settlement ecology sustainability, social organisation, diet and early plant and animal management and domestication, and health. These research themes and issues are explored through integrated interdisciplinary micromorphology (Chapter 12), high-resolution microscopy, geochemistry and biomolecular analyses (Chapter 13), microarchaeology (Chapter 14), zooarchaeology (Chapter 15), new analyses of animal and faecal material (Chapters 12–13 and 16), molluscs (Chapter 17), charred plant remains (Chapter 18) and human remains (Chapter 19).

The rich range of materials, tools and networks of material engagement and exchange are examined in depth in Chapters 20–22, which analyse in turn the diverse chipped stone tools and industries (Chapter 20); other local and exotic materials and artefacts ranging from clay tokens and figurines to alabaster beads and bracelets, shell ornaments and carnelian beads (Chapter 21); and abundant ground-stone tools and technology (Chapter 22). In each chapter we consider the wider implications of these forms of material culture for the identity, productivity and life-histories of the different sectors of Early Neolithic communities in the EFC.

Following a discussion of the public engagement and impact of the project (Chapter 23), we conclude the volume with a thematic synthesis and discussion of the Neolithic transition in the EFC (Chapter 24). This concluding chapter critically reviews the key discoveries from the CZAP survey and excavations in light of the major themes outlined in this introduction including: climate and environment, management and use of biodiverse resources, built environment and health and social relations. This latter section includes examination of sub-themes including the life-course, gender, cooperation, inequality, and ritual and burial practices. These developments are reviewed through a theoretically informed lens that includes examination of issues and concepts from current transition and sustainability studies. We hope that the research presented in this volume does full justice to the connectivity, diversity and resilience of the Early Neolithic communities of the Zagros uplands in the Eastern Fertile Crescent.

2. EXCAVATION, RECORDING AND SAMPLING METHODOLOGIES

Amy Richardson, Roger Matthews and Wendy Matthews

Multi-scalar interdisciplinary excavation, recording and sampling protocols were established by the Central Zagros Archaeological Project in the 2008 excavations at Sheikh-e Abad and Jani in western Iran. These protocols were designed with a view to optimum recovery and recording of a wide range of materials (Matthews *et al.* 2013a: 32), as well as to enable an integrative, holistic approach to the analysis, interpretation and publication of the excavations. Over the course of seven field seasons at Bestansur and two short seasons at Shimshara, in Iraqi Kurdistan, these procedures were reassessed and refined in response to experience and the special characteristics of the excavated sites and deposits. For post-excavation analysis, details of specific methodologies are provided by the specialist contributions in Chapters 12–22.

Project infrastructure

The project operates under a Memorandum of Understanding with the Sulaimaniyah and Erbil Directorates of Antiquities and Heritage, with agreement from the State Board of Antiquities and Heritage, Baghdad. The project is fully collaborative with colleagues at Sulaimaniyah Directorate of Antiquities and Heritage, in particular its Director Kamal Rasheed Raheem. The project also works in collaboration with the staff of Slemani Museum, led by its Director, Hashim Hama Abdullah. Throughout each field season, activities in the field have been supported by and benefitted from the guidance and substantial expertise of government representatives, Kamal Raeuf Aziz, Sabr Ahmed Sabr, Perween Yawar Manda and Sami Hama Rashid, who participate in the project as key team members. A significant number of men and women living in modern Bestansur village work with us on site, in the field laboratories, and at the Expedition House. Our local team, guided by our foreman Umaid Hama Rashid and senior staff Amir Mohammed, Mohammed Abdulkarim, Rahim Mahmud, and Brahim Mahmud, have accrued a wealth of knowledge and experience working with excavation projects and safeguarding sites across the Shahrizor Plain and beyond.

The Expedition House is located in modern Bestansur village, approximately 1km north of the site, providing accommodation, flotation facilities and processing space in the courtyard, and field laboratories for post-excavation analysis of archaeological material (Fig. 2.1), as well as storage for tools between field seasons. All primary analysis, including sample processing, microscopy, and finds analysis, is conducted in the field during the course of excavations, with all team members participating in laboratory hours each working day, providing an opportunity for team members to exchange information and ideas. During post-excavation analysis, a small sub-sample of archaeological materials are selected for further analysis and exported. These sub-samples include archaeological bone and archaeobotanical samples for radiocarbon dating and isotopic analyses, and micromorphological sediment blocks for resin impregnation and thin section analysis. All exports are submitted for the approval of the Sulaimaniyah Directorate of Antiquities and Heritage and cleared in advance with airport security and customs. Export records have been retained for all items and will be used to repatriate material when analyses are complete.

Figure 2.1. Post-excavation processing of archaeological samples and materials at the Expedition House.

Figure 2.2. Wendy Matthews (right in blue) training students and local workers in description, recording and interpretation of archaeological deposits at Bestansur.

Project management

The excavations were conducted by the project co-directors, Roger Matthews and Wendy Matthews, in collaboration with the Sulaimaniyah Antiquities Directorate led by Kamal Rasheed Raheem. The co-directors and representatives from the Directorate supervised a team of staff, students and local workers. Post-excavation analyses were run by individual specialists, in most cases in collaboration with and supported by students and local workers.

To ensure best practice, all team members were provided with project handbooks prior to the season, detailing all steps and protocols of excavation, sampling and post-excavation operations, and trained in the field by senior members of the team. More than 50 students and archaeologists from the UK, the Kurdish Region, Iraq, Iran and all over the world have been trained in recording procedures in the field (Fig. 2.2) and in post-excavation processing at the Expedition House.

Site management

Over large, open excavation areas, such as Bestansur Trenches 7, 10 and 12/13, we constructed steel and white plastic sheeting shelters with liftable sides which afforded protection from the summer sun and the spring rain as well as allowing air to circulate (Fig. 2.3). The management of moisture is a critical issue for the shrink-swell clays of the Shahrizor Plain. As the clay-rich sediments dry, they crack and distort, destabilising fragile features and materials, including unbaked clay objects and bone, which become increasingly difficult to extract (Chapters 12, 19 and 21). The shrinking clays also retract to create voids, into which intrusive material can penetrate otherwise undisturbed deposits. Furthermore, whereas sharp boundaries and clear colour distinctions may be visible in freshly excavated deposits particularly in filtered light, the drying clays pale to a homogeneous tone that masks the divisions between mudbrick and plaster or cut and fill (Fig. 2.4). To minimise the effects of drying on intact Neolithic architecture and deposits, we kept surfaces, architectural features and trench sections covered with plastic sheeting whenever possible. Sections of sheeting were rolled up from sections and peeled back from excavations as required (Fig. 2.5). When drying impeded visibility, water sprays were employed to dampen deposits.

The variable success in trials to conserve mudbrick architecture have been well documented at the Neolithic site of Çatalhöyük in Turkey and highlight

Figure 2.3. Excavating under a shelter in Trench 7 at Bestansur.

Figure 2.4. An exposed section in Trench 7, with dried and cracked deposits.

some of the challenges of leaving the site exposed for extended periods (Lingle and Seifert 2017). At the end of each season we back-filled the trenches with the excavated soil after covering and protecting all standing walls and features with sacks of earth and plastic sheeting (see Chapter 8; Fig. 2.6). This membrane prevented destruction of the architecture and features between seasons, minimising root

Figure 2.5. Retention of moisture and protection of surfaces and sections with plastic covers whilst excavating: a) Trench 10 Building 5 Space 50 beads and human bone; b) Trench 9.

Figure 2.6. Protecting walls with sacks filled with earth, prior to back-filling, Trench 10 at Bestansur.

activity and burrowing through the most sensitive parts of the site.

Excavation and recording protocols

In excavation we applied a standardised practice of excavation, sampling and recording across all contexts, whether Neolithic or post-Neolithic in suspected date, while the intensity of sampling and recording was increased once intact Neolithic deposits were reached in each trench (Fig. 2.7). Excavations have been conducted drawing on the experiences and rigorous scientific approaches applied at Neolithic sites facing similar challenges, such as Sheikh-e Abad in Iran (Matthews *et al.* 2013a), Çatalhöyük in Turkey (Hodder 2000), and WF16 in Jordan (Mithen *et al.*

Figure 2.7. Amy Richardson (left) and Jade Whitlam (right) excavating a column sample through a Neolithic snail shell midden in Trench 5 at Bestansur.

2018). We strategically placed investigative trenches, some of which were subsequently expanded into open-area excavations to examine buildings, external areas, middens and streets/corridors.

Under the guidance of the responsible senior team member, each trench was laid out and excavated by a combined team of staff, students and local excavators. Each context was assigned a number when excavation commenced and defined by the excavator. In exceptional cases, specialists would oversee the removal of fragile materials, such as human and animal bone, assigning identifying numbers on the context plan. All deposits were excavated using a single context recording system based on that used at Sheikh-e Abad (Matthews *et al.* 2013a: 32), including detailed records of stratigraphic relationships, deposit descriptions, sketch plans and sections, sampling and finds records. Team members were responsible for recording information, assigning sequential numbering from centralised registers for all contexts (C), samples (SA), small finds (SF) and bulk finds (BF), as well as for plans, sections, features (F), spaces (Sp), and buildings (B). In the case of human bone, where multiple individuals were clustered in a single burial, skulls and skeletons were numbered as subsets of the context (e.g. C1631 SK1). All paper records were checked, scanned, and entered in the digital database (see data management below).

In the field, each context was described according to spatial category, spatial type, deposit type, and material type, based on an agreed set of terminologies to establish consistency in our descriptions. Protocols for soil descriptions follow those applied at Sheikh-e Abad and draw on established procedures (Hodgson 1976; Courty *et al.* 1989; W. Matthews 1995) to characterise the upper and basal boundaries, bedding, consistency, structure and texture of deposits. Excavators provided initial interpretations in the field including considerations of the origins and nature of deposits, activities and agencies in the depositional history, and observations on post-depositional alterations. These descriptions informed post-excavation integrated discussions of the site, as discussed below.

Excavated contexts were planned, sections drawn and photographs taken. Elevation values were recorded at multiple points across each context and included in a central register, as well as noted on plans and sections. Elevations provided in the text in Chapter 9 are taken from the upper boundary, located at the centre of the context for consistency, as deposits across the site slope away from the centre of the mound. In-field recording procedures, all paperwork, plans, registers and forms were completed on-site by the excavator responsible during the course of excavation, in order to ensure all information was recorded and up to date. Paper records were employed on-site and, following completion, all paperwork was submitted to the data manager, for checking and digitising. Thus, all original records exist in three forms: original field hard copy, scanned pdf of field copy, and digitised entries from the records into the project data-base. All field records and photographs have been filed and archived on hard drives housed in separate locations at the University of Reading.

Sampling procedures

An archive sample, approximately 0.25 litres, was retained from all excavated contexts for future reference and sub-sampling. In order to maximise recovery from Neolithic levels, whole earth samples up to a maximum of 50 litres (or whole context if smaller than 30 litres) were sent from each context for processing through the flotation tank (Chapters 14 and 18), for recovery of the light fraction, including macro- and micro-botanical remains, and the heavy fraction including chipped stone, ground stone tools, clay objects, faunal remains and molluscs. The remainder of the context was dry-sieved through a 4mm mesh, where appropriate. The densely compacted clay-rich Neolithic deposits are tightly bound both when damp and in arid weather. In the case of deposits larger than 300 litres, one or more samples were sent for flotation, a sample was processed through dry-sieving, and the remainder was checked by hand before disposal on the spoil-heap, with a volumetric tally maintained for each context. The total volume of each context was fully quantified.

Systematic sampling was augmented by strategic sampling for further analysis, including investigation of architectural materials through micromorphology (Fig. 2.7), botanical materials including phytoliths, dung spherulites, and pigment characterisation. Key stages in the excavation and recording process are detailed in Fig. 2.8.

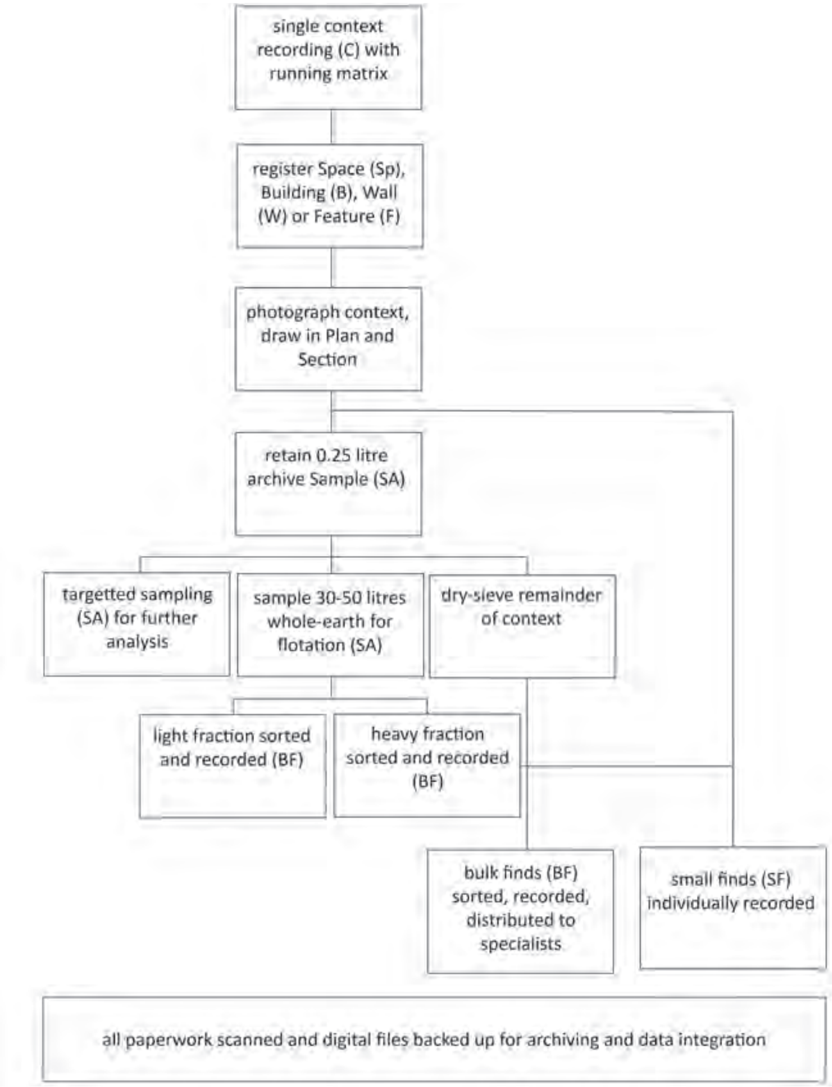


Figure 2.8. Simplified schema of recording procedures.

Labelling and storage

Pre-printed Tyvek labels, with permanent markers, were used to ensure consistency and preservation of records. Each label was marked with the appropriate date, excavators' initials and context number. Sample numbers were included where appropriate. Labels and inventories have been retained with all material as it was processed, including all SAs (Samples), SFs (Small Finds) and BFs (Bulk Finds). At the end of each season, fragile finds were archived in the project's dedicated depot at the Sulaimaniyah Directorate of Antiquities, and bulk finds stored in the secure excavation stores at Bestansur village. All Small Finds have been submitted to the Slemani Museum, some of which are now on display in the newly refurbished Prehistory Gallery (Fig. 2.9).

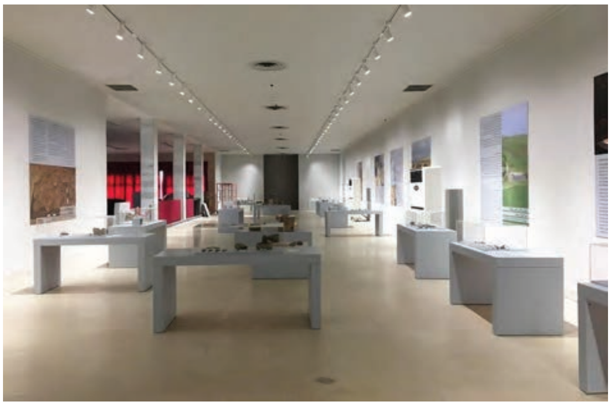


Figure 2.9. Finds from Bestansur on display in the Slemani Museum, during redesign of Prehistory Gallery.

3-D recording trial

In 2014, a 3-D recording trial was conducted by Jeroen De Reu (Ghent University) during the third season of excavations at Bestansur as a test case of the recording methodology (De Reu *et al.* 2013; 2014).

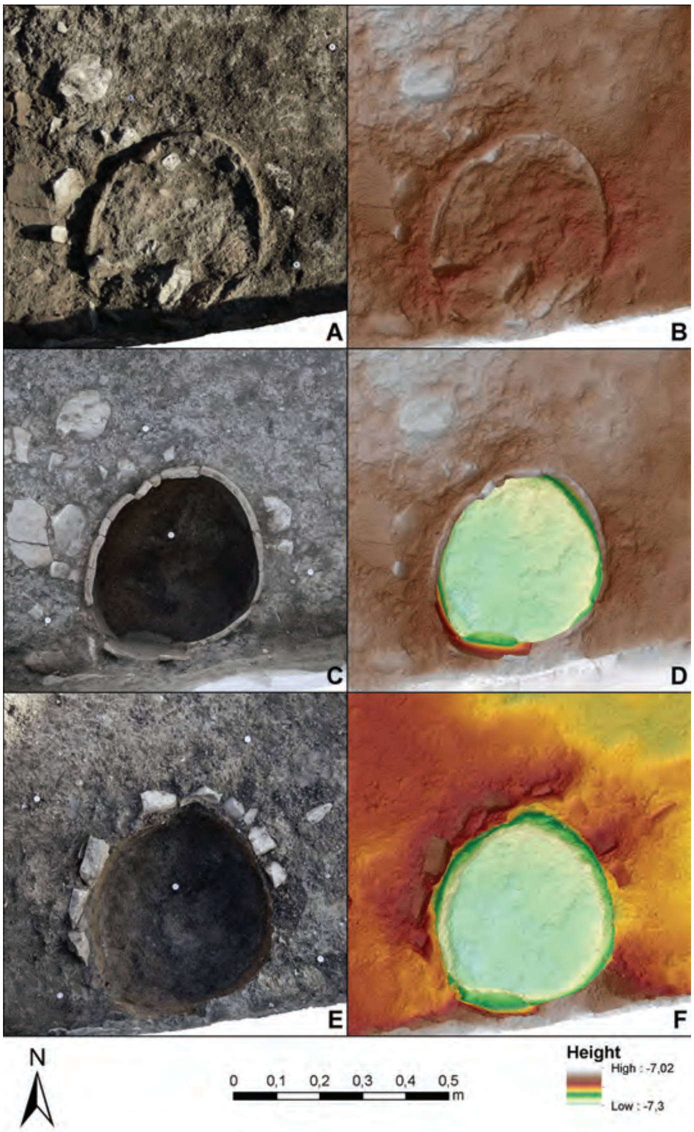


Figure 2.10. Orthophoto (A, C and E) and DSM (B, D and F) of a sequence of recordings of a post-Neolithic tannur in Bestansur Trench 10 (recording 03 (A, B), 09 (C, D) and 10 (E, F)), by Jeroen De Reu.

The resulting dataset counts over 20,000 images, providing challenges towards the management and integration of data. The excavation was recorded with a total of 13,664 photographs taken during 66 different recordings. The 3-D recordings included excavation surfaces, sections and profiles, stone walls, archaeological remains (e.g. bone) and sampling locations (e.g. pXRF). For all 66 recordings at least one 3-D model has been successfully generated. Orthophotos, DSMs and vertical ortho-images have been produced to achieve a full GIS-integration of the 3-D data. By means of image-based 3-D modelling, the texture of the archaeological remains has been documented with time-slices of the excavation process (Fig. 2.10).

Image-based 3-D modelling was tested on a sample of 18 ground stones, *c.* 50% of which were successfully digitally processed, and on a selection of 14 small finds, few of which were successfully processed; among these was a marble flanged bracelet fragment (SF187; Chapter 21). The trial highlighted the potential for 3-D geolocated recording during excavation, although we chose not to implement the strategy in subsequent seasons due to the interruption to workflow in the field and problems processing the data. Improvements in software and hardware in the intervening years have rectified a number of the issues we encountered, as demonstrated by subsequent 3-D photogrammetry conducted by Sheri Pak from the University of British Columbia (Fig. 2.11). These protocols are being implemented in future work at Bestansur.

Data management

All paperwork was digitally scanned prior to transit

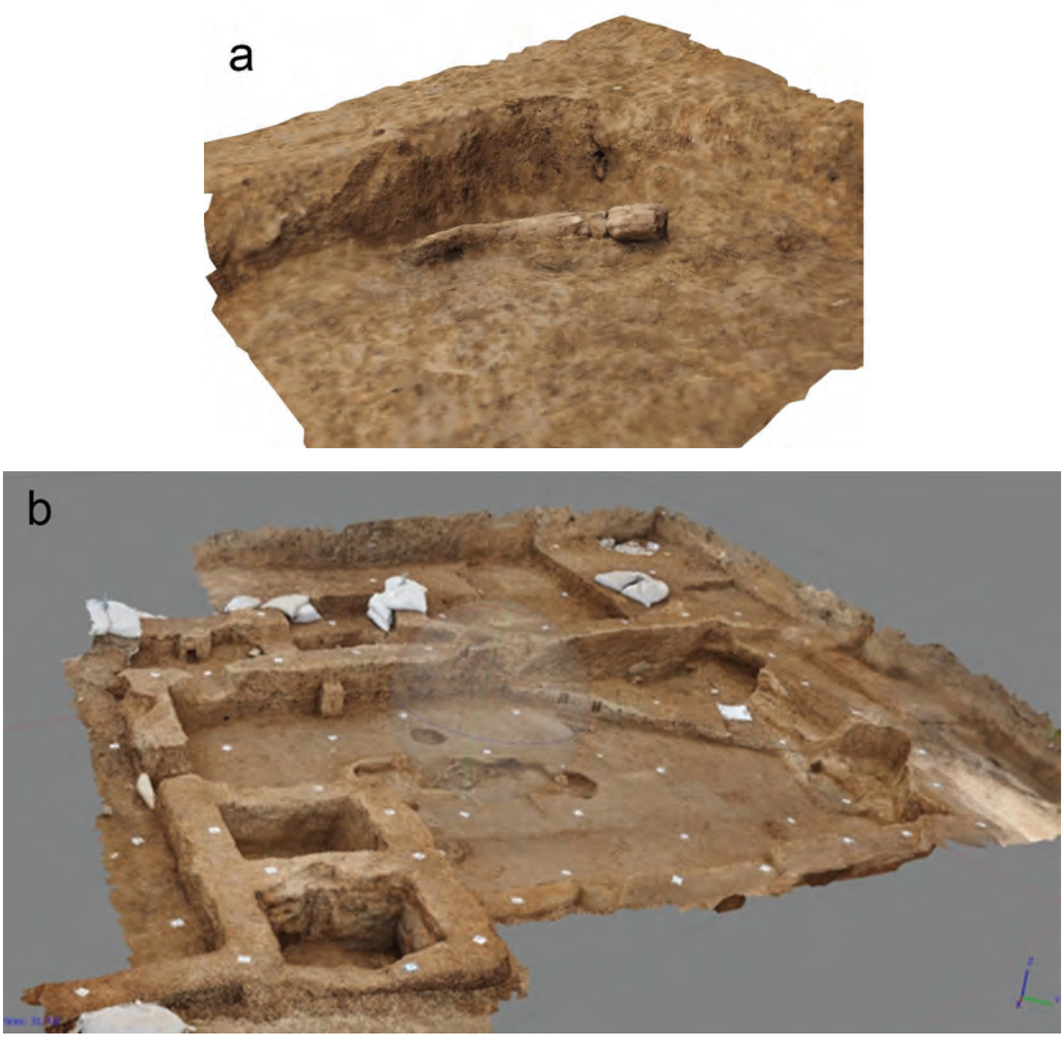


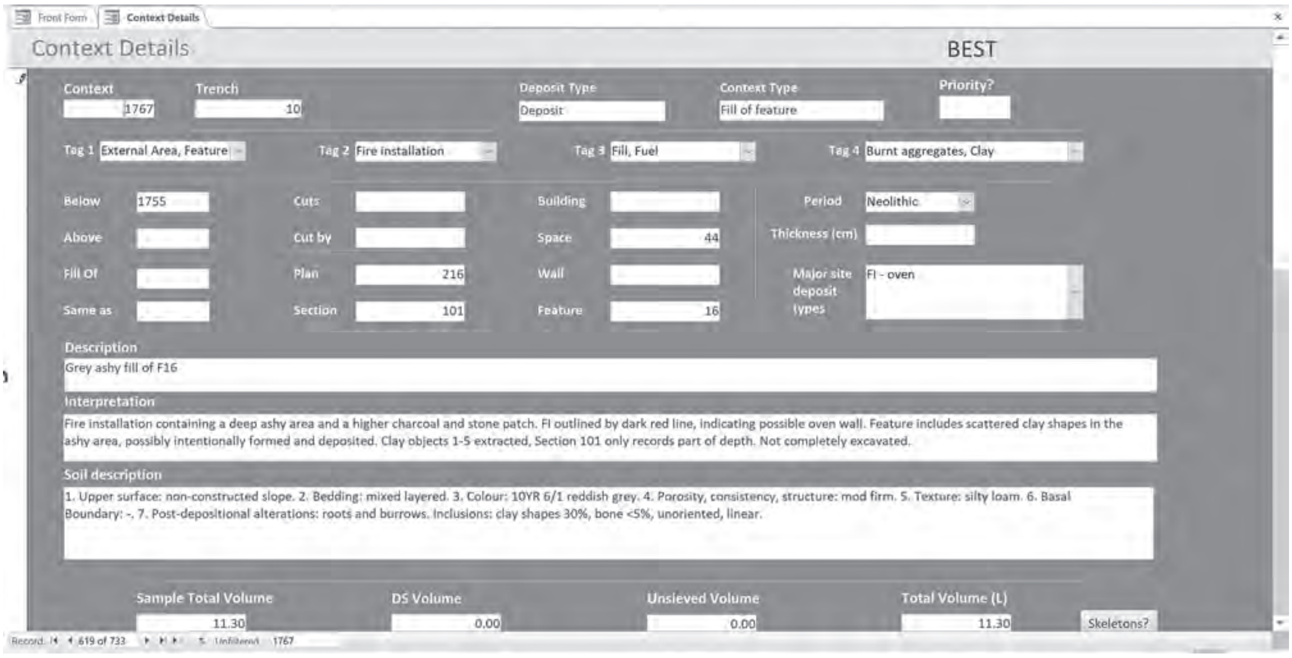
Figure 2.11. 3-D photogrammetry by Sheri Pak in 2017, a) a Neolithic horn core; b) Building 5, Trench 10.

and multiple copies of the complete digital archive separately held in order to ensure data security. Initial trials using the Integrated Archaeology Database (IADB) proved useful for the archiving of data for Sheikh-e Abad and was tested at Bestansur with a view to constructing an internally networked multi-user platform run through a router. However, fluctuating power supply, high temperatures and levels of dust were found adversely to affect electronic equipment in the field. A purpose-built Microsoft Access database (.accdb) provided suitable flexibility in the field, with the option to commute data between systems. Primary data entry was conducted in the field and laboratory, then checked and updated on return to the UK. Data relationships have provided the option to query data using inbuilt tools and a series of forms linking the tables have assisted in making the database accessible to team members (Fig. 2.12).

Team members recorded bulk finds data into a spreadsheet, with weekly summaries of the volumes of material recovered provided to Sulaimaniyah Directorate of Antiquities and Heritage. Spreadsheets from all specialists have been incorporated into a single repository, tailored to address the specific needs of the project. Cloud computing has made it possible for all team members to contribute to the database from anywhere and to access the most recent versions of the data. These data will be archived and made freely available through the Archaeology Data Service (archaeologydataservice.ac.uk). The data hierarchy was constructed on the basis shown in Fig. 2.13, while Figs 2.13-2.16 provide examples of completed record forms.

Integrated approaches

All project team members, including excavators, specialists and students, contributed to the interpretation and reflexive approaches to the investigations. Regular team meetings in the field prioritised contexts to inform the ongoing excavations, incorporating preliminary post-excavation analysis into the strategic planning of investigations and allowing the team to flag and respond to key interpretations of deposits and explore the relationships between the strands



Context Details BEST

Context: 1767
Trench: 10
Deposit Type: Deposit
Context Type: Fill of feature
Priority?:

Tag 1: External Area, Feature
Tag 2: Fire installation
Tag 3: Fill, Fuel
Tag 4: Burnt aggregates, Clay

Below: 1755
Above:
Fill Of:
Same as:
Cuts:
Cut by:
Plan: 216
Section: 101
Building:
Space: 44
Wall:
Feature: 16
Period: Neolithic
Thickness (cm):
Major site deposit types: FI - oven

Description: Grey ashy fill of F16

Interpretation: Fire installation containing a deep ashy area and a higher charcoal and stone patch. FI outlined by dark red line, indicating possible oven wall. Feature includes scattered clay shapes in the ashy area, possibly intentionally formed and deposited. Clay objects 1-5 extracted, Section 101 only records part of depth. Not completely excavated.

Soil description: 1. Upper surface: non-constructed slope. 2. Bedding: mixed layered. 3. Colour: 10YR 6/1 reddish grey. 4. Porosity, consistency, structure: mod firm. 5. Texture: silty loam. 6. Basal Boundary: -. 7. Post-depositional alterations: roots and burrows. Inclusions: clay shapes 30%, bone <5%, unoriented, linear.

Sample Total Volume: 11.30
DS Volume: 0.00
Unsieved Volume: 0.00
Total Volume (L): 11.30

Figure 2.12. Screenshot from the CZAP Bestansur database.

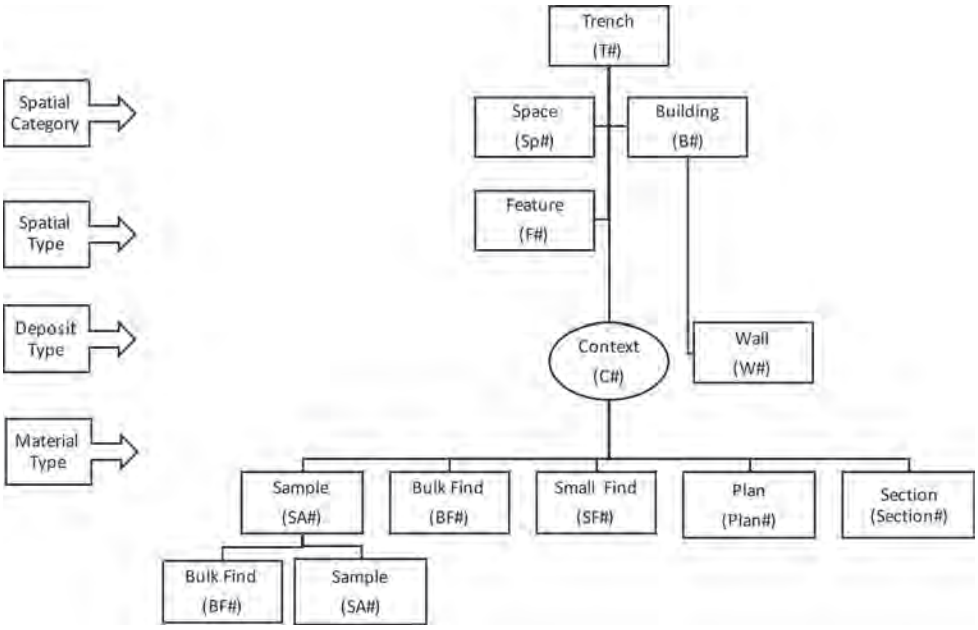
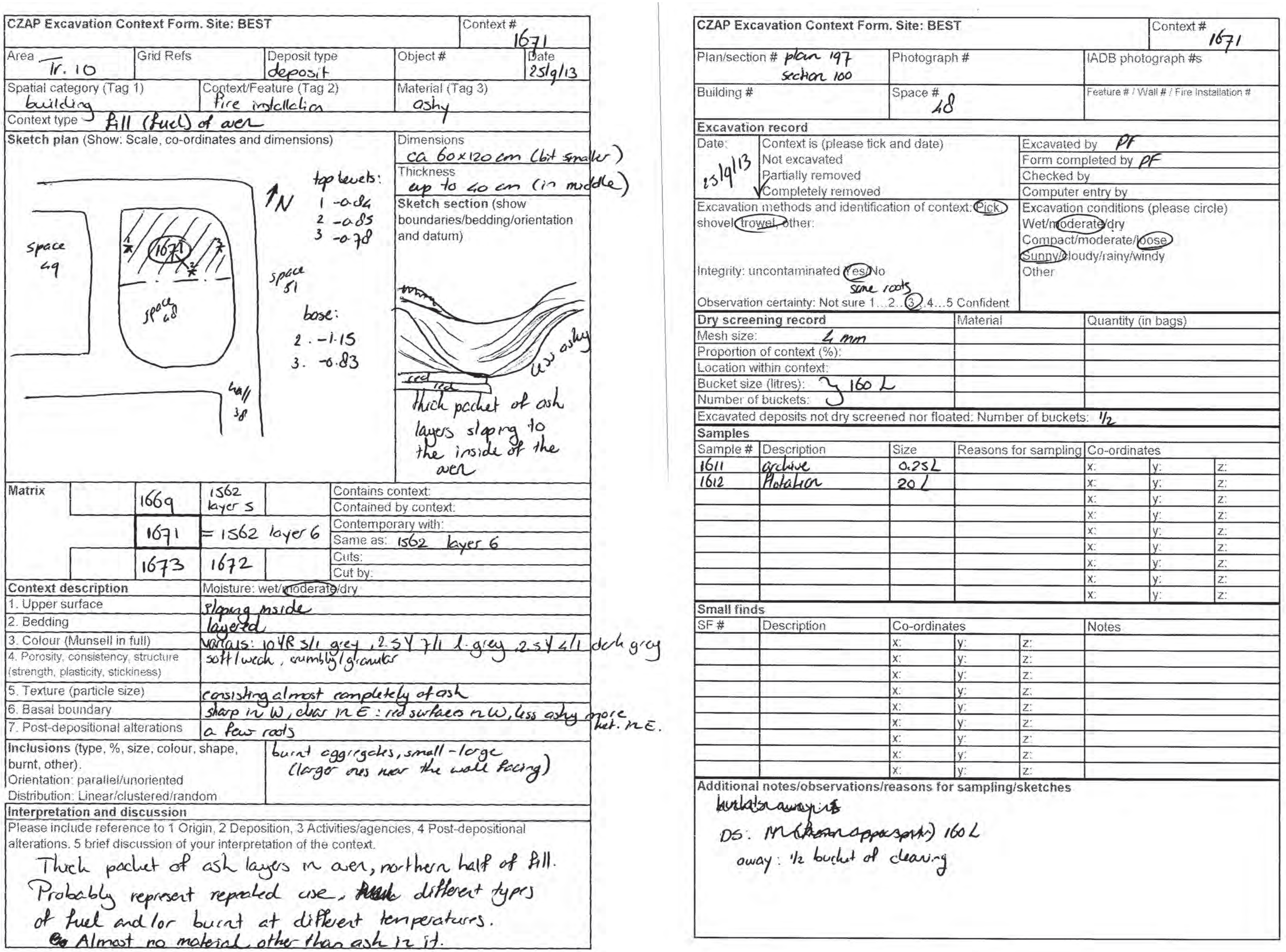


Figure 2.13. Data hierarchy and relationships.

of investigation. Field reports were provided to the Sulaimaniyah Directorate of Antiquities and Heritage at the end of each field season. Following each field season, archive reports of the preliminary results of the excavations and post-excavation analyses were written by all project participants and are openly available at: https://www.czap.org/archive-reports.

Between field seasons, team members conducting post-excavation analysis of the zooarchaeology, heavy residue, chipped stone, small and bulk finds, ground stone, micromorphology, archaeobotany and human bone contributed key results from the analysis and participated in discussions on the interpretations of areas of site. For these discussions, each analyst provided a context-by-context summary of the data and observations for the Trench or Space under consideration to construct an integrated understanding of the activities represented in the archaeological record. The interpretations produced in these discussions were compiled into working documents (Fig. 2.18) that form the core of our understanding of the site and inform the site chapters throughout this volume.



CZAP Excavation Context Form. Site: BEST Context # 1671

Area Tr. 10	Grid Refs	Deposit type deposit	Object #	Date 25/9/13

Spatial category (Tag 1) building
Context/Feature (Tag 2) fire installation
Material (Tag 3) ashy
Context type fill (fuel) of oven

Sketch plan (Show: Scale, co-ordinates and dimensions)

Dimensions ca 60x120 cm (bit smaller)
Thickness up to 40 cm (in middle)

Sketch section (show boundaries/bedding/orientation and datum)

Matrix

1669	1562 layer 5	
1671	= 1562 layer 6	
1673	1672	

Contains context:
Contained by context:
Contemporary with:
Same as: 1562 layers 6
Cuts:
Cut by:

Context description	Moisture: wet/[✓ moderate]/dry
1. Upper surface	sloping inside
2. Bedding	layered
3. Colour (Munsell in full)	varies: 10YR 5/1 grey, 2.5Y 7/1 l. grey, 2.5Y 4/1 dark grey
4. Porosity, consistency, structure (strength, plasticity, stickiness)	soft/weak, crumbly/granular
5. Texture (particle size)	consisting almost completely of ash
6. Basal boundary	sharp in W, clear in E: red surfaces in W, less ashy more het. in E.
7. Post-depositional alterations	a few roots
Inclusions (type, %, size, colour, shape, burnt, other). Orientation: parallel/unoriented Distribution: Linear/clustered/random	burnt aggregates, small-large (larger ones near the wall facing)

Interpretation and discussion

Please include reference to 1 Origin, 2 Deposition, 3 Activities/agencies, 4 Post-depositional alterations. 5 brief discussion of your interpretation of the context.

Thick packet of ash layers in oven, northern half of fill.
Probably represent repeated use, ~~[illegible]~~ different types of fuel and/or burnt at different temperatures.
~~[illegible]~~ Almost no material other than ash in it.

CZAP Excavation Context Form. Site: BEST Context # 1671

Plan/section # plan 197 section 100	Photograph #	IADB photograph #s
Building #	Space # 48	Feature # / Wall # / Fire Installation #

Excavation record

Date:	Context is (please tick and date)	
25/9/13	Not excavated	Excavated by PF
	Partially removed	Form completed by PF
	Completely removed ✓	Checked by
		Computer entry by

Excavation methods and identification of context: [✓ Pick], shovel, [✓ trowel], other:

Integrity: uncontaminated [✓ Yes]/No some roots

Observation certainty: Not sure 1…2..[✓ 3]..4…5 Confident

Excavation conditions (please circle)
Wet/[✓ moderate]/dry
Compact/moderate/[✓ loose]
[✓ Sunny]/cloudy/rainy/windy
Other

Dry screening record	Material	Quantity (in bags)
Mesh size: 4 mm		
Proportion of context (%):		
Location within context:		
Bucket size (litres): 160 L		
Number of buckets:		

Excavated deposits not dry screened nor floated: Number of buckets: 1/2

Samples

Sample #	Description	Size	Reasons for sampling	Co-ordinates		
1611	archive	0.25L		x:	y:	z:
1612	flotation	20 L		x:	y:	z:
				x:	y:	z:
				x:	y:	z:
				x:	y:	z:
				x:	y:	z:
				x:	y:	z:
				x:	y:	z:
				x:	y:	z:

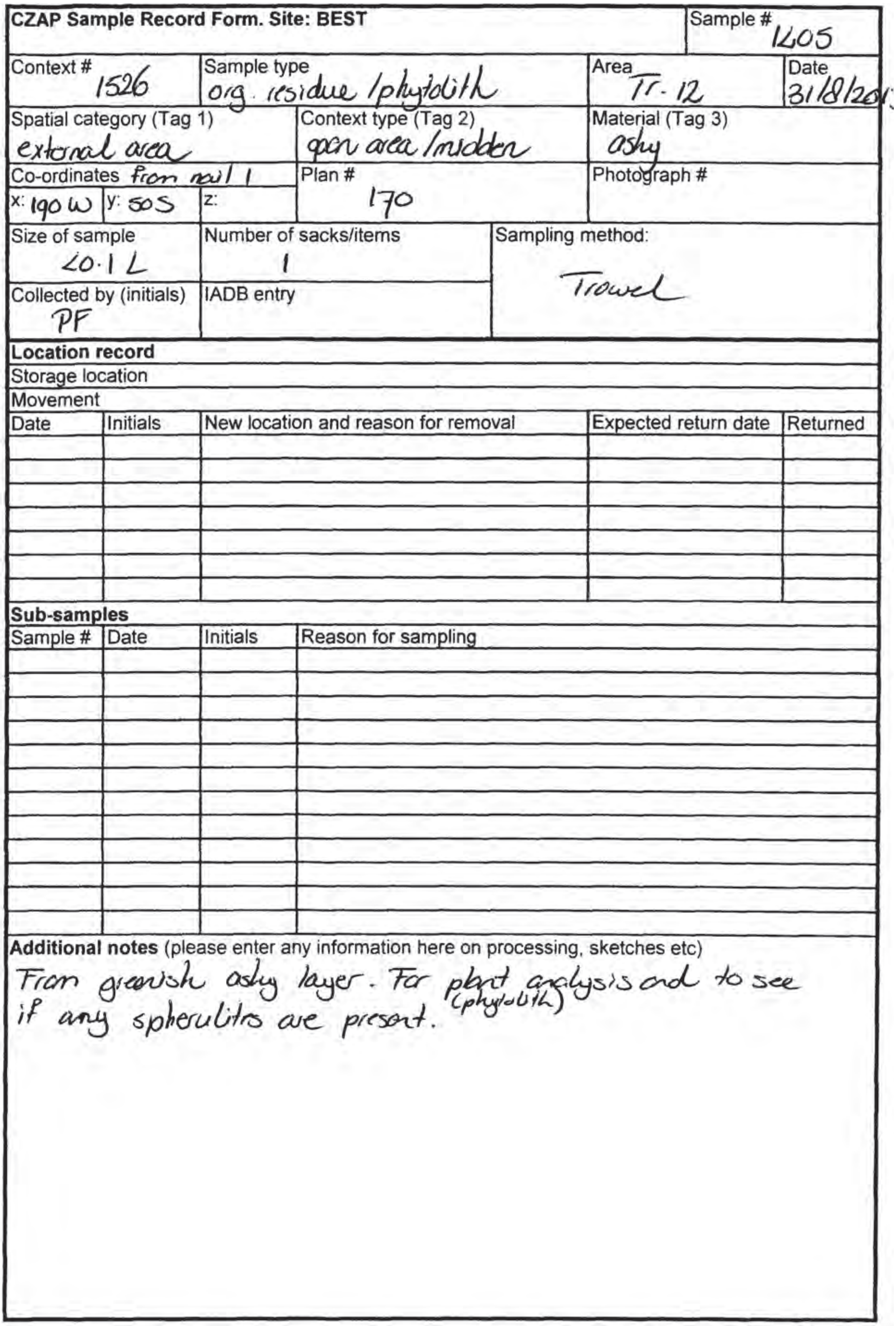
Small finds

SF #	Description	Co-ordinates			Notes
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	
		x:	y:	z:	

Additional notes/observations/reasons for sampling/sketches

~~[illegible]~~
DS: [illegible] 160 L
away: 1/2 bucket of cleaning

Figure 2.14. Example context recording form.



CZAP Sample Record Form. Site: BEST

Sample # 1205

Context # 1526

Sample type org. residue /phytolith

Area Tr. 12

Date 31/8/201

Spatial category (Tag 1) external area

Context type (Tag 2) open area /midden

Material (Tag 3) ashy

Co-ordinates from nail 1

x: 190 W

y: 50S

z:

Plan # 170

Photograph #

Size of sample <0.1 L

Number of sacks/items 1

Sampling method: Trowel

Collected by (initials) PF

IADB entry

Location record

Storage location

Movement

Date	Initials	New location and reason for removal	Expected return date	Returned

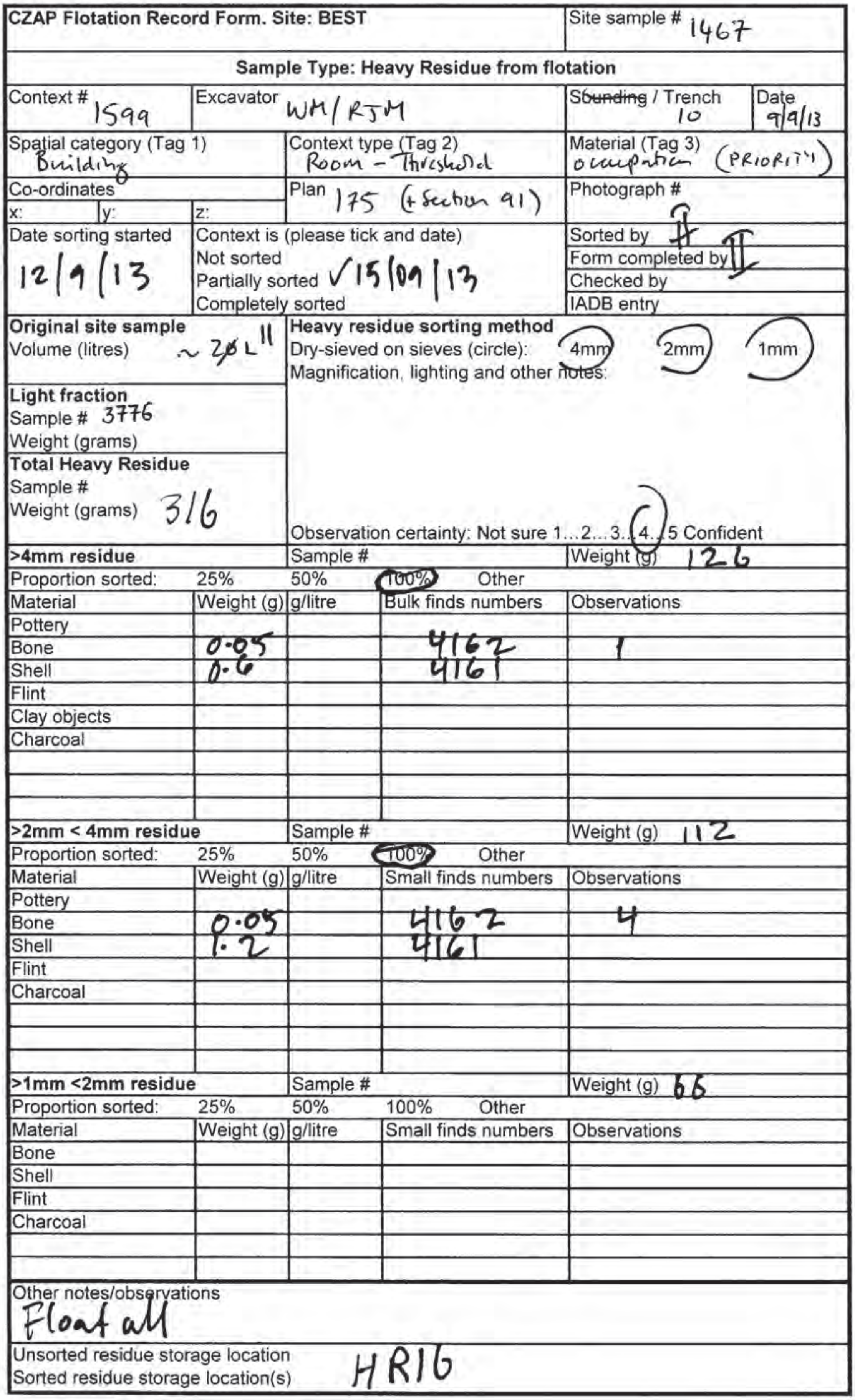
Sub-samples

Sample #	Date	Initials	Reason for sampling

Additional notes (please enter any information here on processing, sketches etc)

From greyish ashy layer. For plant (phytolith) analysis and to see if any spherulites are present.

Figure 2.15. Example sample recording form.



CZAP Flotation Record Form. Site: BEST

Site sample # 1467

Sample Type: Heavy Residue from flotation

Context # 1599

Excavator WM/RJM

~~Sounding~~ / Trench 10

Date 9/9/13

Spatial category (Tag 1) Building

Context type (Tag 2) Room – Threshold

Material (Tag 3) occupation (PRIORITY)

Co-ordinates x: y: z:

Plan 175 (+ Section 91)

Photograph #

Date sorting started 12/9/13

Context is (please tick and date)
Not sorted
Partially sorted ✓ 15/09/13
Completely sorted

Sorted by
Form completed by
Checked by
IADB entry

Original site sample
Volume (litres) ~ 20L"

Heavy residue sorting method
Dry-sieved on sieves (circle): [✓ 4mm] [✓ 2mm] [✓ 1mm]
Magnification, lighting and other notes:

Observation certainty: Not sure 1…2…3…[✓ 4]…5 Confident

Light fraction
Sample # 3776
Weight (grams)

Total Heavy Residue
Sample #
Weight (grams) 316

>4mm residue Sample # Weight (g) 126

Proportion sorted: 25% 50% [✓ 100%] Other

Material	Weight (g)	g/litre	Bulk finds numbers	Observations
Pottery				
Bone	0·05		4162	1
Shell	0·6		4161	
Flint				
Clay objects				
Charcoal				

>2mm < 4mm residue Sample # Weight (g) 112

Proportion sorted: 25% 50% [✓ 100%] Other

Material	Weight (g)	g/litre	Small finds numbers	Observations
Pottery				
Bone	0·05		4162	4
Shell	1·2		4161	
Flint				
Charcoal				

>1mm <2mm residue Sample # Weight (g) 66

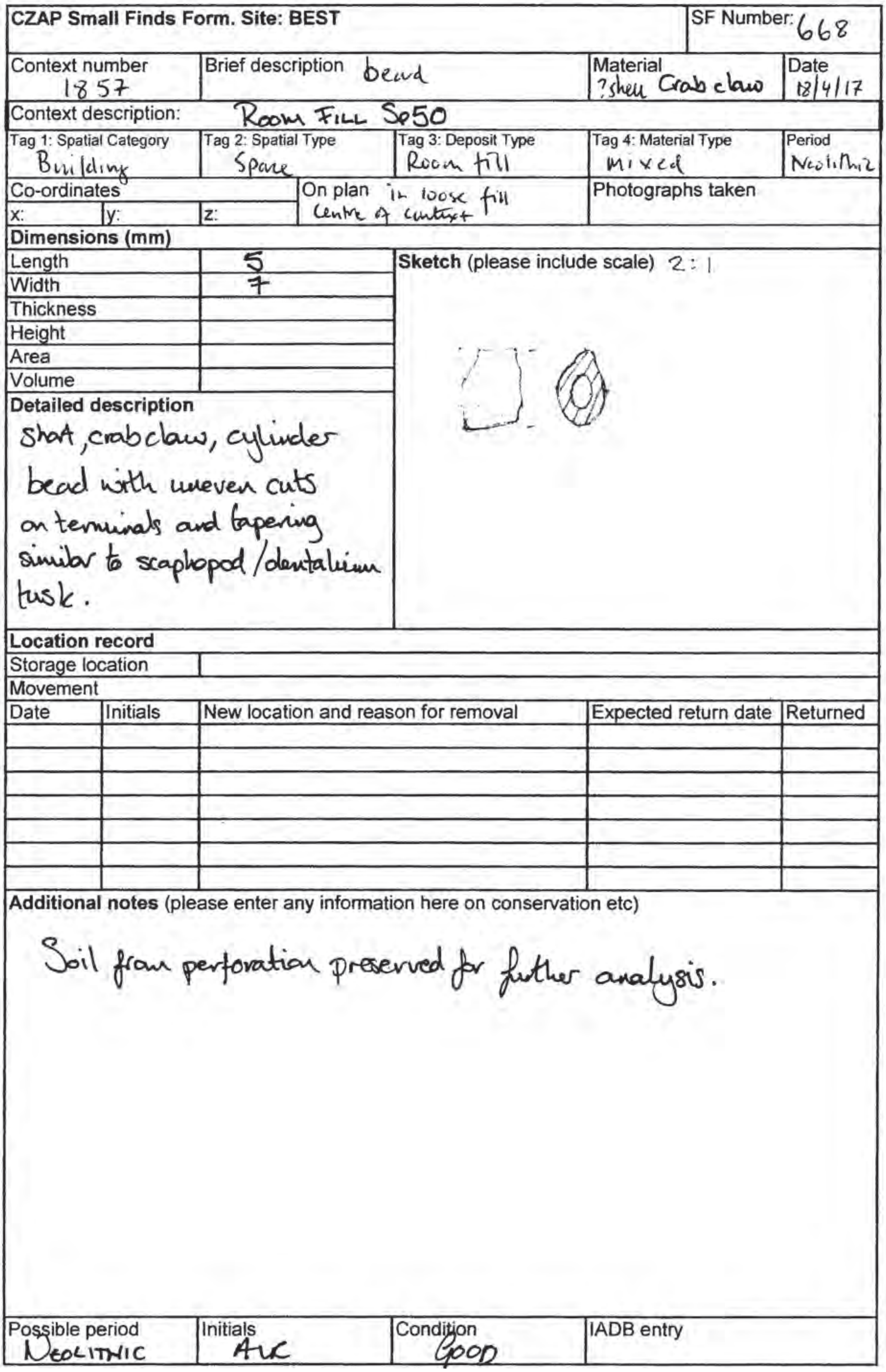
Proportion sorted: 25% 50% 100% Other

Material	Weight (g)	g/litre	Small finds numbers	Observations
Bone				
Shell				
Flint				
Charcoal				

Other notes/observations
Float all

Unsorted residue storage location
Sorted residue storage location(s) HR16

Figure 2.16. Example flotation recording form.



CZAP Small Finds Form. Site: BEST

SF Number: 668

Context number	Brief description	Material	Date
1857	bead	?shell Crab claw	18/4/17

Context description: Room Fill Sp50

Tag 1: Spatial Category	Tag 2: Spatial Type	Tag 3: Deposit Type	Tag 4: Material Type	Period
Building	Space	Room fill	Mixed	Neolithic

Co-ordinates x: y: z:

On plan: in loose fill centre of context

Photographs taken

Dimensions (mm)

Length	5
Width	7
Thickness	
Height	
Area	
Volume	

Sketch (please include scale) 2:1

Detailed description

Short, crab claw, cylinder bead with uneven cuts on terminals and tapering similar to scaphopod/dentalium tusk.

Location record

Storage location

Movement

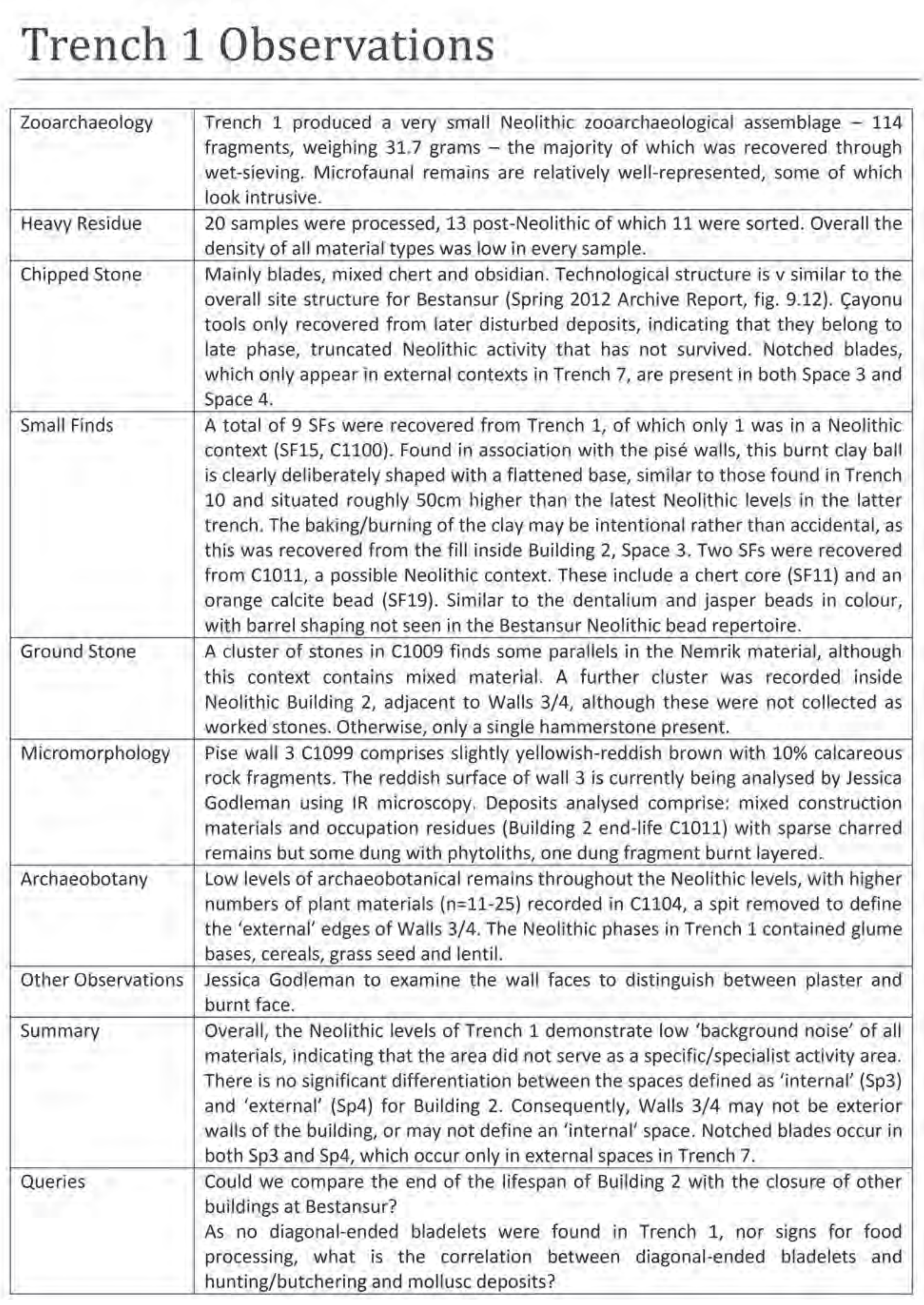
Date	Initials	New location and reason for removal	Expected return date	Returned

Additional notes (please enter any information here on conservation etc)

Soil from perforation preserved for further analysis.

Possible period	Initials	Condition	IADB entry
NEOLITHIC	AK	GOOD	

Figure 2.17. Example small finds recording form.



Trench 1 Observations

Zooarchaeology	Trench 1 produced a very small Neolithic zooarchaeological assemblage – 114 fragments, weighing 31.7 grams – the majority of which was recovered through wet-sieving. Microfaunal remains are relatively well-represented, some of which look intrusive.
Heavy Residue	20 samples were processed, 13 post-Neolithic of which 11 were sorted. Overall the density of all material types was low in every sample.
Chipped Stone	Mainly blades, mixed chert and obsidian. Technological structure is v similar to the overall site structure for Bestansur (Spring 2012 Archive Report, fig. 9.12). Çayonu tools only recovered from later disturbed deposits, indicating that they belong to late phase, truncated Neolithic activity that has not survived. Notched blades, which only appear in external contexts in Trench 7, are present in both Space 3 and Space 4.
Small Finds	A total of 9 SFs were recovered from Trench 1, of which only 1 was in a Neolithic context (SF15, C1100). Found in association with the pisé walls, this burnt clay ball is clearly deliberately shaped with a flattened base, similar to those found in Trench 10 and situated roughly 50cm higher than the latest Neolithic levels in the latter trench. The baking/burning of the clay may be intentional rather than accidental, as this was recovered from the fill inside Building 2, Space 3. Two SFs were recovered from C1011, a possible Neolithic context. These include a chert core (SF11) and an orange calcite bead (SF19). Similar to the dentalium and jasper beads in colour, with barrel shaping not seen in the Bestansur Neolithic bead repertoire.
Ground Stone	A cluster of stones in C1009 finds some parallels in the Nemrik material, although this context contains mixed material. A further cluster was recorded inside Neolithic Building 2, adjacent to Walls 3/4, although these were not collected as worked stones. Otherwise, only a single hammerstone present.
Micromorphology	Pise wall 3 C1099 comprises slightly yellowish-reddish brown with 10% calcareous rock fragments. The reddish surface of wall 3 is currently being analysed by Jessica Godleman using IR microscopy. Deposits analysed comprise: mixed construction materials and occupation residues (Building 2 end-life C1011) with sparse charred remains but some dung with phytoliths, one dung fragment burnt layered.
Archaeobotany	Low levels of archaeobotanical remains throughout the Neolithic levels, with higher numbers of plant materials (n=11-25) recorded in C1104, a spit removed to define the 'external' edges of Walls 3/4. The Neolithic phases in Trench 1 contained glume bases, cereals, grass seed and lentil.
Other Observations	Jessica Godleman to examine the wall faces to distinguish between plaster and burnt face.
Summary	Overall, the Neolithic levels of Trench 1 demonstrate low 'background noise' of all materials, indicating that the area did not serve as a specific/specialist activity area. There is no significant differentiation between the spaces defined as 'internal' (Sp3) and 'external' (Sp4) for Building 2. Consequently, Walls 3/4 may not be exterior walls of the building, or may not define an 'internal' space. Notched blades occur in both Sp3 and Sp4, which occur only in external spaces in Trench 7.
Queries	Could we compare the end of the lifespan of Building 2 with the closure of other buildings at Bestansur? As no diagonal-ended bladelets were found in Trench 1, nor signs for food processing, what is the correlation between diagonal-ended bladelets and hunting/butchering and mollusc deposits?

Figure 2.18. Example of an integrated interpretations working document from Bestansur Trench 1.

3. PALAEOCLIMATE AND ENVIRONMENT OF THE IRAQI CENTRAL ZAGROS

Matt Bosomworth, Dominik Fleitmann and Maria Rabbani

Introduction

A key aim of the Central Zagros Archaeological Project is to examine the transformations in human–environment relationships associated with increasing sedentism and management of plants and animals, and to understand the climatic and environmental context in which these shifts in subsistence strategies occurred. The transition from hunter-gather to farmer-villager societies between *c.* 10,000 and 7000 BC coincides with the most recent glacial-interglacial transition, a period of major global climate change from the relatively dry and cold Pleistocene to the more stable, wet and warm Holocene from *c.* 9750 BC. As a result, it has long been suggested that climate and environmental change acted as a significant causal mechanism for social transformations during this period, often highlighting the role climate amelioration may have had on the spread and presence of plants and animals outside of their glacial refugia during the early Holocene (Wright 1993; Bar-Yosef 1998; Willcox *et al.* 2009; Zeder 2011).

Until recently, environmental evidence gained primarily from pollen reconstructions, along with the absence of archaeological sites, suggested that the central Zagros was relatively dry and less habitable than other regions in Southwest Asia during the late glacial period and early Holocene (van Zeist and Bottema 1977; Hole 1996). More recently though, the identification or reinvestigation of a number of key sites that include Sheikh-e Abad (Matthews *et al.* 2013a), Asiab (Zeder 2000), Ganj Dareh (Zeder 2008), Chogha Golan (Riehl *et al.* 2015) and now Bestansur has demonstrated that the central Zagros was occupied during the early Holocene and was likely to have been a key region for the Neolithic transition (Matthews *et al.* 2013a; Riehl *et al.* 2013; Zeder 2015). However, the current palaeoclimate evidence needed to provide the climatic and environmental context for this region remains scarce. In the Iraqi central Zagros there are currently no palaeoclimate records that cover the last glacial-interglacial transition. This is the result of a sparsity of suitable climatic archives to analyse (e.g. lakes), combined with wider issues that have hampered research for much of the last few decades. Attempts to characterise the palaeoclimate of the region have mostly been dependent on a handful of lake sediment records from the Iranian Zagros, particularly Lake Zeribar (van Zeist and Bottema 1977). Other climatic and environmental archives from wider Southwest Asia have therefore been used to infer climatic fluctuations in the Iraqi central Zagros, largely ignoring the large spatial heterogeneity in local and regional climate conditions across Southwest Asia (Clarke *et al.* 2016).

Extensive reviews have been conducted of palaeoclimate change for broader Southwest Asia during the Holocene and its relationship with human societies (Robinson *et al.* 2006; Roberts *et al.* 2018; Jones *et al.* 2019). This chapter begins by critically reviewing the current environmental and geological conditions of the Iraqi central Zagros. Then, using the palaeoclimate and palaeoenvironmental data available, we examine the existing evidence of climate and environmental variability during the glacial-interglacial transition providing an environmental context for the Neolithic transition. We also highlight major outstanding problems and complexities of palaeoenvironmental studies in this region. The chapter will also explain how new research and palaeoenvironmental samples collected as part of this project, which are currently being analysed at the University of Reading and with collaborators, will attempt to address these outstanding problems.

Topography, geology and environment of the central Zagros

The topography of the central Zagros is diverse and has a significant impact on local and regional climates and environments (Simpson *et al.* 2015). The Zagros mountains form the eastern arc of the Fertile Crescent and stretch from the eastern Taurus mountains in Turkey to the Persian Gulf in the south. The mountains create sudden changes in elevations that cause sharp gradients in precipitation and temperature (Asouti and Kabukcu 2014). Generally, in Iraqi Kurdistan, precipitation decreases and temperature increases moving away from the mountains in the north east to the low altitude desert steppe in the southwest (Stevanović *et al.* 2009). The consequence of this complex topography and the resultant steep climatic gradients is the existence of distinct geobotanical zones related to altitude.

Although now heavily reduced by deforestation and overgrazing, the majority of the Zagros region's natural landscape is covered by 'Kurdo-Zagrosian steppe-forest' (Zohary 1973), which consists mainly of deciduous, broad leaved trees or shrubs with low coverage and a dense ground cover of steppe vegetation. The dominant arboreal species are oak (*Quercus* spp.) and pistachio (*Pistacia* spp.). Kurdo-Zagrosian steppe-forest is found in elevations of between *c.* 700m and 2000m. The steppe-forest is generally less dense and more impoverished in southern regions of the central Zagros (e.g. around Sulaimaniyah), relative to better watered northernly areas. Below elevations of about 500–700m, there is not enough reliable precipitation for oak growth and the steppe-forest gives way to Mesopotamian steppe vegetation (*Astragalus* spp., *Salvia* spp). Above the upper timber line (*c.* 2000m), where temperature inhibits the growth of steppe-forest vegetation, sub-alpine plants are present (Zohary 1973).

The site of Bestansur (35°22′36.7 N, 045°38′44.4 E, *c.* 550m asl) is located on the Shahrizor plain, a lowland piedmont zone of the western foothills of the central Zagros mountains, in Sulaimaniyah province, Iraq. The plain is fertile and, in more recent periods, has been known for its agricultural productivity, with slightly to moderately alkaline soils (Sehgal 1976; Altaweel *et al.* 2011). The soil type of the Shahrizor plain has been described as a deep phased chestnut soil type, a dark brown, friable surface soil containing 1–4% organic matter (Buringh 1960; Zakaria *et al.* 2013).

Present climate

The climate of northeast Iraq can be characterised as semi-arid Mediterranean (Frenken 2009) and is highly seasonal with cold, wet winters and hot, dry summers. This seasonal climatic pattern is related to the interaction of two major climate systems, the mid latitude westerlies from the North Atlantic and the Indian Ocean Monsoon system in the south (Luterbacher and Xoplaki 2003; Rohling *et al.* 2013; Fig. 3.1).

In the summer, climate in northeast Iraq is influenced by the East African and Indian monsoons and the position of the Inter-Tropical Convergence Zone (ITCZ) as both cause subsidence of dry air in the sub-tropical belt, which is found north of Iraq during summer. In winter, the ITCZ is in the southern hemisphere, allowing temperate westerly storm tracks from the North Atlantic and Eastern Mediterranean to dominate the region. This system steers moist air and Mediterranean generated cyclones eastward (Lionello *et al.* 2017), resulting in wet winters (Ulbrich *et al.* 2012). The interaction between the African/Indian Monsoons and the North Atlantic/Mediterranean weather domains strongly controls the amount of spring rainfall, which is highly variable and is fundamental for water availability in the region (Giorgi and Lionello 2008; Reuter *et al.* 2018). Understanding these dynamics and how they may have changed in the past is therefore key to understanding changes in water availability.

At present, the Iraqi central Zagros receives 98% of its rainfall between October and May; 82% of it between November and March (Flohr *et al.* 2017). Mean annual rainfall varies greatly due to the complex topography. In the Shahrizor plain mean rainfall is ~700mm (Halabja rainfall station for the period 2002-2012). Generally, the rainfall season starts in October, peaks in February (~125mm) and continues until April or May, with no rainfall during the summer months (Zakaria *et al.* 2013). However, inter-annual rainfall is highly variable, often reliant on the amount of spring rainfall (Black *et al.* 2010; Reuter *et al.* 2018) which can lead to the region experiencing cycles of wet years and drought years. Mean air temperature in the Shahrizor ranges from 6.5°C in January to 33°C in August (Zakaria *et al.* 2013).

Palaeoclimate: approaches and issues

Our understanding of palaeoclimate change during the last deglaciation is derived from information obtained from climate proxy archives, such as terrestrial and marine sediment sequences and stalagmites. Due to climate and geography of the region there is a general scarcity of terrestrial climate archives. Palaeoclimate

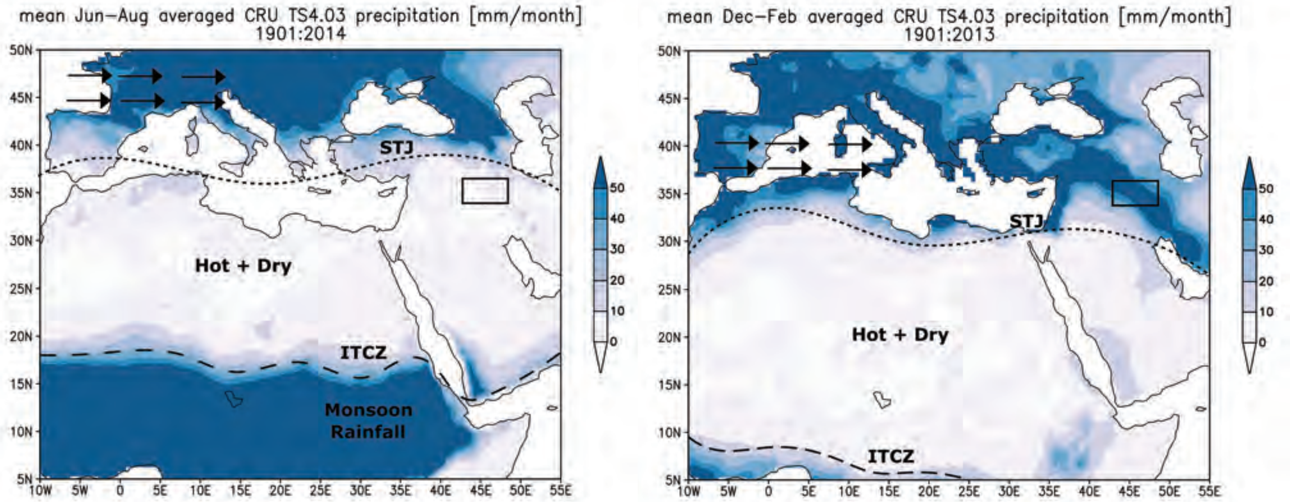


Figure 3.1. Summer and winter position of the major regimes that control the climate of the Central Zagros. Precipitation maps were produced by KMNI (https://climexp.knmi.nl/start.cgi). Box = Central Zagros, STJ = Sub-tropical Jet, ITCZ = Inter tropical convergence zone. Arrows indicate North Atlantic westerlies.

investigations in the Eastern Fertile Crescent (EFC) have predominantly involved lake sediment cores. Lake records can provide continuous, sometimes high-resolution time series of past environmental change. The history of paleoenvironmental investigations of lake sediment records in the central Zagros extends relatively far back, with pioneering interdisciplinary work between archaeologists and geologists in the 1950s and 1960s (van Zeist and Wright 1963). Early investigations tended to focus on pollen to reconstruct past vegetation cover and moisture availability (van Zeist and Bottema 1977) and key plant taxa which are highly dependent precipitation thresholds, based on our understanding of modern ecological analogues where these species are found. The specific taxa and their associated annual rainfall analogues are: Chenopodiaceae and *Artemisia* (<100mm), *Poaceae* (100–300mm), Pistachio (*Pistacia)* (300–500mm) and deciduous oak (*Quercus*) (>500mm) (Rossignol-Strick 1995). The relative abundances of these different taxa can therefore be used as a proxy for effective moisture and temperature. However, pollen percentage data do not take account of differential production, dispersal and preservation between individual taxa (Roberts *et al.* 2018).

Palynological investigations are crucial in determining a clear correlation between the archaeology and the environment, helping to detect human signals which might not be reflected in the archaeological record in order to better understand human–environmental relationships. However, detecting human impact can be difficult depending on the nature of the landscape as pollen diagrams may not always represent the regional vegetation accurately due to differential production, dispersal, and preservation processes (Roberts 2002). For example, since pistachio is a low pollen grain producer, this might explain its low percentages in the pollen record. According to Roberts (2002: 1006), if underrepresentation of pistachio is considered, then the Early Holocene period had a denser tree cover than what can be inferred from the pollen diagram in the western Zagros region.

More recently, due to the availability of new techniques, the analysis of oxygen isotopes ($\delta^{18}O$) of biogenic and non-biogenic lake carbonates has become a common method employed (Stevens *et al.* 2001; 2006) and provides a 'common currency' for comparisons with other types of palaeoclimate archives (Roberts *et al.* 2018). The $\delta^{18}O$ values of lake carbonates are closely related to the isotopic composition of the lake waters in which $\delta^{18}O$ values of lake waters can be controlled by several factors and must therefore be assessed on a site to site basis (Leng and Marshall 2004). Standard interpretations of Southwest Asian lake $\delta^{18}O$ records from lake systems suggest they are a proxy for the Precipitation–Evaporation (P:E) balance, whereas more positive (negative) $\delta^{18}O$ values indicate shifts to drier conditions (Jones and Roberts 2008). However, it has also been argued that changes in the seasonal distribution of rainfall could be a significant factor in changes to $\delta^{18}O$ values (Stevens *et al.* 2001; 2006; Dean *et al.* 2015; 2018; Djamali *et al.* 2010). Other proxy data analysed from lake sediment records from the region include plant macrofossils, diatoms, molluscs and organic content (Wasylikowa 2005; Wasylikowa *et al.* 2006).

The most intensively studied record from the central Zagros region that covers the late Pleistocene–Holocene transition is from Lake Zeribar (van Zeist and Bottema 1977; Stevens *et al.* 2001; Wasylikowa 2005; Wasylikowa *et al.* 2006) (35°132′ N, 46°107′ E), located at an altitude of 1300m asl in northwest Iran. The lake has been investigated for the purposes of palaeoclimate research since the early 1960s with multiple cores being taken, dating back to 42,000 years BP (Stevens *et al.* 2001). Multi-proxy analyses include δ^{18}O and δ^{13}C values of lake carbonates, as well as pollen, diatoms and macrofossils (van Zeist and Bottema 1977; Stevens *et al.* 2001; Wasylikowa *et al.* 2006).

However, the sampling resolution of the Zeribar record is low, with a data point once every 200 years or more. This coarse temporal resolution only allows centennial climate events identifiable at best. There are also significant weaknesses with the radiocarbon dates of the record themselves. Only a handful of ^{14}C dates were measured and on bulk sediment material in the 1960s. As a result, ^{14}C dates are affected by the so-called 'hard-water effect' and age uncertainties are certainly several hundred years or more as a result. These chronological limitations make it difficult to investigate human and environmental interactions precisely. Moreover, the lake is located on the leeward side of the Zagros mountains, which are likely to act as a barrier to rainfall, as a result of orographic relief, receiving half the amount of rainfall as the western side of the Zagros (Brookes *et al.* 1982: 192). It is likely, therefore, that the nature of palaeoclimate change and conditions of the western Zagros, including those at Bestansur, would differ from those recorded at Zeribar. Other key lake records from the Iranian Zagros include Lake Urmia (37°32′ N, 45°05′ E, 1315m asl; Djamali *et al.* 2008) and Lake Mirabad (33°05′ N, 47°43′ E, 800m asl; Griffiths *et al.* 2001; Stevens *et al.* 2006) but again these are all located on the leeward side of the Zagros mountains.

Though caves are abundant in the Zagros region, only a few new speleothem (e.g. stalagmites, stalactites, flowstones) records are available, and were sampled in collaboration with CZAP, such as from Gejkar Cave (35°48′ N, 45°09′ E, 650m asl; Flohr *et al.* 2017) and Shalaii Cave (35°08′ N, 45°19′ E, 739m asl; Marsh *et al.* 2018) located close to Sulaimaniyah in northern Iraq, 13.5km east of Zarzi, and *c.* 40km southeast of Bestansur, respectively. However, the current published speleothem-based climate reconstructions are discontinuous and do not cover the late Pleistocene–Holocene transition.

Due to the uncertainties and limitations of currently existing records from the central Zagros, other records from wider Southwest Asia are often used to help support the interpretation, and to characterise the palaeoclimate and palaeoenvironmental of the central Zagros region of Iraq. These include lake sediment cores from Turkey (Wick *et al.* 2003; Jones and Roberts 2008; Dean *et al.* 2015) and Iran (Sharifi *et al.* 2015) and speleothems from the western Levant (Bar-Matthews *et al.* 1997; Verheyden *et al.* 2008; Cheng *et al.* 2015). However, given the evidence for the spatially highly variable climatic conditions in Southwest Asia during the Holocene (Clarke *et al.* 2016) using these records is less than ideal. The key terrestrial palaeoclimate records that cover the late Pleistocene-Holocene transitions are indicated in Figure 3.2.

Palaeoclimate summary

The following discussion provides a general overview of palaeoclimate conditions during the last deglaciation focused primarily on stable isotope and pollen data from Lake Zeribar. To aid interpretation and provide a longer-term context for the climate of the late Pleistocene and early Holocene we review data between the end of the Last Glacial Maximum (LGM) at around 14,000 BC and 4000 BC.

During the LGM, δ^{18}O values from lake carbonates at Lake Zeribar are at their most positive (*c.* –1‰ VPDB). Pollen assemblages from Lake Zeribar and Lake Urmia are dominated by *Artemisia* and Chenopodiaceae and there is an absence of arboreal tree pollen. This represents a steppe/semi-desert type environment (Freitag 1977) of extreme aridity and cold temperatures, and is also corroborated by plant macrofossil (Wasylikowa 2005; Wasylikowa *et al.* 2006) and diatom assemblages from the core (Snyder *et al.* 2001). Records from across Southwest Asia indicate that these were ubiquitous conditions during the LGM, except for small areas of refugia in the lower Levant (Asouti and Austin 2005; Asouti *et al.* 2015).

Following the LGM, the Zeribar δ^{18}O record displays a steady shift toward more negative values indicating increasing moisture availability during the late glacial period. Wetter conditions are also indicated by the presence, albeit modest, of pistachio in the pollen assemblage and a decrease in *Artemisia*. This wetter phase broadly coincides with the Bølling–Allerød oscillation (12,750–10,750 BC). However, the pollen assemblage is still dominated by steppe vegetation and no oak is present, suggesting a rather dry and cold climate persisted. This persistence of steppe conditions is in contrast to the situation in the Levant where steady afforestation seems to be occurring during the late glacial period (Asouti and Kabukcu 2014).

This amelioration in climate was, however, interrupted by the Younger Dryas, a late glacial climatic reversal. Greenland ice core records date this event as occurring between *c.* 10,950–9750 BC (Rasmussen *et al.* 2006). The Younger Dryas is identifiable in the Zeribar isotope record as a shift to more positive δ^{18}O values (Fig. 3.3), an increase in diatom-inferred conductivity (Snyder *et al.* 2001) and plant macrofossil evidence that indicates increased salinity and lower lake levels (Wasylikowa 2005). The Younger Dryas is identifiable in the Zeribar core between about 10,750 and 10,050 BC.

At the start of the Holocene (*c.* 9750 BC), δ^{18}O values

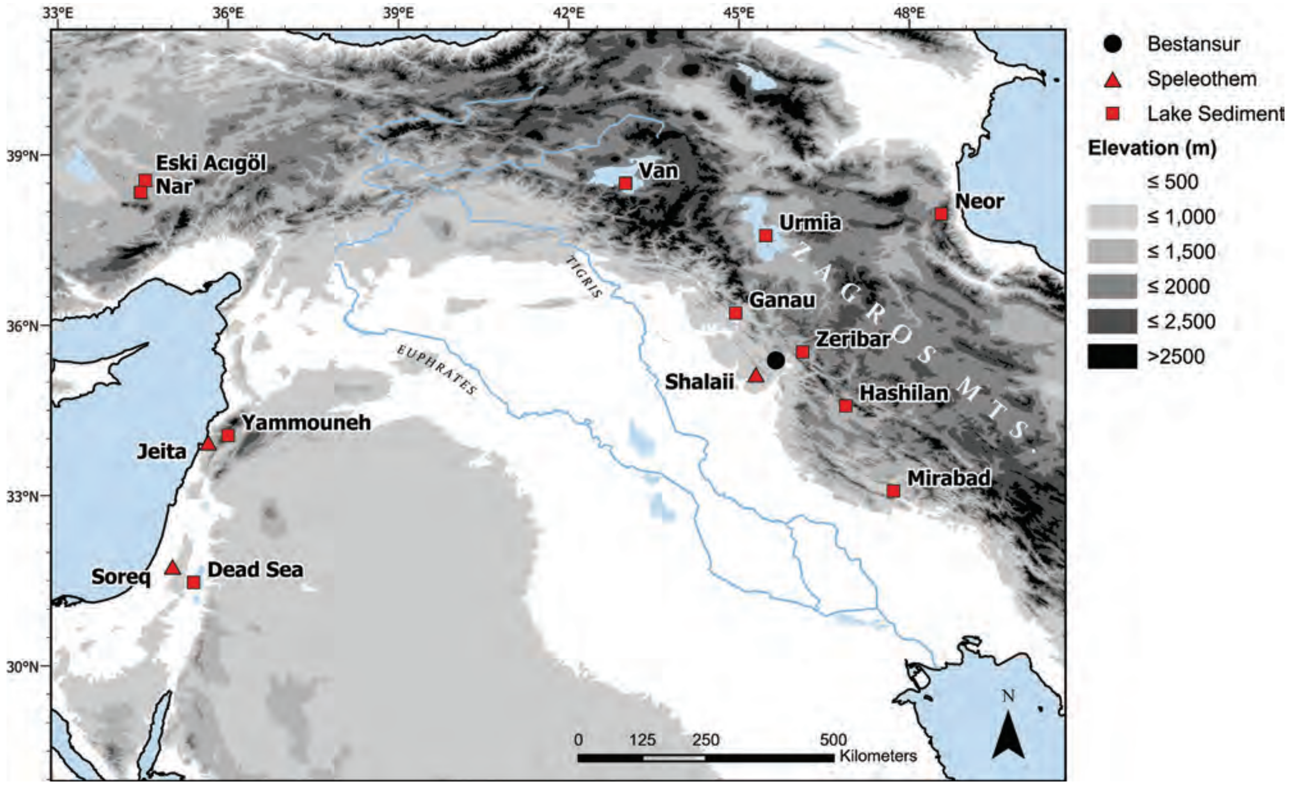


Figure 3.2. Location of key terrestrial palaeoclimate records from southwest Asia that cover the glacial-interglacial transition.

from Zeribar recover to pre-Younger Dryas levels quickly. $\delta^{18}O$ data from other lake sediments from Nar, Van and Eski Acigöl display a similar improvement and it has been suggested that the amelioration in climate took place in less than a century (Roberts *et al.* 2018). Isotopic values from Zeribar in the early Holocene maintain a steady trend towards more negative values until ~6050 BC. The early and middle Holocene witnesses a rapid increase in grass species (*Poaceae*) (~50%) and some arboreal pollen, as well as a decrease in steppe species, similarly indicating a shift to warmer and wetter climatic conditions. Despite the evidence of rapid and continuous climate amelioration, expansion of oak remains limited and slow relative to other records from Southwest Asia, particularly the Levant and western Turkey (Baruch and Bottema 1991). Peak oak values (~60%) are not reached until the mid-Holocene (*c.* 4050 BC). The scarcity of oak and the increased presence of the more drought resistant *Pistacia* (5–15%) during the early and middle Holocene has been used to suggest that the EFC was relatively dry compared to other regions during this period (van Zeist and Bottema 1977) or at least experienced prolonged and severe summer droughts (Djamali *et al.* 2011). Similar depictions of vegetation changes are attested from Lake Urmia and Mirabad (Griffiths *et al.* 2001; Djamali *et al.* 2008).

Discrepancies and problems

The apparent discrepancy between oak pollen concentrations and the $\delta^{18}O$ record during the early Holocene arguably represents the largest unsolved problem in paleoenvironmental studies in the EFC and has been discussed thoroughly in the literature (Roberts 2002; Jones and Roberts 2008; Jones 2013; Asouti and Kabukcu 2014). Early pollen studies suggested that the low arboreal pollen quantities were evidence of a relatively dry early Holocene (van Zeist and Bottema 1977), whereas more negative $\delta^{18}O$ values suggest wetter conditions (Roberts *et al.* 2008). This contrasts greatly with the situation in the Levant where arboreal pollen levels recover rapidly following the end of the Younger Dryas (Asouti and Kabukcu 2014). This contradiction has been termed the early Holocene precipitation paradox (Stevens *et al.* 2006; Jones 2013).

Stevens *et al.* (2001) interpreted changes in $\delta^{18}O$ values as a shift in seasonality, arguing that more negative values indicate a higher proportion of winter rainfall and by doing so explain the apparent contradiction between the isotopic and pollen data. This has been given support by other investigations that have suggested that an intensified monsoon system during the early Holocene would have shifted the sub-tropical high-pressure belt further north during spring, displacing moist mid-latitude

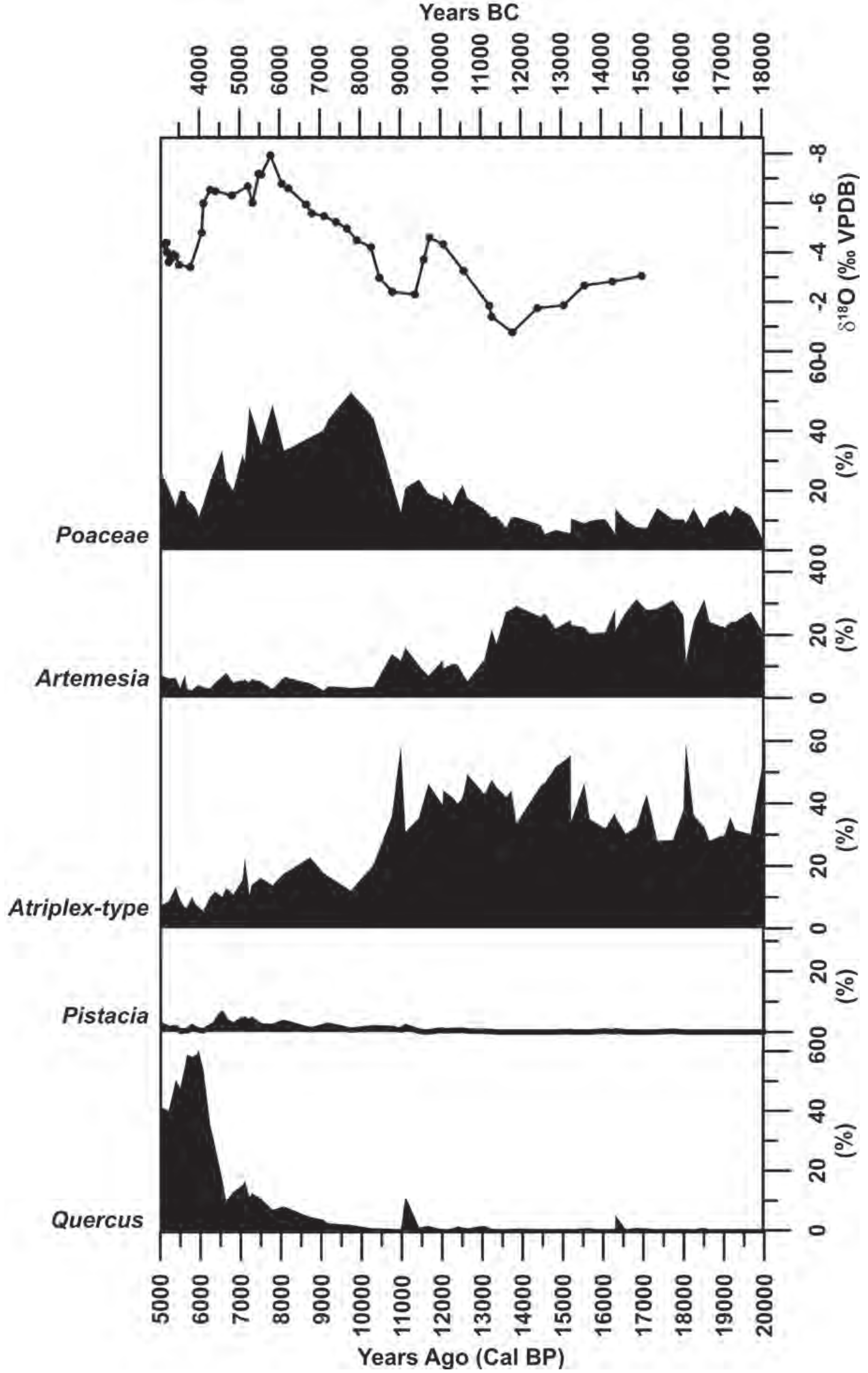


Figure 3.3. Isotope and key pollen data as a % of the total pollen count from Lake Zeribar (Stevens et al. 2001; van Zeist and Bottema, 1977).

westerlies and preventing them from reaching the region (Djamali *et al.* 2010). Djamali *et al.* (2010) argue that spring rains only began to penetrate the region when the monsoon began to weaken during the mid-Holocene, providing suitable conditions for the spread of oak woodland. Macrofossil indicators of water-level changes occurring at the same time as the expansion of oak in the region also support a climatic explanation for the delay of oak growth (Wasylikowa 2005). However, Jones and Roberts (2008) question this interpretation. They argue it is an over-simplification to suggest the $\delta^{18}O$ levels are solely controlled by changes in the seasonal distribution of rainfall. They suggest that, given the similarities between the Zeribar $\delta^{18}O$ record and the $\delta^{18}O$ records from lake sediments in Turkey, moisture availability (P:E) is likely to be an important control and therefore the early Holocene was moister than Stevens *et al.* (2001) suggest.

Other mechanisms have been proposed to explain the delay in oak expansion during the early Holocene that are not climate related (Jones and Roberts 2008). Roberts (2002) suggests that anthropogenic activity, which could include burning, woodland clearances and, indirectly, grazing, may have impeded the spread of deciduous woodland. This interpretation is to some extent supported by increases of charcoal, particularly of awn fragments from grasses (Wasylikowa *et al.* 2006). However, anthropogenic explanations struggle to explain why humans would have had such a large impact on the regional landscape during the early Holocene and then why this may have suddenly ceased during the mid-Holocene, to allow for the expansion of oak woodland. Furthermore, there is evidence of and many reasons for natural processes that lead to the presence of charred particles in the sediment cores. Other investigations have suggested that the ecological properties of the tree species themselves may have been responsible for the delay, due to their rates of dispersal from their glacial refugia (Roberts 2002), and the existence of suitable edaphic conditions (van Zeist and Bottema 1991). Asouti and Kabukcu (2014) suggest that oak woodland in the central Zagros is actually itself a product of the displacement of grasslands by grazing, cultivation and settlement expansion rather than an indication of wetter conditions. Therefore the existence of oak represents an anthropogenic landscape rather than one principally determined by palaeoclimate and natural environnment agencies. Ultimately, a consensus is yet to be reached on the correct explanation for the paradox. Further palaeoclimate investigations, perhaps utilising alternative archives (e.g. speleothems) are needed.

One limiting factor for palaeoecological studies in Southwest Asia is the rarity of lake bodies that extend back to as early as the Late Glacial period (e.g. Djamali *et al.* 2011). The available pollen records for this region, as already mentioned, include Lake Zeribar, Lake Mirabad, Lake Urmia and Lake Van. However, some of these records suffer from dating problems, e.g. hard water effect and low numbers of radiocarbon dates (van Zeist and Bottema 1997; Djamali *et al.* 2008), as well as being low-resolution studies (van Zeist and Bottema 1977). In order to make more specific correlations between palaeoenvironmental and archaeological data, both the temporal resolution and spatial scale of the data sets need to be of high-resolution (Walsh *et al.* 2017: 403). Furthermore, to improve detection of anthropogenic indicators, the distance between an archaeological site and the pollen study site needs to be taken into consideration as a greater distance between them reduces the likelihood of finding a strong human signal.

To address these problems, limnological investigations are being carried out at two study sites in the central Zagros region; Hashilan wetland and Lake Ganau. Hashilan wetland (34°34′ N, 46°53′ E) is a 260ha freshwater wetland located at an elevation of 1310m above sea level, 35km west of the Early Neolithic site of Sheikh-e Abad and 35km northwest of Kermanshah in the Zagros mountains of western Iran. It is fed by rainwater and two karstic springs that originate from the Khorein mountains. Lake Ganau (36°12′ N, 44°56′ E) is a small hydrogen sulphide-rich lake located 1.35km north of the Neolithic site of Shimshara and near the north-western bank of the modern Dokan lake on the Rania plain, Iraq, 131km northwest of Sulaimaniyah city and consists of several spring basins which are fed by the same underground flow zone wells (Ali *et al.* 2012). Analysis of high-resolution multi-proxy palaeoenvironmental records with robust age-depth models will shed light onto the widely discussed delay in oak expansion and to what extent the nature and timing differed from other studies in this region. These records will allow precise correlations and comparisons with other already existing records of this region, and further our understanding of the role of anthropogenic activity on past environmental changes during the late Glacial to early Holocene. Both study sites go back as far as at least the Late Glacial Period providing long sequence records that will place climatic and vegetational changes as well as the human response in the Zagros region within the wider region and context, while appreciating local differences across Southwest Asia. These are of major significance as recent published research is on sequences that only date to the Mid to Late Holocene (Brisset *et al.* 2019).

Additionally, new speleothem research is being conducted on samples from Iraqi Kurdistan including Shalaii Cave to help better understand the palaeoclimate and environment of the central Zagros, in collaboration with the University of Reading, the University of Basel, University College

London and other institutions. Although none of the current available and published results cover the late Pleistocene–early Holocene transitional period, new speleothem studies have demonstrated their potential to improve our understanding of past hydrological changes in northeast Iraq. For example, Flohr *et al.* (2017) were able to use a speleothem from Gejkar Cave in Iraqi Kurdistan, collected in collaboration with CZAP, to show increasing aridity over the last 1000 years. Following this, Marsh *et al.* (2018) and Amin *et al.* (2019) examined two speleothems from Shalaii Cave, revealing evidence of hydrological change covering time periods of AD 938±42 to AD 1456±29 and 6075 BC±38 to 5027±219 years BC. The new samples that span the late Pleistocene to early Holocene, partly facilitated by CZAP, will add significantly to the issues discussed in this chapter.

Conclusions

Providing an accurate palaeoclimatic and paleoenvironmental context for the Neolithic transition in the EFC is essential if we are to fully comprehend human-environmental relationships and the causal mechanism behind societal transformations. Based on existing palaeoenvironmental evidence from lake sediments in the central Zagros there are clear indications of significant palaeoclimate changes during the last deglaciation and early Holocene. The end of the last glacial was a period of cold temperatures and extreme aridity in which steppe vegetation dominated the environment. These conditions prevailed until the beginning of the Holocene, when there was a transition to warmer and wetter conditions, albeit slower than in other regions, with an increase in grass and pistachio woodland and a reduction of steppe species.

However, there are still a number of important questions that need to be answered. Perhaps the most notable is an explanation for the 'early Holocene precipitation paradox', the discrepancy between pollen and isotopic values from Iranian lake records. There is extensive discussion in the literature attempting to answer the problem, but a consensus is yet to be reached (Roberts 2002; Jones and Roberts 2008; Djamali *et al.* 2010; Schmidt *et al.* 2011; Roberts *et al.* 2018). Until this issue is resolved we will be unable to come to a full understanding of environmental conditions in the central Zagros during the early Holocene. The aim therefore in this and future research by the University of Reading and collaborators is to collect and analyse samples from the region close to key Neolithic sites to study micro-climate and -environment. As part of this project, speleothems from Iraqi Kurdistan and lake sediments from Iraqi Kurdistan and Iran are currently being analysed, as well as cores in the vicinity of the Neolithic site and major spring at Bestansur (Chapter 6).

This chapter has also demonstrated the over reliance on lake records from Iran for our current understanding of palaeoenvironmental change in the Iraqi Zagros. These records suffer from large age uncertainties due to the limitations of dating methods and scarcity of dateable material at the time of the original analyses. Furthermore, the sampling resolution of these records only allows for long term trends to be identified. Finally, the location of these records on the eastern side of the Zagros mountain chain suggests that these lakes could be under the influence of different local and regional climate dynamics than those on the western side of the Zagros because of orographic effects.

The ongoing investigation of these new multi-proxy archives from lakes and speleothems from the Iraqi and Iranian Zagros are key to attempt to answer both of these problems and are being conducted in collaboration with CZAP. Speleothems from Iraqi Kurdistan have recently shown their ability to produce precisely dated and highly resolved palaeoclimate records to answer outstanding questions and fill spatial and temporal gaps in this region (Flohr *et al.* 2017; Marsh *et al.* 2018). A team from the University of Reading and the University of Basel are currently attempting to build on this work and utilise speleothems from Iraqi Kurdistan to investigate conditions during the early Holocene. This new lake record and speleothem data from close to key Neolithic sites will provide key insight into local and regional micro-climatic and -environmental variation, which this critical review has shown is highly variable in the Zagros and key to understanding local and regional strategies during the transition to more sedentary farming lifeways in this core zone in the EFC.

4. INTENSIVE FIELD SURVEY IN THE ZARZI REGION

Roger Matthews, Wendy Matthews, Amy Richardson and Kamal Raeuf Aziz

Research aims and context

The CZAP team conducted a short season of intensive field survey in January 2013, in the region of Zarzi, the type site for the Epipalaeolithic lithic industries of the Eastern Fertile Crescent (Wahida 1981).The cave or rock shelter site of Zarzi is located approximately halfway between the two Neolithic sites of Bestansur and Shimshara (Fig. 4.1). The survey included systematic, intensive field-walking in transects in order to search for archaeological sites, including isolated single finds. The emphasis of the survey was on early prehistoric issues with the particular aim to identify sites of Late Pleistocene and Early Holocene date that would be approximately contemporary with the project's research focus on the transition from hunter-forager to farmer-herder in the Early Neolithic period, *c*. 10,000–7000 BC. The project permit issued by the Directorates of Antiquities and Heritage in Erbil and Sulaimaniyah allows for archaeological survey by the CZAP team in a region 15 × 15km, with the Chemi Tabin valley of Zarzi located in the north of the survey region (Fig. 4.2).

We also undertook initial exploration of appropriate cave sites, in particular with the aim to identify potential candidates for speleothem analysis in order to contribute new evidence for research into the past climate of the region, including the interaction between changes in climate and human ecology and social interactions during the Late Pleistocene and Early Holocene (Chapter 3).

The region of Zarzi and the Chemi Tabin valley was chosen for intensive survey partly because of the important discoveries made at Zarzi cave, where an Epipalaeolithic sequence was excavated in the 1920s and 1980s (see below; Garrod 1930; Wahida 1981). Wahida argued that there were likely to be seasonally occupied open-air sites within the vicinity of Zarzi cave given climatic amelioration after the Late Glacial Maximum and during the Bølling–Allerød interstadial in particular. Through intensive survey of the environs of Zarzi we aimed to situate the Epipalaeolithic occupation of the cave within a wider landscape context, and to investigate the possibility of there being archaeological sites in this valley and its adjacent region which span the transition from the Epipalaeolithic into the Early Neolithic.

Methodology: systematic intensive field-walking

Archaeological surveys in Iraq have generally focused on readily identifiable components in the landscape such as tells, route-ways and rock-cut sites, employing what may be called an extensive survey methodology. There has so far been little use in Iraq of systematic, intensive field survey techniques that have been developed in Mediterranean archaeology and frequently applied in landscape research projects in countries such as Italy, Greece, Bulgaria and, occasionally, Turkey (Matthews and Glatz 2009). Only with the application of systematic, intensive techniques can truly representative quantities and types of archaeological material be recovered and adequate emphasis given to less obvious features in the archaeological landscape such as lithic scatters or small rural or camp sites. It is essential to employ a methodology appropriate to the discovery and recording of small-scale early prehistoric sites, as otherwise sites of this date are likely to be under-represented and may lie buried below alluvium or

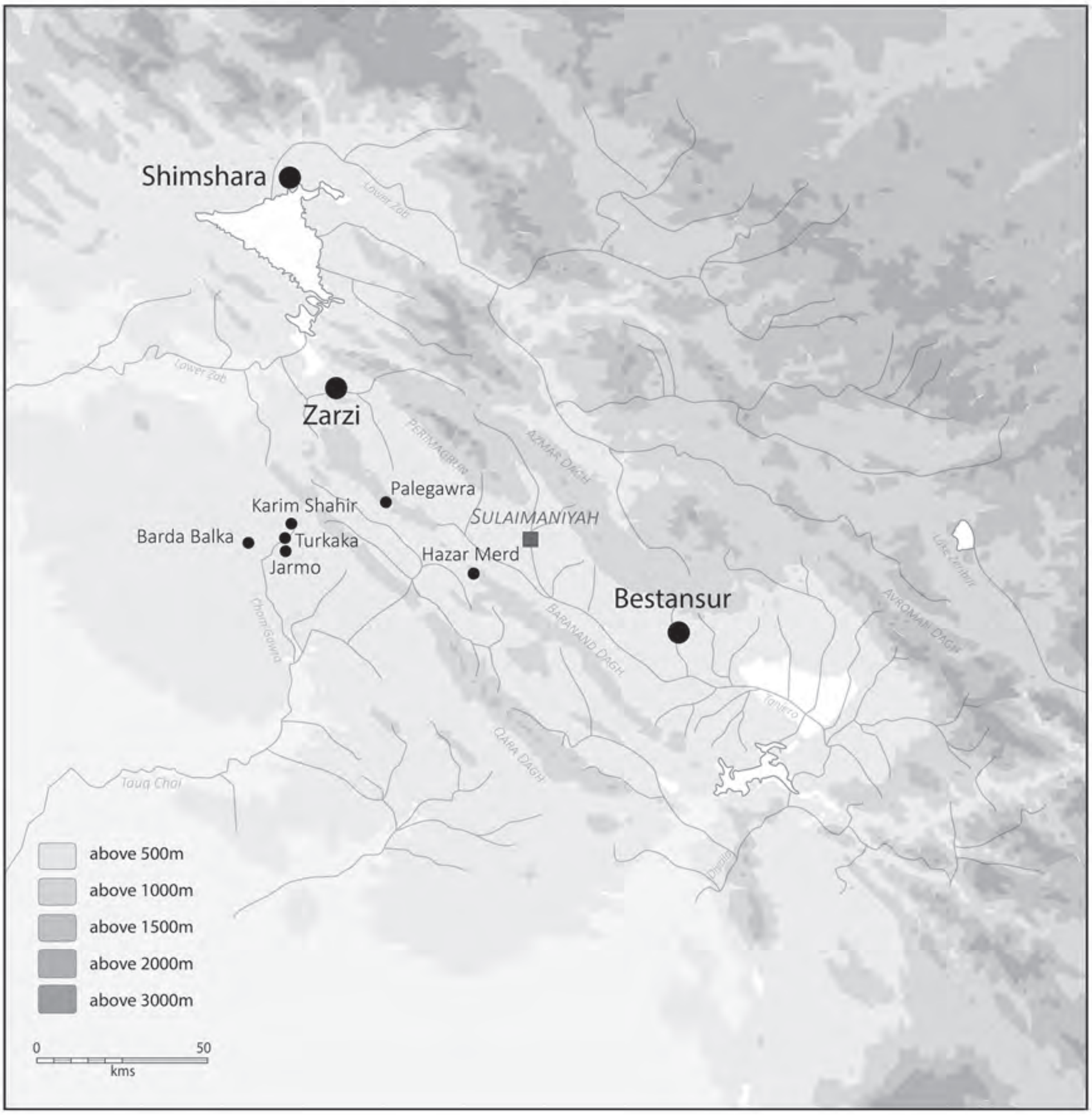


Figure 4.1. Location of Zarzi in relation to Bestansur and Shimshara.

colluvium. The potential for intensive field survey in the region, however, has been highlighted by the results from Palaeolithic-focused survey along the Tigris valley north of Mosul, for example, which detected no fewer than 22 small-scale Lower Palaeolithic sites in an area of 15km^2, including spreads of hand-axes and chopping tools (Inizan 1985; Mazurowski 1987). A similarly intensive foot survey in western Kermanshah province in Iran, close to the border of Iraq, identified large numbers of Upper Palaeolithic and Epipalaeolithic sites, the latter with lithics in the Zarzian tradition (Biglari and Shidrang 2016).

During the January 2013 Zarzi survey season, a total of ten transects, each 2.5km long, was walked in three major zones, with a consistent team of six members walking at 20m intervals, thus covering a breadth of 100m (Figs 4.3–4.5). Survey zones and transects within the zones were not randomly chosen but were selected on the basis of a range of factors, including type of landscape, nature of local resources, and proximity to known archaeological sites. We carried out the survey in winter as the ground vegetation cover is low at this time of year and thus visibility of artefacts and cultural debris on the ground is high. Weather conditions, however, were mixed and on occasion stormy, but there was no snow cover and we were able to walk transects for three full days and to conduct cave survey for two further days. We will conduct further periods of survey in the Zarzi region in future seasons in accordance with the CZAP permit, to build on the important sites discovered here.

The location of the three survey zones is indicated on the map, Figure 4.2. Within these zones ten transects were walked (Zone A: Transects 1–6; Zone B: Transects 7–9; Zone C: Transect 10). The priority was to survey along the major river valleys of the

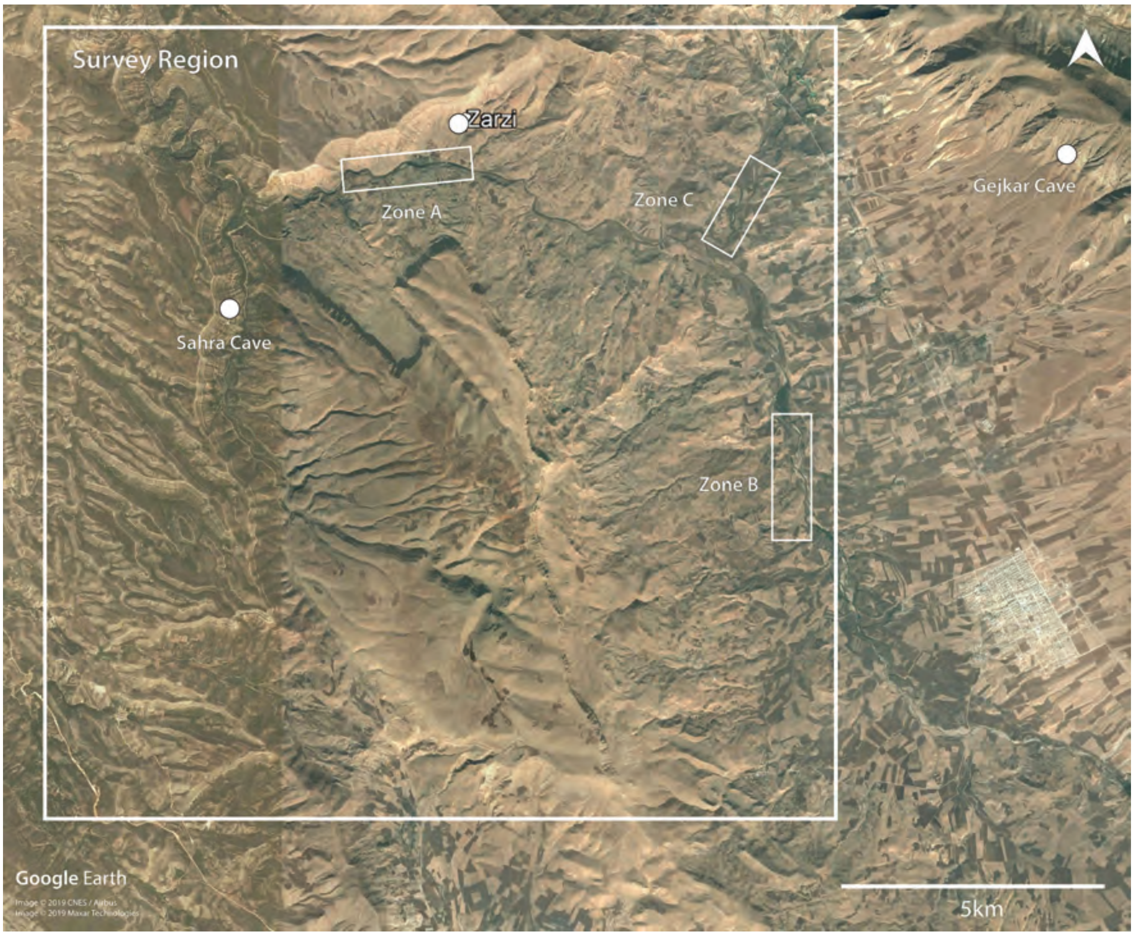


Figure 4.2. 15 × 15km extent of CZAP Zarzi survey region, showing location of intensive survey zones and visited caves.

Figure 4.3. Intensive field-walking in Zone A, below Qizkapan Iron Age rock-cut site (top left).

Figure 4.4. Intensive field-walking in Zone B.

Figure 4.5. Intensive field-walking in Zone C.

Table 4.1. Archaeological sites investigated during the Zarzi survey.

Zone/Transect	*Site*	*Name*	*Material*	*Dating*
A	ZS1	Zarzi cave	Lithics	Epipalaeolithic ('Zarzian')
A	ZS2	Zarzi slopes	Lithics	Epipalaeolithic ('Zarzian')
A/3	ZS3	None	Lithics	Epipalaeolithic ('Zarzian')
A/1	ZS4	Holina	Lithics	?
C/10	ZS5	None	Hand-axe	Lower Palaeolithic ('Barda Balkan')
C/10	ZS6	None	Lithics, pottery	Chalcolithic/Early Bronze Age

region, walking on the terraces parallel with the river courses, as these are prime locations for sites close to water sources and above the flood zone. In total, six archaeological sites were located and investigated during the survey, as summarised in Table 4.1. Each site was assigned a site code and details of the location and extent recorded. The identified sites are discussed below within their chronological contexts. Given the low quantities of cultural materials encountered on these sites, we collected 100% of finds from the surface of all detected sites. All finds from the survey are stored in the dedicated CZAP store within Sulaimaniyah Directorate of Antiquities.

Results

A Lower Palaeolithic find

In the context of Palaeolithic research, one of the most significant sites is the bifacial Acheulian hand-axe find at ZS5 in Zone C, Transect 10 (Figs 4.6–4.7), at a location 725m above sea level on an eroded terrace of a small stream near its confluence with the Chemi Tabin (Figs 4.8–4.9). The site appears to consist of a single hand-axe, perhaps discarded after use or re-deposited from elsewhere by natural agencies. We could not find any associated lithic material in the vicinity. The hand-axe has excellent parallels with material excavated at the Lower-Middle Palaeolithic site of Barda Balka (Wright and Howe 1951; Braidwood and Howe 1960; Howe 2014: pls 9–11), located only 25km to the south-southwest at an altitude of 740m above sea level, as well as dispersed artefact scatters in the region of Barda Balka and Jarmo (Braidwood and Howe 1960: 62). While difficult to date precisely, Rowan's recent reassessment of Howe's original dating estimation suggests that Barda Balka, and therefore the hand-axe from ZS5, must be dated to *c*. 250,000 BP or earlier and that upland sites such as Barda Balka, Shanidar and Hazar Merd represent summer camps for seasonally mobile hunter-gatherers during the Lower and Middle Palaeolithic (Rowan 2014: ix–xi). Archaeological surveys in the Iranian high Zagros to the southeast and east have recovered evidence for a significant Lower Palaeolithic presence, although no sites of this date have been excavated (Biglari and Shidrang 2006; Conard *et al*. 2013; Heydari-Guran 2014).

Faunal remains from Barda Balka (Fraser 1953; Howe 2014: 22) give a unique insight into the ecology of the lower Zagros region during this far-distant time, with evidence for Indian elephant, rhinoceros, large cattle, sheep or goat and, most commonly, a type of equid which may be onager. It is likely that many of these species were hunted or scavenged at these small, dispersed sites by hominin groups, who we cannot identify to species due to the absence of physical anthropological remains. Intriguingly, edible land snails, *Helix salomonica*, also occur amongst the Barda Balka deposits but it is not clear whether they were used as a food resource at that date. The solo find of an Acheulian hand-axe at site ZS5 adds important knowledge to our sparse understanding of the distribution and extent of Lower Palaeolithic activity in this region of Southwest Asia.

The Epipalaeolithic of the region and Zarzi cave

We located a highly significant Epipalaeolithic site at ZS3 in Zone A, Transect 3. ZS3 is a flat open site located on a spur overlooking the Chemi Tabin river and situated within line of sight of Zarzi cave, across the river exactly 1km to the northeast (Fig. 4.10). Site ZS3 consists of a dispersed scatter of chipped stone materials over an area of *c*. 50 × 50m (Fig. 4.11), as well as a large boulder of limestone with three cup hollows (Fig. 4.12) and a small number of ground-stone implements (Fig. 4.13). The chipped stone material compares well with Epipalaeolithic assemblages excavated at Zarzi cave, including small blades and burin facets (Wahida 1981; 1999). The distinctive cup-holed limestone boulder has good parallels at Late Pleistocene Natufian sites in the WFC (Terradas *et al*. 2013: 56–57), where they are associated with an intensification of food production involving grinding and pounding of grass seeds and nuts such as acorns using hand-held pestles (Nadel *et al*. 2009). Similarly, at ninth millennium BC Pınarbaşı in central Anatolia, limestone bedrock mortars may have been used for pounding of almond and terebinth nuts, common in

Figure 4.6. Lower Palaeolithic hand-axe at site ZS5. Scale: 25cm.

Figure 4.7. Lower Palaeolithic hand-axe from site ZS5. Scale: 10cm.

Figure 4.8. Terrace location of site ZS5, looking northeast.

the archaeobotanical evidence from the site (Baird 2012: 195).

The presence of the cup-hollow boulder at site ZS3 indicates that significant time and energy were invested by the Epipalaeolithic community at the site, firstly in hollowing out the 10–12cm-deep holes in the boulder surface and secondly in repeated use of the boulder over a lengthy period of time, probably for processing of plants or nuts and/or pigments such as ochre as identified at other sites of this period (Nadel *et al*. 2009). This investment in turn suggests a long-term, if episodic, attachment to place shaped by seasonal availability of valued resources. If associated with acorn or almond processing, the cup-holed boulder fits with evidence for an increase in oak and almond trees in the region during the last centuries of the Late Pleistocene, as attested at Zarzi and Palegawra caves.

We interpret site ZS3 as a small open-air site of hunter-foragers. We will excavate this site in the next phase of the project in order to establish whether there are traces of architecture, and to investigate the nature and duration of activities on this advantageous knoll overlooking the Chemi Tabin river below. Open-air sites of this period are extremely difficult to locate, being small, low and with dispersed surface remains, and they can only be detected using intensive survey methods. Site ZS3 is the first open-air (non-cave or rock shelter) Epipalaeolithic site identified in this region since Braidwood's 1951 discovery of the sites of Turkaka and Kowri Khan on the Chemchemal Plain 25km south-southwest of Zarzi (Braidwood and Howe 1960, 55–57; Wahida 1999: 187–188). The discovery of site ZS3 allows us to contextualise the earlier excavations at the famous site of Zarzi cave.

Zarzi cave is located at 760m above sea level within a grand natural amphitheatre created by erosion of the rock massif to the north and west of the site (Figs 4.14–4.15). The cave is modest in size, 2.25m high, 7m deep and 10m wide at its mouth, commanding a panoramic view southwards across the fertile valley below (Fig. 4.16). Zarzi was excavated by Dorothy Garrod in 1928 (Garrod 1930) and by Ghanim Wahida in 1971 (Wahida 1981; 1999). The chipped stone assemblage from the cave defines a distinctive Epipalaeolithic tradition, named as the Zarzian after Garrod's initial excavations, and characterised by small blade-based tools including notched and denticulated blades, scrapers and burins. Geometric microliths are mainly found in the upper levels and the industry is almost entirely chert based with only two fragments of obsidian, both from the Nemrut Dağ source in eastern Anatolia (Renfrew *et al*. 1966: 42; Barge *et al*. 2018; Frahm and Tryon 2018).

Figure 4.9. Zarzi survey, Zone C, Transect 10.

There are no radiocarbon dates but the stone tool typology places the site between 14,000 and 11,000 BC, with evidence for a long duration of episodic use of the cave. During our survey we noted a dispersed distribution of Zarzian lithics on the slopes directly below the cave mouth (Fig. 4.17), possibly washed down from the excavation spoil heaps, which we designated as site ZS2.

The evidence for human presence in the central Zagros region from *c*. 14,000 BC provided by excavations at cave sites, including Zarzi, brings to an end a 10,000-year hiatus in evidence for any human activity in Iraqi Kurdistan. Between the end of the Upper Palaeolithic, as dated at Shanidar level C to *c*. 25,000 BC (Solecki and Solecki 1983), and the earliest dated Epipalaeolithic evidence from the cave sites of Zarzi, Palegawra and Shanidar level B2, at *c*. 15,000 BC, there are as yet no detected cave or open-air sites at all (Matthews 2000: 24–29). The apparent absence of significant, or any, human presence in this elevated region for the millennia between 25,000 and 15,000 BC can be associated with the onset and peak of the Würm Pleniglacial, characterised in this region by extreme dryness, coldness and a lowering of the snow line, as supported by analysis of the pollen record from Lake Zeribar (Bottema and van Zeist 1981).

Figure 4.10. The Epipalaeolithic site of ZS3 in the foreground. Arrow indicates Zarzi cave.

Figure 4.11. Chipped stone artefacts from site ZS3. Scale: 10cm.

Figure 4.12. Boulder with cupholes from site ZS3. Scale: 25cm.

Figure 4.13. Ground-stone polisher or rubber from site ZS3. Scale: 10cm.

Figure 4.14. Location of Zarzi cave within a natural amphitheatre, looking northeast. Arrow indicates Zarzi cave.

Figure 4.15. Zarzi cave, centre, looking north.

Figure 4.16. View from mouth of Zarzi cave, looking southwest. Arrow indicates location of site ZS3, on opposite bank of Chemi Tabin stream.

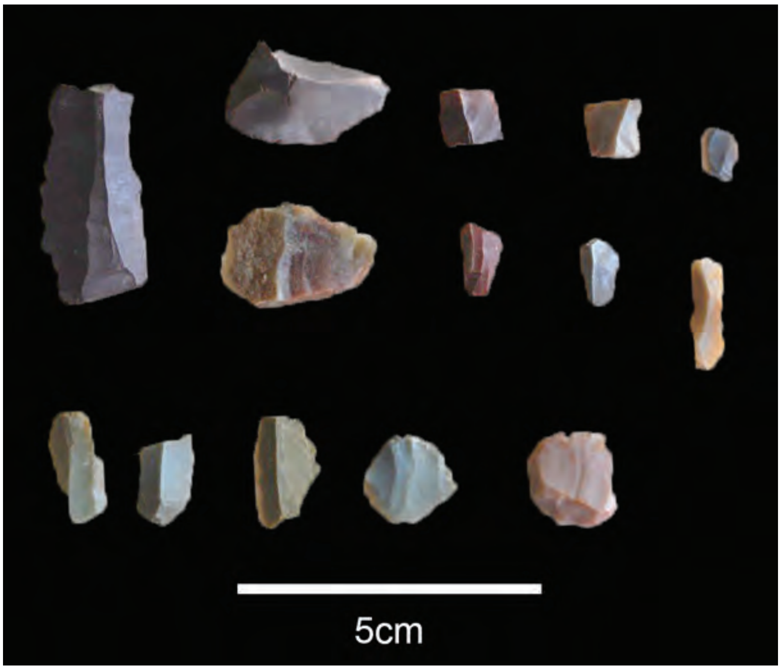


Figure 4.17. Chipped stone items from Zarzi slopes, site ZS2.

Initially, the Epipalaeolithic environment of Zarzi appears to have been steppic and dry, with oak, pine, lilac and almond trees attested only in the latest levels of occupation towards the end of the Pleistocene (Wahida 1999: 194). At about the same time, environmental evidence from the nearby cave site of Palegawra, dated to *c*. 12,500 BC, indicates spread of oak, tamarisk, poplar and conifers (Braidwood and Howe 1960: 59). The valley below Zarzi cave, with its perennial fresh water resources, would have been a major factor in attracting seasonally migrating herds of animals such as gazelle, commonly attested in the

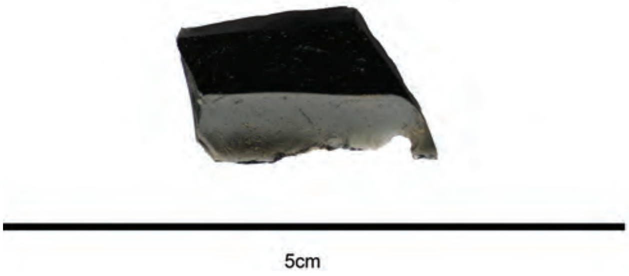


Figure 4.18. Retouched obsidian tool from Transect 9, Zone A. Scale: 5cm.

faunal remains from the cave (Bate 1930), and onager as attested at Palegawra (Turnbull and Reed 1974). The river would have provided a good supply of fish, also well-attested in the Zarzi deposits (Wahida 1999: 190). Edible land snails, *Helix salomonica*, occur in large quantities in the upper levels of Zarzi (Wahida 1999: 194) and Palegawra (Braidwood and Howe 1960: 59), arguably the start of a long local tradition of consumption of this seasonally available food resource (Chapter 17).

Wahida (1981: 31; 1999: 207) argued that cave sites of the region, such as Zarzi, Palegawra and Shanidar, should be viewed as only one component of multi-sited habitation of an extensive landscape, whereby hunter-foragers made use of food and other resources according to seasonal availability and to long-standing cultural traditions. Within this model, he argued that there should be open-air sites contemporary with the cave occupations, and that they would only be located through programmes of intensive field survey. Prior to our survey, the only known Epipalaeolithic open-air sites in Iraqi Kurdistan were Turkaka and Kowri Khan on the Chemchemal plain, which Braidwood and Howe (1960: 55–57) theorised as possible habitation components in a seasonally structured way of living using both caves and open-air sites. More recent regional survey in northwestern Sulaimaniyah province (Van Ess and Luciani 2015) focused on known mounded sites and did not locate occupation earlier than Late Neolithic, as is also the case with the Shahrizor Survey Project (Altaweel *et al*. 2012: 20). The new evidence from site ZS3 provisionally confirms the hypothesis of Braidwood and Howe and Wahida that Epipalaeolithic groups of this region moved between cave and open-air sites perhaps in seasonal or longer-term patterns of mobility, maximising their opportunities for hunting and gathering of a wide range of plant and animal resources. Pending excavation, site ZS3 may be comparable to the Late Epipalaeolithic open-air occupation at Zawi Chemi Shanidar, at a similar altitude on the banks of the Greater Zab, at 425m above sea level, where boulder mortars were also found (Solecki 1981).

Other than sites ZS5 and ZS3, finds from the intensive survey transects included small quantities of isolated finds of sherds, ground-stone, chert and obsidian artefacts, including a single retouched obsidian blade in Transect 9 of Zone A, which could have served as a barb on an arrow fired at moving prey in this upland landscape, possibly during the Neolithic period (Fig. 4.18). Impact damage along the retouched edge suggests that this arrow hit its target (or a nearby solid object). The small mounded site of ZS6 in transect C/10 (Fig. 4.9) yielded a small scatter of lithics and sherds of Chalcolithic and Early Bronze Age date, while on the mound at Holina, site ZS4 in transect A/1, a single piece of worked obsidian was found. Portable x-ray fluorescence analysis of the Holina obsidian confirms the material's origin as the east Anatolian Nemrut Dağ source.

We did not locate sites of definite Neolithic date during the survey and, although we sampled only three small sub-regions of the survey area (Fig. 4.2), taken in conjunction with earlier survey work in the area, in particular the Van Ess-Luciani 2011–13 survey (Van Ess and Luciani 2015), we can at least state that the Epipalaeolithic and Early Neolithic occupation of this region of Sulaimaniyah province is sparse, at most. At present, we know of no sites in this region that fall within the period *c*. 11,000 to 6000 BC, but much further work remains to be carried out.

Cave survey

Initial visits were made to two major caves of the region (Fig. 4.2), within an ongoing programme of palaeoclimate research through analysis of speleothems (Chapter 3). To the east of the survey region, Gejkar cave (Fig. 4.19) was visited and a speleothem sample collected for analysis (Chapters 3, 24; Flohr *et al*. 2017). In the west of the survey region, Sahra cave (Fig. 4.20) was visited and was found not to contain suitable material for sampling. Other caves in the region will be visited in future field activities along with further intensive survey in this key region for integrated palaeoclimatic, geomorphological and archaeological investigations, including targeted excavation, to investigate further the important early prehistory of this region.

Figure 4.19. Entrance to Gejkar cave.

Figure 4.20. Approach to Sahra cave.

5. FLUXGATE GRADIOMETRY SURVEY AT BESTANSUR

David Thornley

Introduction: aims and approaches

A geophysical survey at Bestansur was undertaken to investigate the possible presence of sub-surface traces of structures, features and alignments, in particular in the fields surrounding the mound at Bestansur. We hoped to detect traces of possible Neolithic buildings and features, as well as wall alignments that might relate to the spreads of Iron Age and later pottery recovered from the ploughed fields around the mound.

A Bartington Grad 601-2 dual fluxgate gradiometer was used for the survey, conducted by David Thornley and William Owen over six days in August-September 2012 (Fig. 5.1). Fluxgate gradiometry was used to record magnetic anomalies associated with both natural and human-made features beneath the ground surface. The depth of investigation for the Bartington gradiometer is generally considered to be up to 1.5m. The surface of the mound itself was not surveyed due to the depth of deposits and extensive modern activity.

Features such as mudbrick walls, pits, ditches, fire installations and materials such as ceramics and metals all have magnetic fields of different strengths which create distortions in the earth's magnetic field just above the surface of the ground. The magnitude of these distortions can be measured using the gradiometer and are seen as a contrast in magnetic signature between the feature or material and its surrounding matrix. Stone or limestone walls may also be recognised as they often have a magnetic signature that is less than the surrounding matrix.

Figure 5.1. Fluxgate gradiometry survey over the area southeast of the mound.

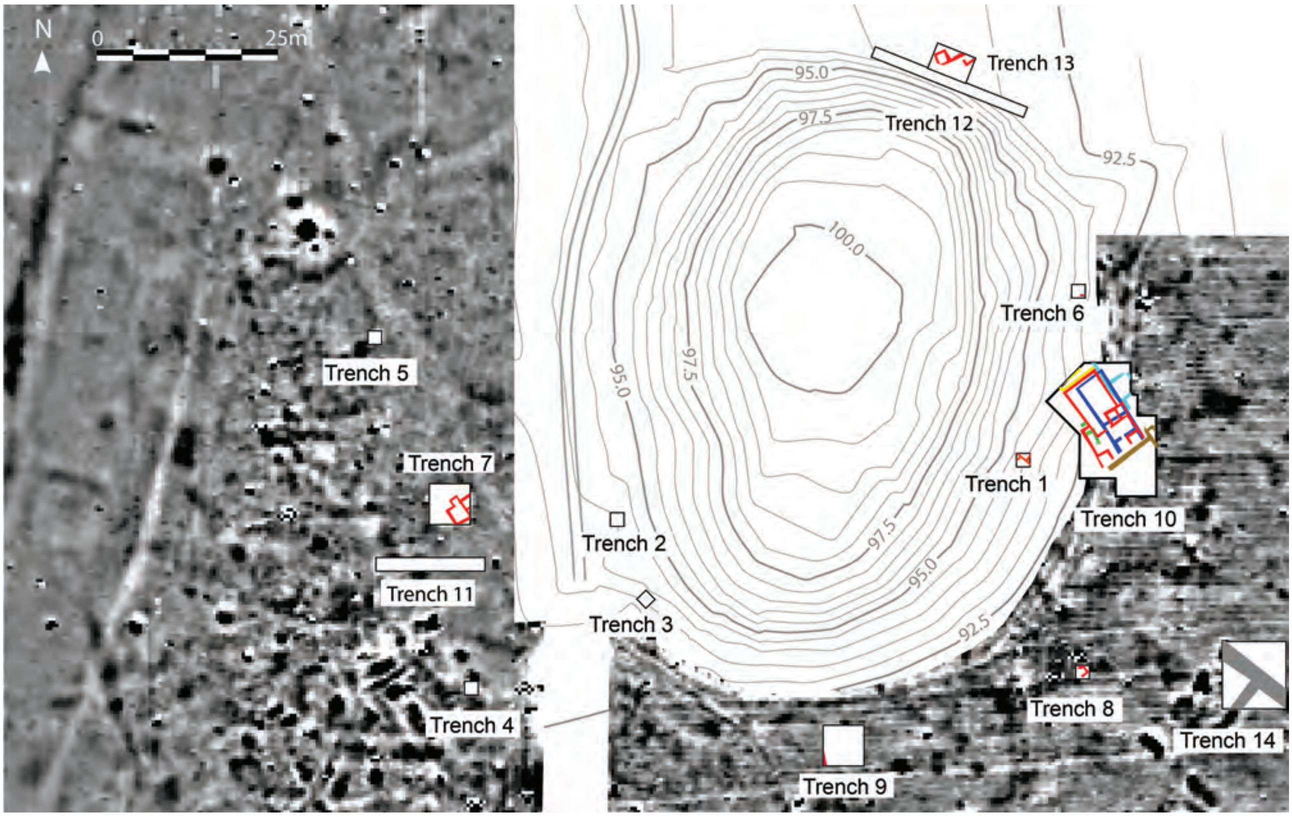


Figure 5.2. Results of the fluxgate gradiometer survey with site elevations and location of trenches.

Areas of burning caused by lighting of fires or fire installations can also have an enhanced magnetic signature (Schmidt 2007).

Methodology

The grid system

The gradiometry was carried out using a system of 30 × 30m grids and partial grids. The whole area to be surveyed was laid out by triangulating the position of the grid corners using tapes and marking these with pegs, which were surveyed in by Ahmed Rasheed Raheem, an expert surveyor from Sulaimaniyah. This enabled us to position the results of the fluxgate gradiometry survey on to a map of the site, in order to target areas for future excavation.

Survey method, data collection and processing

First the instrument was adjusted to give a reading of 0nT at a fixed location to the northwest of the survey area, where very low readings of magnetic signature were encountered. The data was collected in zig-zag fashion, starting in the northeast corner of each grid. The first traverse was made by walking in a southerly direction then turning at the end of the traverse and walking in a northerly direction and so on. The traverse intervals were 0.5m with the sample intervals along each traverse being 0.25m. Yellow plastic washing lines, fixed at each end with a tent peg, were used as a guide to ensure that each traverse was walked in a straight line. These were moved for each traverse. The post processing techniques used were destagger, zero mean traverse, interpolation and low pass filter.

Summary of results

A grey-scale image of the full fluxgate gradiometry survey, in the range –5nt white to +5nt black, is shown in Figure 5.2, overlain onto a map of the site from total station survey.

One aim in this geophysical survey was to detect mudbrick or pisé walls of Neolithic building structures, fire installations and any pits or refuse and midden areas that may be associated with past human activity. Many large almost circular areas of high magnetic response were detected mainly to the east, southeast and south of the mound (Fig. 5.2). They range in size between 10m and 25m and in some areas they overlap, which may represent enclosures or animal pen areas.

The survey also revealed a large rectilinear building that occupies an area of approximately 50 × 60m, located to the southeast of the mound and associated with ceramics datable to the first millennium BC. Trench 14, measuring 10 × 10m and

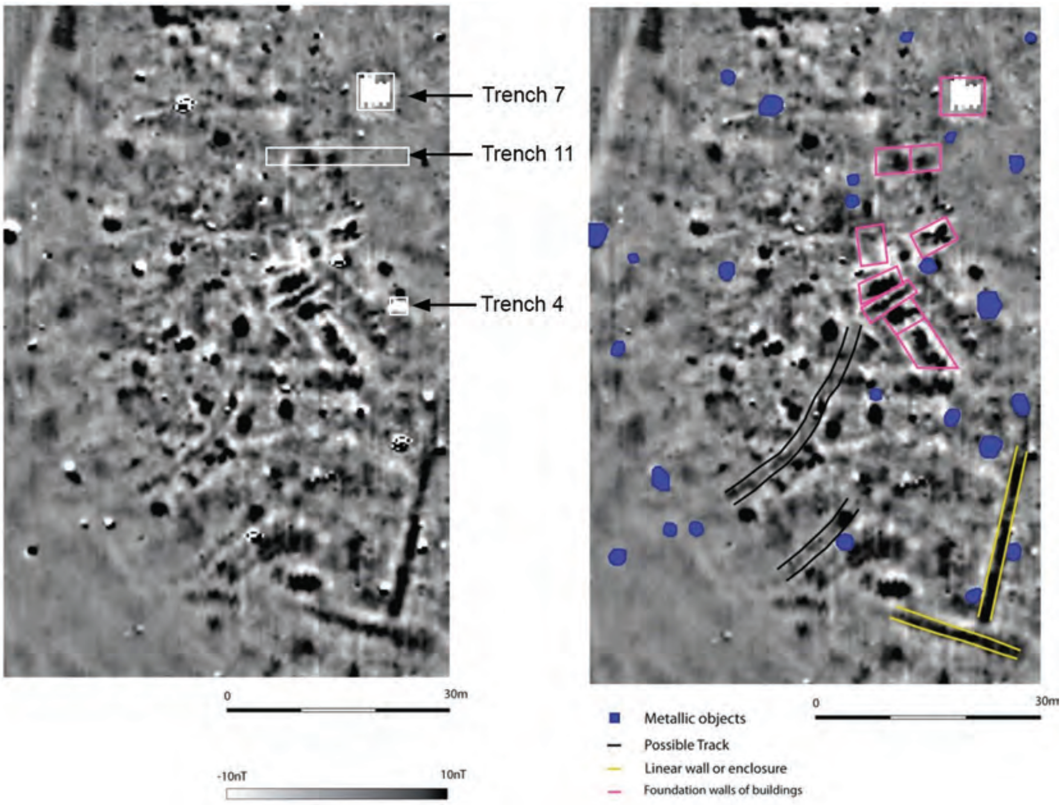


Figure 5.3. Fluxgate gradiometry of the settlement to the southwest of the mound, with interpretation.

located 32m southeast of the mound, was excavated by Lisa Cooper during 2013 in order to investigate this structure and to establish its dating to the Neo-Assyrian period (Cooper *et al.* 2017). Also revealed in the geophysics were rectilinear buildings to the southwest of the mound occupying an area of approximately 50 × 80m, partly bound by wall or ditch enclosures (Fig. 5.2). In some places these buildings appear to be separated by tracks or streets. As yet this area is undated.

Where the survey was conducted near the base of the mound, there was a continuous strip of low magnetic signature that may be associated with the foundation of a boundary wall or drainage ditch. Fluxgate gradiometry also detected plough lines spaced approximately 1m apart as visible in Figure 5.2. As the fluxgate gradiometry has revealed a complex set of data, the evidence and interpretations are analysed separately for five distinctive areas.

Interpretation

Plough lines

In the field to the west of the mound faint plough lines 1m apart were noted, orientated in a north-south direction. These show up weakly on the gradiometry survey. In the field to the south and east of the mound, however, the plough marks are more clearly visible as a series of closely spaced lines, 1m apart. Here they are orientated in an east-west direction, giving readings of +1 to –1 nT.

Settlement to the southwest of the mound with wall or ditch enclosures

A series of buildings was detected by fluxgate gradiometry survey to the southwest of the mound occupying an area of approximately 50 × 80m (Fig. 5.3). There are many dark areas of positive magnetic signature, in the range +20nT to +50nT, which could be interpreted as the floors of buildings. Many of these, but not all, are surrounded by lighter areas of negative magnetic signature in the range –8 to –12nT, which are possibly stone walls or foundations, shown in pink in the interpretation. One structure was investigated and confirmed the presence of stone walls (Trench 11, Chapter 9). Dark areas of positive magnetic signature that are not surrounded by an area of negative magnetic signature could perhaps be associated with pits or middens containing burnt materials.

The magnetic appearance of the buildings is very regular and similar to a set of military barracks, for example, seen in a Roman fort (Schmidt 2007: fig. 5). At Bestansur these are most likely to be buildings of a Neo-Assyrian period or later settlement.

There appear to be two tracks that lead into

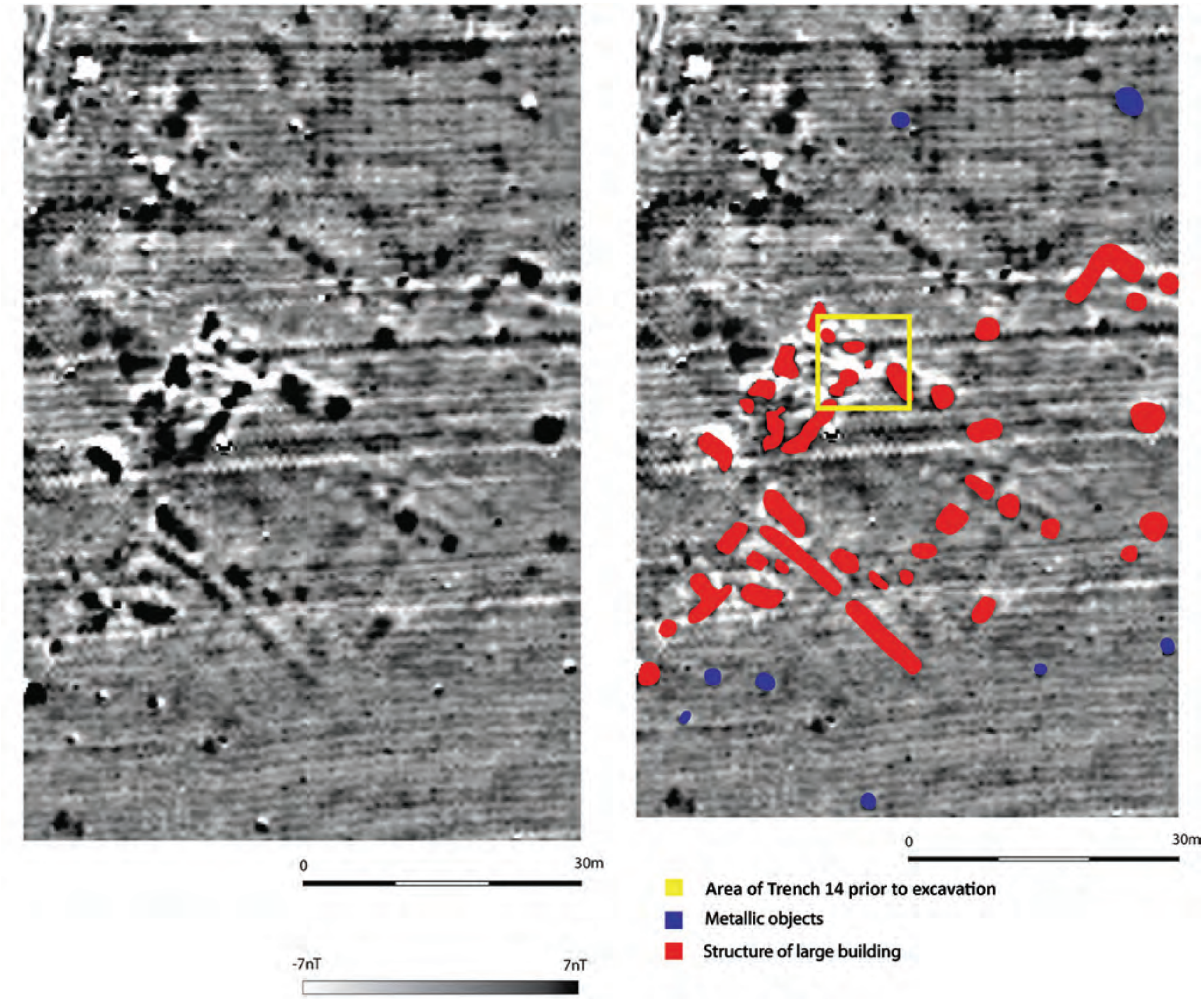


Figure 5.4. Fluxgate gradiometry, with interpretation, of the large rectilinear building to the southeast of the mound, in area later excavated as Trench 14 (Cooper et al. 2018).

the settlement from the west, outlined in black in the interpretation figure (Fig. 5.3). Areas of very high positive magnetic signature associated with an adjacent area of very high negative magnetic signature would normally be indicative of metal objects, here shown in blue. In the southeast corner there are indications of linear walls or enclosures, outlined in yellow.

A building to the southeast of the mound

A large almost rectilinear building complex occupying an area of approximately 50 × 60m was detected to the southeast of the mound (Fig. 5.4). The complex has a clear courtyard within its interior. The darker areas, shown in red in the interpretation, give readings in the range +20nT to +50nT. The main entrance appears to look out in a north-westerly direction towards the mound. The magnetic signature gets steadily weaker towards the southeast but the outline of the building is clearly visible. Excavation of this structure in Trench 14, marked in yellow in Figure 5.4, confirmed the interpretation from surface ceramics that this building dates to the Neo-Assyrian period and was destroyed by fire in the seventh century BC, probably during the Median assault on Assyria in 614-612 BC (Cooper *et al.* 2017).

In the interpretation of the settlement to the southwest of the mound, Figure 5.3, the areas of negative magnetic signature that surround the floors of buildings are shown in pink. However, for interpretation of this southwestern area they have been left as white in Figure 5.4, as it is easier for the eye to see the complexity of this building in this greyscale image.

Comparison of the excavated walls and features in Trench 14 with the magnetic signatures (Fig. 5.5), suggests that the darker areas, highlighted in red in Figure 5.4, represent not the walls of the building but areas of intensive burning perhaps during the

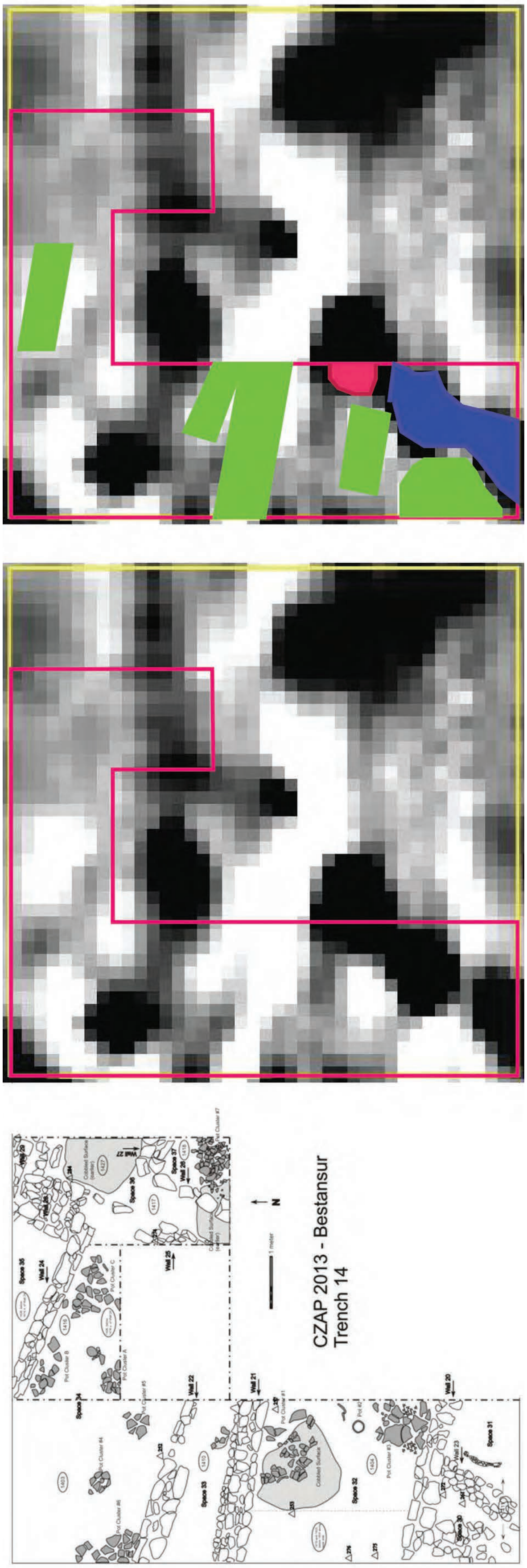


Figure 5.5. Juxtaposition of excavated walls in Trench 14 (left) with results (centre) and interpretation (right) of geophysical prospection.

building's destruction by fire. This is clearly indicated in Figure 5.5 (bottom left) where the excavated walls are indicated in solid green, an area of burnt collapsed pottery in pink and the interior of a room in blue.

There appear to be substantial roughly circular areas of high positive magnetic signature to the north of the building, visible in Figure 5.4, which may represent enclosures or animal pen areas, as they are very large at 10–25m in diameter. There is a possibility that circular anomalies with a diameter closer to 10m may represent Neolithic circular buildings, similar to those at Asiab in highland Iran (Darabi *et al*. 2018), an interpretation to be investigated through future excavation.

The area immediately to the south of the mound

Near the base of the mound there is a continuous strip of low magnetic signature in the range between –6nT to –12nT, indicated in yellow (Fig. 5.6). This gently curving feature, which follows very closely the base of the mound, may perhaps be the foundation of a boundary wall or drainage ditch which could be relatively recent. Geophysical prospection of the Neolithic and multi-period site of Qalat Said Ahmadan on the Peshdar Plain, to the northeast of Shimshara, has detected similar traces of circumvallation of the mound by at least one major stone wall (Tsuneki *et al*. 2015: 41, figs 10.1–10.2).

There is one building similar to that detected in the settlement to the southwest of the mound, with the foundation walls shown in pink in the interpretation figure. Once again there appear to be large-scale broadly circular areas of high positive magnetic signature to the east of this building, which may represent oval ditched structures of an as yet unclear date or nature.

Area to the east of the mound

To the east of the mound there are many obscure circular areas of high positive magnetic signature, some of which appear to overlap (Fig. 5.7). Again, near the base of the mound there is a continuous strip of low magnetic signature in the range between –6nT to –12nT, in yellow in Figure 5.7, probably from the same circumvallation or drainage ditch as illustrated in Figure 5.6. The magnetic signatures show little evidence for the Early Neolithic buildings subsequently identified in this area (Trench 10, Chapter 9).

Area to the west of the mound

To the west of the mound and situated immediately north of the possible settlement, there is a circular feature of approximately 10m diameter (Fig. 5.8).

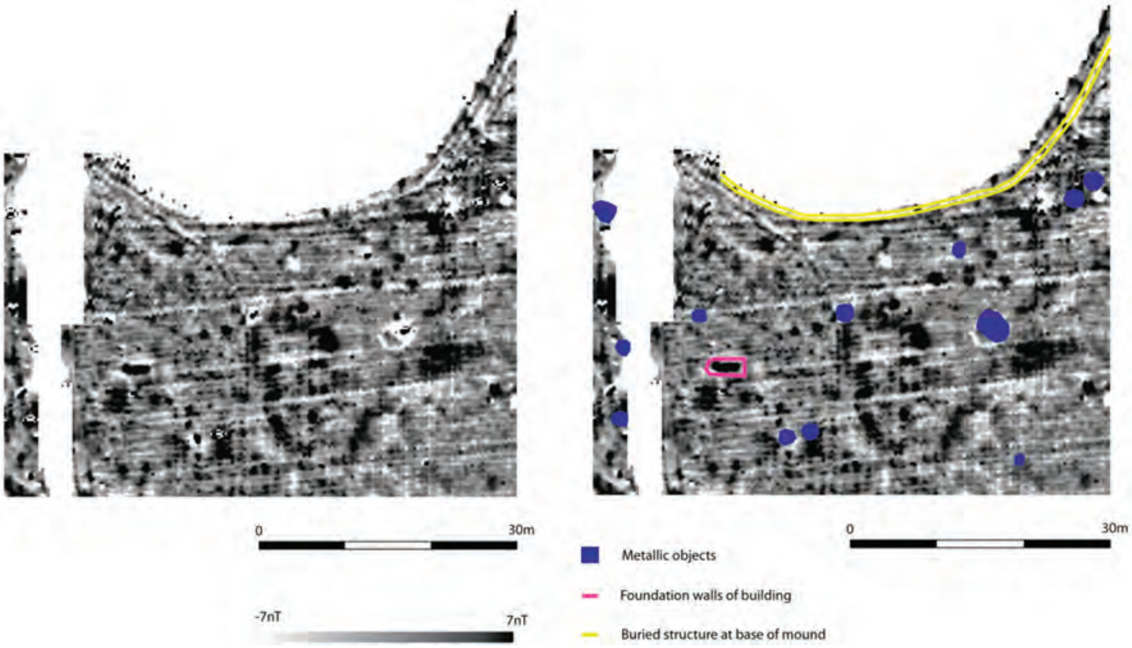


Figure 5.6. Area immediately to the south of the mound, with interpretation.

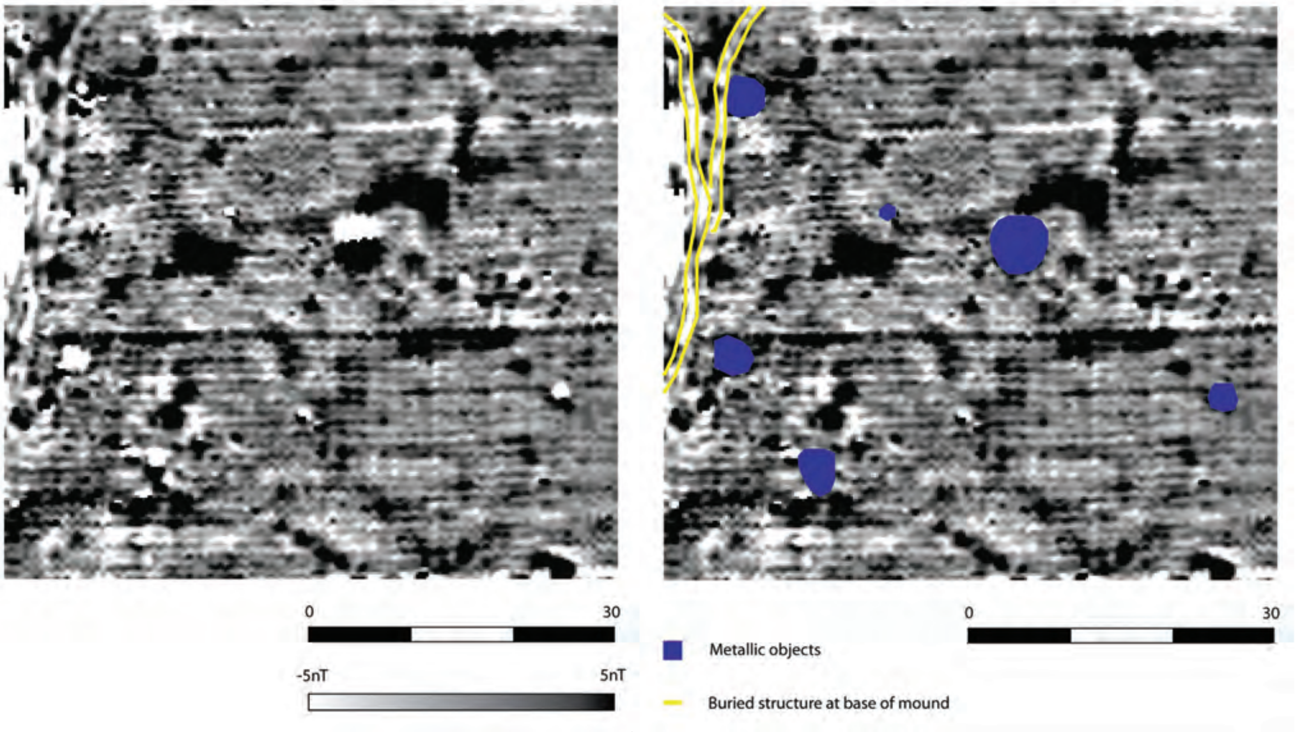


Figure 5.7. Area to the east of the mound, with interpretation.

Within the circular feature, outlined in green, there are regions of high magnetic signature of up to +80nT, which are all enclosed by a halo of negative magnetic signature of –20nT. It is highly likely that this is an area in which burning took place, and it is probable that this was the location of a kiln, perhaps for pottery production.

There are at least four long slightly curving lines, outlined in yellow, of negative magnetic signature –5nT, that appear to converge on this area. Several long linear lines of high magnetic signature +5nT are also shown in orange. These features may be associated with walls or ditches, or even with water courses.

No clear building plans of Neolithic date were detected by the geophysical survey, due to the overburden of colluvium and later period

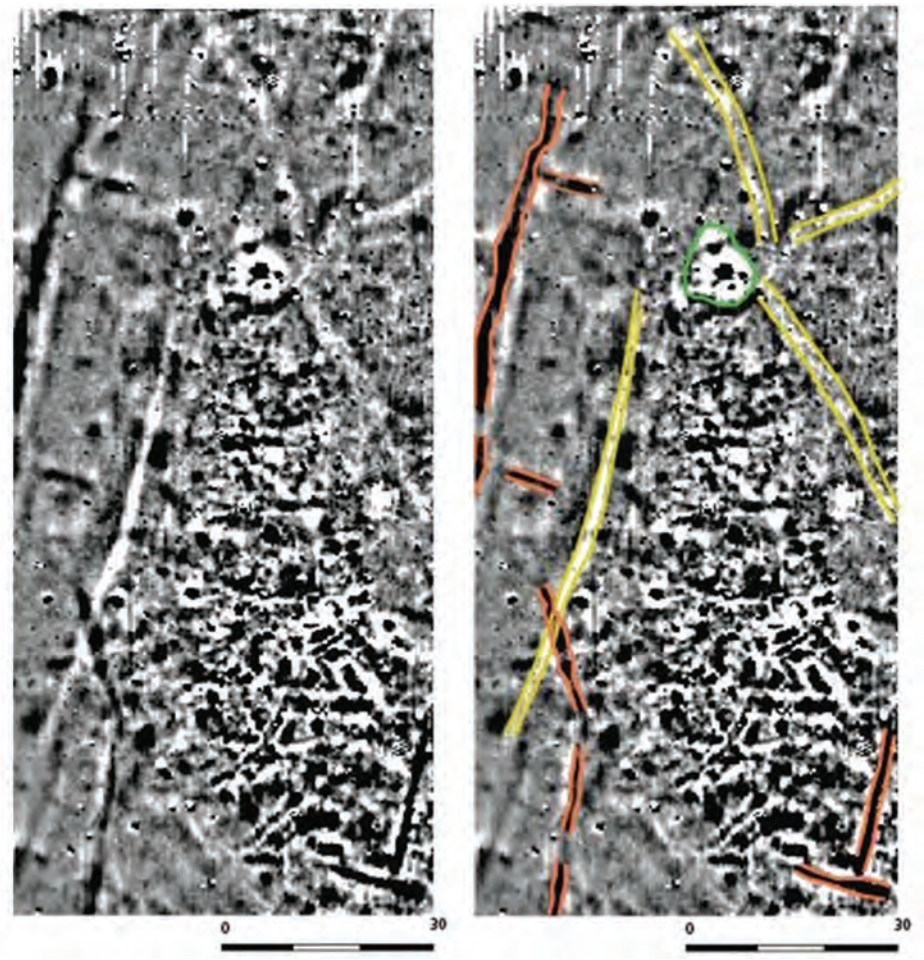


Figure 5.8. Area to the west of the mound, with interpretation.

architecture or cobble and ceramic-rich horizons (Chapter 9). Excavations have revealed that all of the mudbrick architecture from the Neolithic is rectilinear and aligned northwest to southeast. No clear features with this alignment have been detected by geophysical survey in the areas close to the edges of the mound and in the vicinity of excavated trenches which have revealed Neolithic architecture (Fig. 5.2; Chapter 9).

Conclusions and possible future directions

The results of the fluxgate gradiometry survey have been extremely informative in revealing a large well laid-out building to the southeast of the mound and a settlement of several small buildings to the southwest of the mound, which excavations have shown in Trench 14 are of first millennium BC date, of the Neo-Assyrian period. At the base of the mound there appears to be a continuous strip of low magnetic signature that indicates the presence of a possible foundation wall or drainage ditch that surrounds the mound.

To the south and the west of the mound there are several substantial, roughly circular areas of high positive magnetic signature which may be associated with enclosures or animal pen areas, as they are very large at 10–25m in diameter. These features, which may be early in date, do not appear to be present to the east of the mound nor in the area occupied by the large rectilinear building to the southeast.

Long linear strips of positive magnetic signature and slightly curving strips of negative magnetic signature are seen almost exclusively to the west of the mound and these may be foundation walls or ditches or perhaps features associated with water courses. The circular feature immediately to the west of the mound is associated with an area of burning and may be the site of a pottery kiln. The survey has highlighted many extremely interesting sub-surface features but the interpretations given throughout this report can only be substantiated through archaeological excavation, as discussed above.

6. GEOARCHAEOLOGICAL BOREHOLE, SEDIMENT AND MICROFOSSIL ANALYSES AT BESTANSUR

Maria Rabbani, Alessandro Guaggenti, Chris Green, Rob Batchelor and Wendy Matthews

Introduction: aims and objectives

The aim of this research was to conduct pilot investigations into the geoarchaeological context of the mound at Bestansur, in order to:

- investigate the horizontal extent and vertical depth of the Neolithic occupation deposits buried under plough-soil around the visible mound;
- characterise the sedimentary sequences to evaluate the diversity of sediment sources, deposition, post-depositional alterations and preservation conditions;
- recover evidence for the ancient environmental and vegetation regimes in the immediate surroundings of Bestansur.

The site of Bestansur takes the form of a substantial, sharply defined mound rising 7.5–8.0m above the level of the surrounding plain. The eastern edge of the mound is *c*. 100m west of a small perennial stream and the surface of the plain slopes down gently from a level of *c*. 560.48m asl to the west of the mound to *c*. 556.73m asl close to the stream. The stream is entrenched below this level and the alluvial surface adjacent to the stream is between *c*. 544m asl and 548m asl. The surface of the plain is currently used for agricultural land under arable cultivation. In spring 2015 large-scale excavation of the topsoil in the fields to the north of Bestansur was conducted by a fish-farming enterprise to create artificial ponds.

Methodology

Coring

In spring 2014, ten geoarchaeological boreholes were put down, of which nine formed an approximate transect across and around the southern slopes of the mound from BH8 to the west of the mound to BH10 cored through the alluvial surface close to the stream to the east of the mound (Fig. 6.1). Borehole BH5 was put down within Trench 12/13 on the northern edge of the mound. The boreholes were all carried out by hand auger (Fig. 6.2). In the sediments around the mound, gouge and screw augers were used. In the alluvial sediments adjacent to the stream, a Dutch auger (BH10) and a Russian corer (BH11) were used. Augering terminated where it was impossible to advance the auger further by hand, but it is not known whether the auger was obstructed by bedrock or by coarser sediments.

Monolith and micromorphology samples

Four overlapping 0.5m monolith samples (SA1946, SA1947, SA1948, SA2269) were taken from excavated settlement deposits in the southern section of the sounding at the base of Trench 10 on the eastern edge of the mound to provide an important baseline of known sediment characteristics to inform interpretation of sediments recovered from coring (Fig. 6.3). In addition, two micromorphology samples were analysed to characterise occupation and sediment-rich deposits from the same sequence as the monoliths, SA1283 and SA2302 and one from natural sediments at the base of Trench 4, SA447 (Chapter 12).

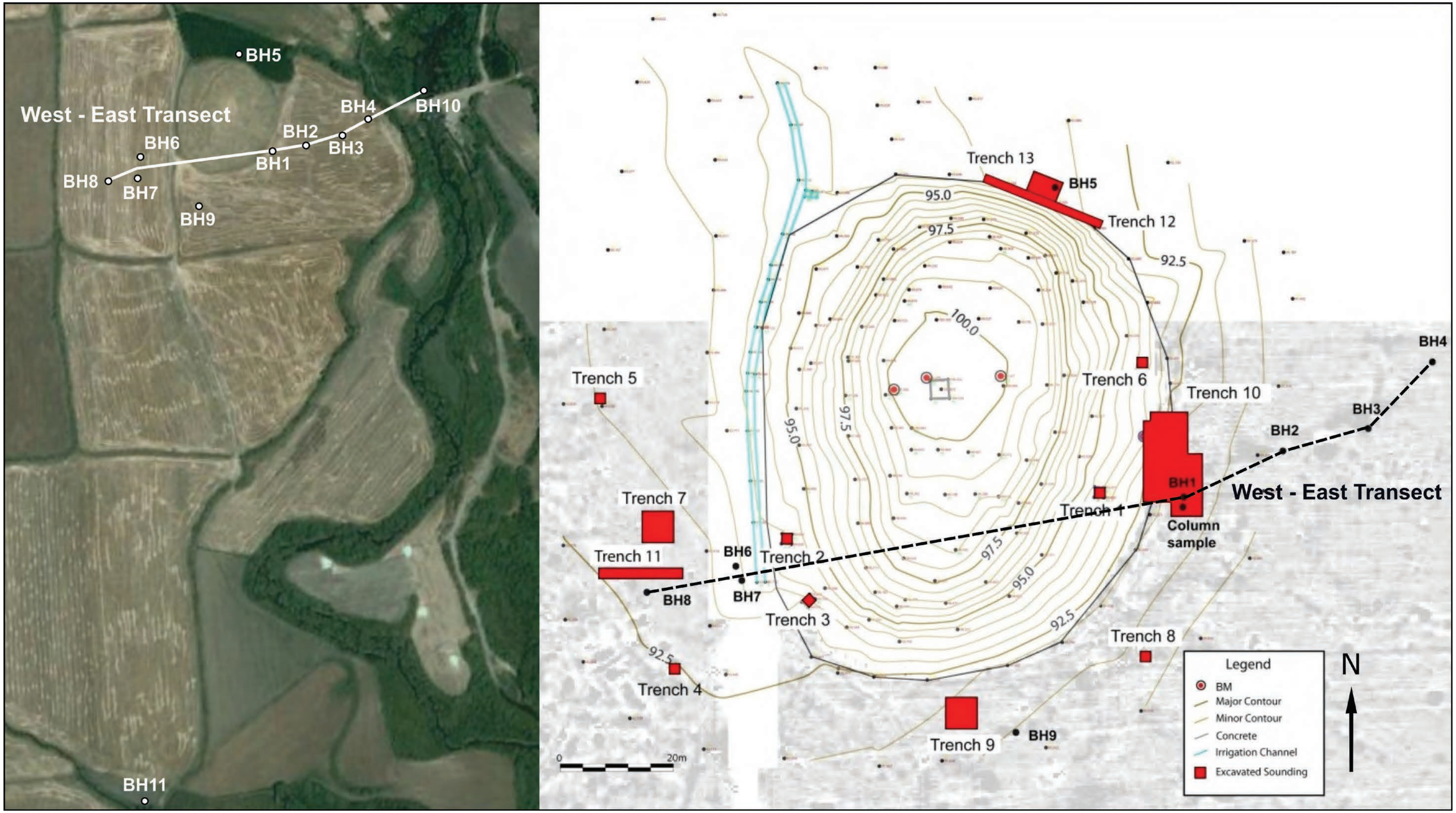


Figure 6.1. Locations of the boreholes and column samples in relation to the mound and archaeological trenches at Bestansur.

Figure 6.2. Coring by hand between the mound of Bestansur and the local stream.

Sediment descriptions

All the samples were returned to the laboratories at the University of Reading for detailed description, sub-sampling and assessment in 2014. Further assessment of the cores in 2019 identified additional units. Due to fragmentation and compression of the cores, the boreholes are represented with approximate depths and illustrated with sediment descriptions (Figs 6.10–6.15). Monolith samples were not looked at during the 2019 re-assessment due to degradation of the samples.

The lithostratigraphy was described using standard procedures for recording unconsolidated and organic sediments, noting colour (Munsell values), textural composition and sorting (gravel, sand, silt, clay), structure (compact, blocky, crumby), organic matter (peat, detrital wood/plant remains), charcoal, archaeological remains (burnt clay, flint debitage, bone) and unit boundaries (sharp, diffuse).

Sedimentary and microfossil analyses

Following detailed examination and description of the samples, three boreholes (BH2, BH9 and BH11) were selected for sub-sampling to determine particle size distribution, and organic matter and calcium carbonate content, and to assess the preservation in the sediments of pollen, non-pollen palynomorphs, phytoliths, diatoms and microcharcoal. The processing of these samples followed standard techniques (Bengtsson and Enell 1986; Battarbee *et al*. 2001; Branch *et al*. 2005) and the microfossils were identified using type collections, keys and photographs (Moore *et al*. 1991; Reille 1992; van Hoeve and Hendrikse 1998; van Geel *et al*. 2003; Doveri 2004; van Geel and Aptroot 2006). The boreholes selected for detailed examination sample the alluvial sediments adjacent to the stream (BH11) and the two deepest sequences (2.60m) from the surface of the plain surrounding the mound (BH2 and BH9).

Spot sub-samples from micromorphology block samples collected prior to impregnation and bulk samples from natural deposits at the base of Trench 4 were subject to particle size, pH, and XRD analyses as part of a wider study to characterise the geochemistry, mineralogy and properties of sediments, architectural materials and occupation deposits at the site in order to evaluate the diversity of sources, deposition, post-depositional alterations and preservation conditions (Chapter 12). Portable XRF analysis was conducted on impregnated resin-slices that mirror the micromorphology thin-sections to characterise the elemental composition of sediments and occupation deposits (Chapter 13).

Figure 6.3. Overlapping monolith samples from Trench 10 sounding. Looking south, scales = 50cm and 25cm.

Results of the sedimentary sequence analysis

In evaluating the core samples, it is important to note that the depth to which the boreholes penetrated was variable due to the hardness of the clay-rich sediments. The borehole depths varied from 0.50m to 2.60m (Fig. 6.4).

The sediments preserved in the core samples from boreholes put down from the surface of the plain surrounding the mound were seen to be relatively uniform in the field, displaying only minor visible variations either between or within samples (Tables 6.1–6.11; Figs 6.4–6.5). The sediments are calcareous and fine-grained, silt-rich with subsidiary sand and clay and scattered and localised small clasts of limestone. Sediment colour is brown or yellowish brown, ranging to dark grey to very dark grey for the spring sediment (Tables 6.1–6.11). It was possible in the laboratory, however, to recognise stratigraphic units within the sediment based on variations of colour and texture and/or the amount of anthropogenic material present. Individual units ranged in thickness from less than 0.01m up to 0.80m with an average thickness of *c.* 0.25m. The presence of common and/or varied material of anthropogenic origin (mainly baked clay and charcoal with occasional pieces of chipped stone debitage) was often associated with slightly darker sediment colour, and units with these characteristics were recorded as 'occupation layers'.

The cores recovered from boreholes put down in the alluvial sediments adjacent to the stream (BH10 and BH11) were distinguished mainly in terms of colour – dark to very dark grey (7.5YR 4/1 to 10YR 3/1 and 7.5YR 3/1) – and by the complete absence of visible anthropogenic material.

From the selected deep sequences through the plain around the mound, in borehole BH2, six 'occupation layers' were identified, with the thickest deposit measuring 0.50m, and in borehole BH9, eleven 'occupation layers' were identified in the re-assessment (Fig. 6.15).

Insights into the stratigraphic sequences in and around the mound and the immediate environs were established by combining the data from these cores and the excavated trenches (Fig. 6.6). These indicate that natural deposits occur at a depth of 1m below the surface (559.57m asl) in Trench 4 to the south-west of the mound, and at a depth of 1.82m (559.85m asl) in Trench 5 to the west of the mound. According to the re-assessment, natural deposits were also reached in BH4, to the east of the mound, at a depth of 1.25m (555.72m asl).

To the south of the mound, Neolithic sediments were encountered 0.20m below the surface, measuring >0.04m thick in Trench 9, and 0.50m below surface measuring >0.02m thick in Trench 8. The deposit overlying the Neolithic is *c.* 0.20–2m thick off the mound. Iron Age and later deposits occur at depths of >0.35m. Topsoil is *c.* 0.25m deep to the south of the mound. This corresponds with the results from BH9, which demonstrated 0.22m of topsoil, which overlay a continuous stratigraphic sequence of occupation deposits. The data obtained from BH9 further complemented the results of Trench 9, showing that to the south of the trench, there is >2.20m of Neolithic deposits exhibiting a range of sedimentary layers (Table 6.8; Fig. 6.15).

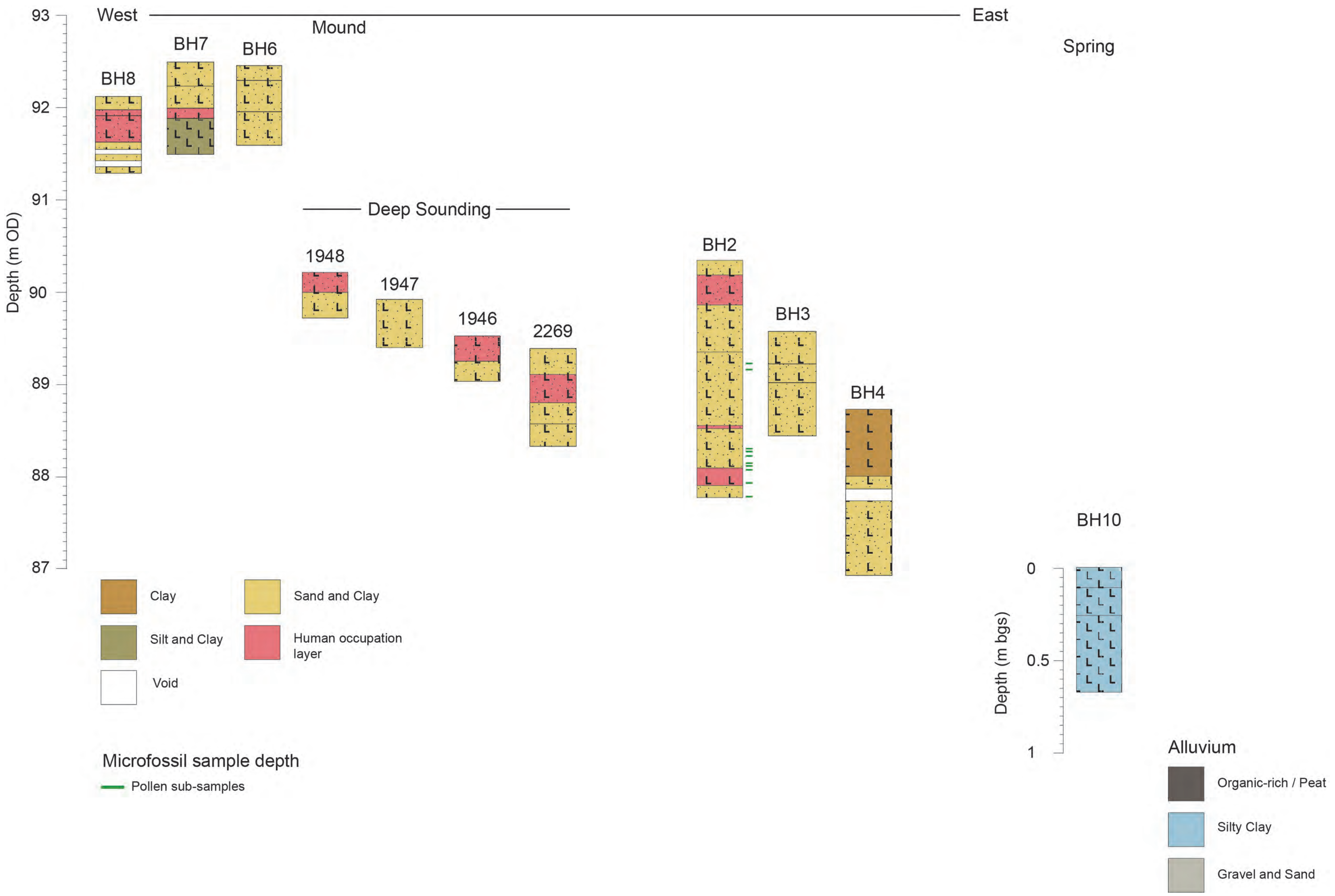


Figure 6.4. West–east Transect of boreholes across the archaeological site of Bestansur (distances between sequences are not to scale).

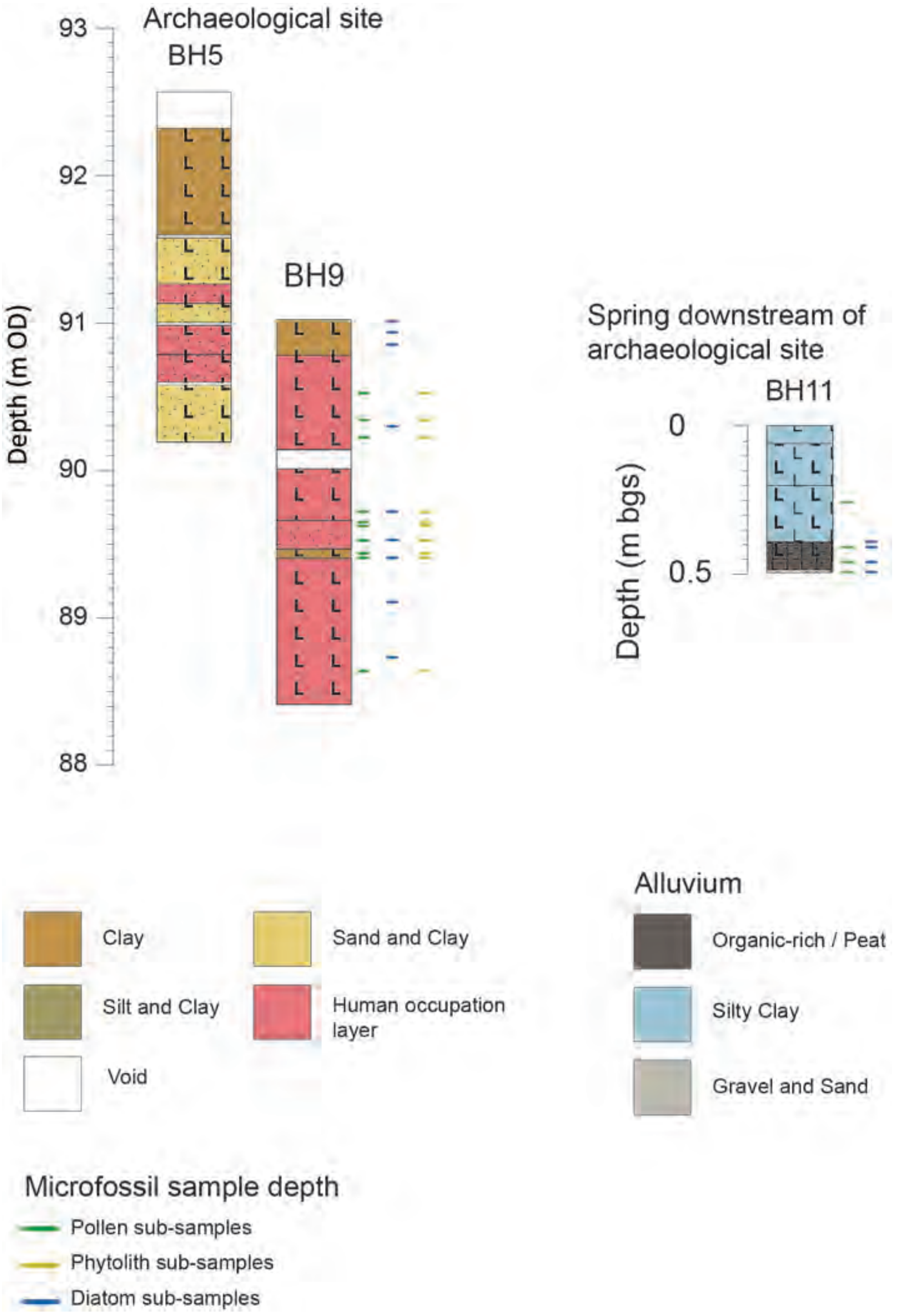


Figure 6.5. Borehole logs of BH5, BH9 and BH11 at Bestansur (distances between sequences are not to scale).

To the east, anthropogenic deposits were encountered as far as 40m from the centre of the mound in BH4, at 0.74m below the surface (559.98m asl), 0.15m thick, and directly overlay a natural sandy clay. Anthropogenic deposits were also encountered (557.19–556.40m asl) in BH3 and 0.15m below the surface (558.14m asl) in BH2. Nearby, closer to the mound and to the west of BH2, Neolithic deposits were encountered in Trench 10 at a depth of 1m below surface (560.73m asl). Borehole BH2 shows that *c.* 20m to the west of the mound there is significant stratigraphic depth to anthropogenic deposits. When assessed in relation to nearby trenches, it is most likely that these deposits largely relate to the Neolithic period and demonstrate a variety of sedimentary layers including thicker packing or levelling deposits, and finer occupation layers and surfaces. Similarly, the lowest deposit in BH3, may also be ascribed to the Neolithic as inferred by inclusions of small pieces of burnt clay, much like those found during excavation in Trench 10, and mollusc shell. However, no surfaces were identified in this core, but this may be because the borehole only reached a maximum depth of 1.15m below surface level (556.40m asl). If this is compared to the level in which natural deposits were identified

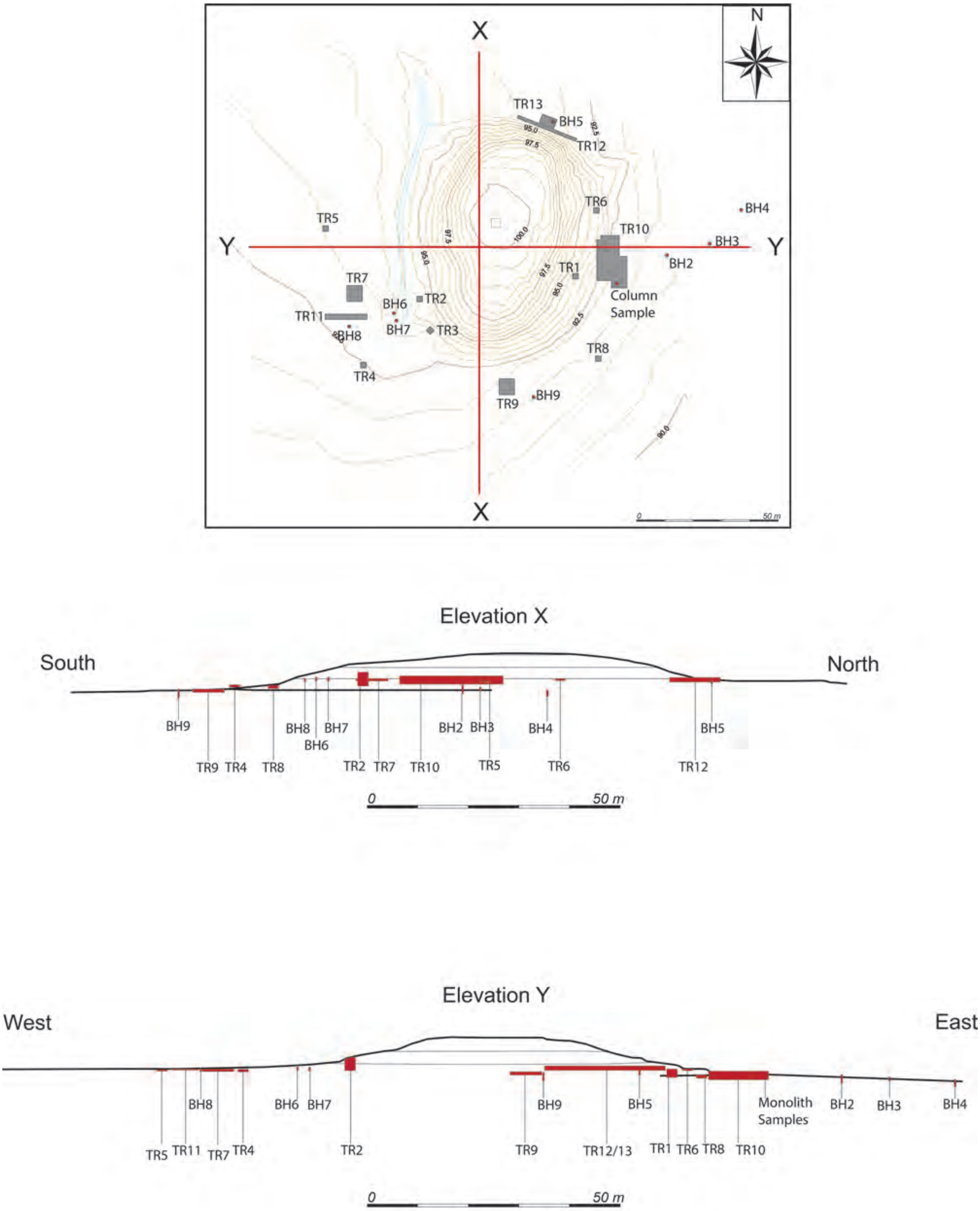


Figure 6.6. North–south and East–west elevation cross-sections of Bestansur with trenches and boreholes (highlighted in red).

in BH4 (555.72m asl), it is possible that there is another 0.50m of Neolithic deposits below the lowest deposit identified in BH3.

To the west of the mound anthropogenic deposits were encountered in all three boreholes: BH6, BH7 and BH8. The overlying topsoil ranged from 0.14–0.17m in thickness. In comparison to Trenches 2 and 3, in the immediate vicinity of boreholes BH6 and BH7, it is likely that the anthropogenic deposits identified in the cores, ranging from 559.95–559.59m asl and 560.32–559.46m asl respectively, relate to Iron Age or later activity. Neither two of these boreholes are considered to have reached Neolithic levels. This is reinforced by excavations in nearby Trench 2, which reached Neolithic deposits 2m below surface level (560.01m asl), with both Trenches 2 and 3 demonstrating later activity at a higher level. The difference in height of these two phases seen in Trench 2 and BH6 and BH7 can be explained by the rise of the mound. Borehole BH8 was located to the south of Trench 11, further west of the two aforementioned boreholes. Anthropogenic deposits were identified at a depth of 0.23m from the surface (559.93m asl), containing inclusions of pottery fragments, which allowed for identification of these units as later activity. This matches the information obtained during the excavation of Trench 11, in which later deposits and structures were excavated directly below the topsoil. In turn these later features overlay Neolithic deposits at 0.73m below surface (560.39m asl), as reflected in BH8, where deposits devoid of later material, and similar in terms of both inclusions and structure to those of other Neolithic deposits across the site, were seen at 0.5m below surface (559.58m asl). During the excavation of Trench 4, located 12m south-southeast of BH8, Neolithic deposits (560.07m asl) were encountered directly below topsoil, indicating that an area approximately 5–10m around Trench 11 and BH8 witnessed later activity. Furthermore, the levels from excavation and borehole survey indicate a slightly depressed area on the location of BH8 and between Trenches 7 and 4. The stratigraphic units of BH8 do not show as dense and finely stratified units as seen in boreholes BH2, BH5 or BH9, neither does it show a wide variety of sedimentary deposits, which also reflects the information recovered from nearby Trench 4.

Results from BH5, which was put down through Trench 13 to the north of the mound, reveal that there are 2.50m of Neolithic deposits in this area, down to a total depth of 558.16m asl. This complements the results of the excavations undertaken in Trenches 12 and 13 which revealed architectural features, surfaces and Neolithic deposits to a maximum depth of 561.85m asl. Analysis of the deposits in 2019 revealed a detailed stratigraphy within the core, which consisted of finely layered occupation deposits, surfaces, plastered floors, architectural material and structures, and episodes of packing material or levelling deposits. Considering the level in which natural deposits were encountered elsewhere across the site, we might expect to find another 1m of Neolithic deposits below the lowest point reached in BH5.

Results of the particle size analysis, calcium carbonate and organic matter determinations

Particle size analysis showed that the sediments in Boreholes BH2 and BH9 were broadly similar, consisting of 55–60% silt with subsidiary and approximately equal amounts of sand and clay (Fig. 6.7). The occupation layers show considerable variability in particle size, suggesting they represent a range of material sources and activities. In both boreholes there is obvious clay enrichment at levels between 0.32m and 0.64m below the ground surface (bgs), almost certainly representing evidence of pedological processes associated with the present-day topsoil. In BH9 in which anthropogenic material is present at most levels, particle size distributions are more varied than they are in BH2. Thus for example, although silt values for units below the soil horizons (below *c.* 0.64m bgs) are similar in the two boreholes (mean values: BH2=57.69%; BH9=56.95%) standard deviations are significantly different, respectively 3.57 (n=11) in BH2 and 11.46 (n=15) in BH9.

Mean calcium carbonate ($CaCO_3$) values are broadly similar in BH2 (14.93%) and BH9 (16.93%) (Fig. 6.7), but in BH2 there is a greater difference between near-surface and deeper calcium carbonate values than there is in BH9. The down-hole increases in $CaCO_3$ between the upper and lower halves of the two cores are +5.4% in BH2 and +1.4% in BH9. Given the variability in construction materials and calcitic ash-rich hearth and oven rake-out in occupation deposits recorded in excavations across the mound (Chapters 7 and 12), these variations in $CaCO_3$ are more likely to represent variation in building materials, floor surfaces, packing and occupation deposits and occupation deposits than downward leaching of $CaCO_3$ in the vicinity of BH2.

Organic matter content is low in both boreholes (means: BH2=4.65; BH9=4.33) and rather constant throughout the depth of the core in BH2 but displaying a slight downward decrease in BH9 (Fig. 6.7). There is no evidence that either calcium carbonate values or organic matter values in units tentatively recognised as 'occupation layers' are consistently different from values in other units.

The particle size data for BH11 relates entirely to levels above 0.5m bgs that lie within the depth range probably affected by pedological processes. There is evidence in the profile of clay (and silt) enrichment at shallow depth which might be of pedological origin, but which alternatively may reflect changes in the historic depositional environment on the alluvial surface. Calcium carbonate content (mean=12.26%) is slightly lower than in Boreholes BH2 and BH9, but organic matter content is significantly higher (mean=26.64%) (Fig. 6.7).

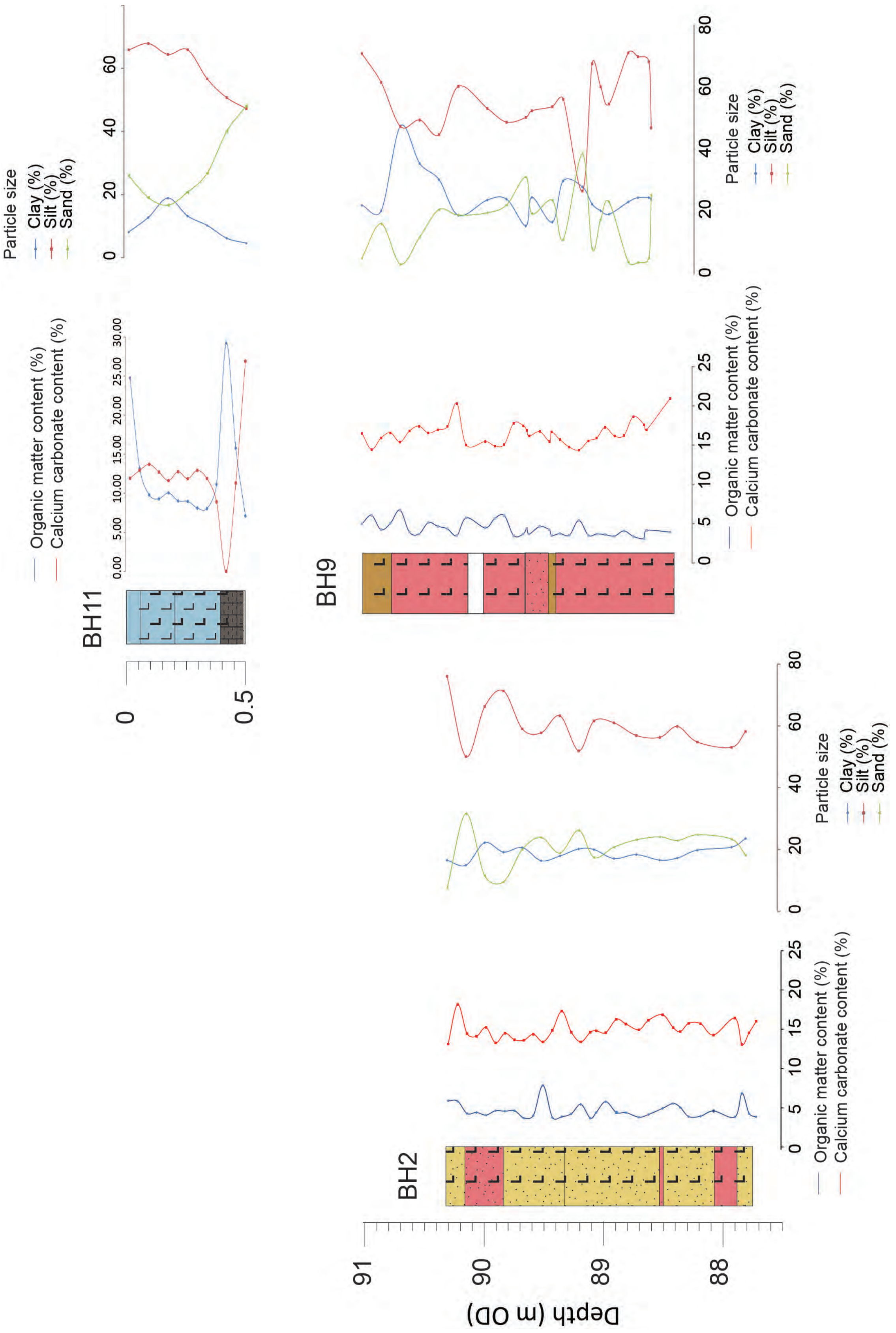


Figure 6.7. Results of the organic matter and calcium carbonate content, and particle size analyses for BH2, BH9 and BH11, Bestansur.

Microfossil assessment

The microfossil assessment was based on examination of sub-samples from the cores recovered in Boreholes BH2, BH9 and BH11 and was mainly focused on the units tentatively identified as 'occupation layers' and on the organic-rich layers in BH11. Pollen, non-pollen palynomorphs (fungal spores) and microcharcoal were assessed from each borehole, diatoms were assessed from Boreholes BH9 and BH11, and phytoliths were assessed from BH9 only (Tables 6.12–6.15).

Pollen

No pollen was recorded in samples taken from BH9 (Table 6.12) and pollen was present in only four of the samples taken from BH2, but only as a small number of Poaceae grains, a single grain of *Pinus* from a sample midway down the core and a single grain of *Betula* near the bottom of the core. None of this sparse pollen assemblage came from apparent 'occupation layers'. Pollen was present in samples from BH11, but again in very low concentrations consisting entirely of herbaceous taxa, including *Chenopodium* sp., *Taraxacum* sp., Poaceae, Cyperaceae and Asteraceae. On account of the absence or very low concentration of pollen grains in Boreholes BH2 and BH9 it is not possible to draw any significant conclusions from these results regarding the history of vegetation around the archaeological site. For discussion of other plant remains including phytoliths and charred macro and micro-fossils and the diverse plant remains preserved in micromorphological thin-sections, see Chapters 12, 13 and 18. For further discussion of pollen studies in this region, see Chapter 3.

Non-pollen palynomorphs

Fungal spores were present in all samples examined from boreholes BH9 and BH11 and in nine of the 11 samples from BH2 (Table 6.13, Fig. 6.8). Concentrations were generally low throughout BH2 and most of BH9 but higher in BH11. *Glomus*, *Zygnema*, *Coniochaeta*, *Chaetomium* and *Sordaria* were among the taxa identified. *Glomus* is an arbuscular mycorrhizal fungus that forms symbiotic relationships with plant roots; *Zygnema* is a freshwater alga indicative of shallow stagnant water; and *Coniochaeta*, *Chaetomium* and *Sordaria* are all taxa flourishing in a wide variety of environments including soil, plant debris and the dung of herbivores, which has been widely identified in Neolithic deposits through thin-section micromorphology and spot smear slides (Chapters 12 and 16).

Despite an increase in the use of non-pollen palynomorph (npp) analysis, which highlights their increasing significance in palaeoecological studies, there is a scarcity of such studies in this region (see Djamali *et al.* 2009). As can be seen, npp analysis provides ecological information to provide a better picture of the environmental conditions and since some npp producing organisms react faster and to more subtle changes in environmental conditions than flowering plants (Barthelmes *et al.* 2006: 47) they can play an important part in studies investigating human and climatic impact upon changes in vegetation, as well as the presence of herbivores (Van Geel 2006).

Phytoliths

Phytoliths were present in all nine samples from BH9 (Table 6.14, Fig. 6.9). Phytoliths of inconsistent morphology, which are typically produced by trees, were common in the sample closest to the bottom of the borehole but were scarce or absent at shallower depths higher up in the sequence. Bulliform phytoliths, typically produced by reeds, and two specimens of cereal-like forms were recorded midway down the core between 1.29m and 1.59m bgs (557.70–557.40m asl). At this same level (1.40m bgs, 557.59m asl) well-preserved multicellular phytoliths were common. As they are easily destroyed by soil disturbance, this may indicate that low energy conditions prevailed during the primary deposition of sediment at this level. Elsewhere in the core single cell phytoliths are dominant.

Phytoliths are also ubiquitous and well-preserved in excavated deposits across the site, as attested in a wide range of spot and micromorphological samples discussed in Chapters 12 and 16. The presence of cereal-like phytoliths in BH9 is particularly noteworthy, given the sparsity of charred cereal-like grains recovered by water-flotation from Neolithic levels (Chapters 12 and 18).

Diatoms

No diatoms were present in the samples from BH9 and only two complete specimens and two broken specimens were recorded in the four samples from BH11 (Table 6.15).

Microcharcoal

Microcharcoal was present in low concentrations throughout BH11 and in most samples from BH9 but was absent from the two deepest samples in BH9 at depths of 557.39–556.61m asl (Table 6.12). In BH2 microcharcoal was present in four of the 11 samples examined, with a high concentration at 556.15m asl, at the top of one of the units tentatively identified as an 'occupation layer'.

Interpretation and discussion

The geoarchaeological borehole investigations, coupled with excavations, have provided new

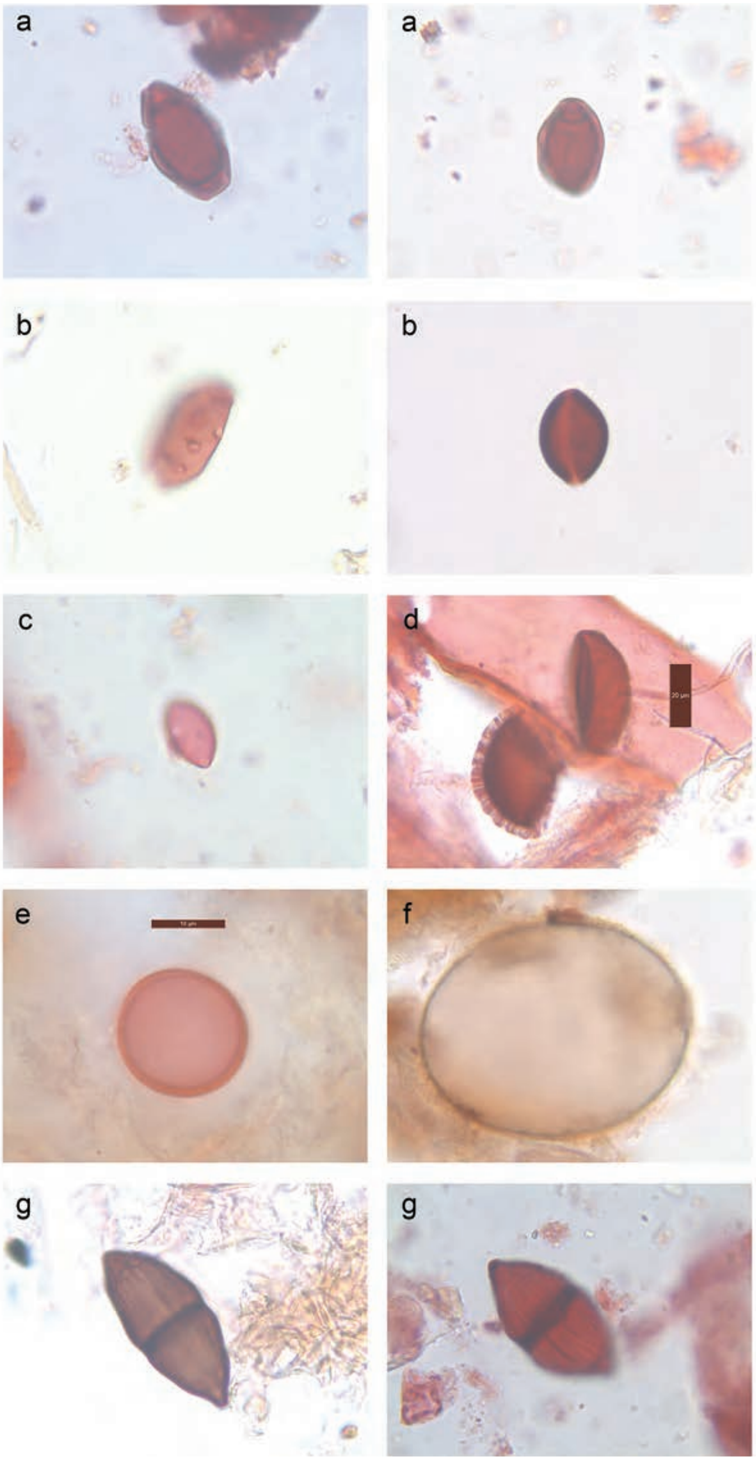


Figure 6.8. A selection of the non-pollen palynomorphs recorded during the assessment: (a) unknown spore in SA242, BH2; (b) Zygnema type spore (left) and Coniochaeta spore (right) in sample 80, BH9; (c) HdV7B spore; (d) Sordaria spore (right); (e) aquatic spore (algae?); (f) parasite egg?; (g) unknown spores recorded in every sample in BH11

insights into the processes forming the sediments both surrounding and making up the archaeological site of Bestansur and the floodplain of the nearby stream.

1. Natural deposits include: a) dark grey organic-rich deposits in the vicinity of the spring that are likely to include better preserved pollen and will be investigated in the future; and b) a yellowish brown silty clay loam that overlies bedrock geology, and represents sedimentary type deposits and processes, present in Trench 4, C1087-88, SA447 for example (Chapters 7 and 12). It is likely that natural deposits were also reached in BH4. The natural deposits in BH4 exhibit a similar matrix to those of C1087-88 in Trench 4 although it varied in colour. As BH4 is in

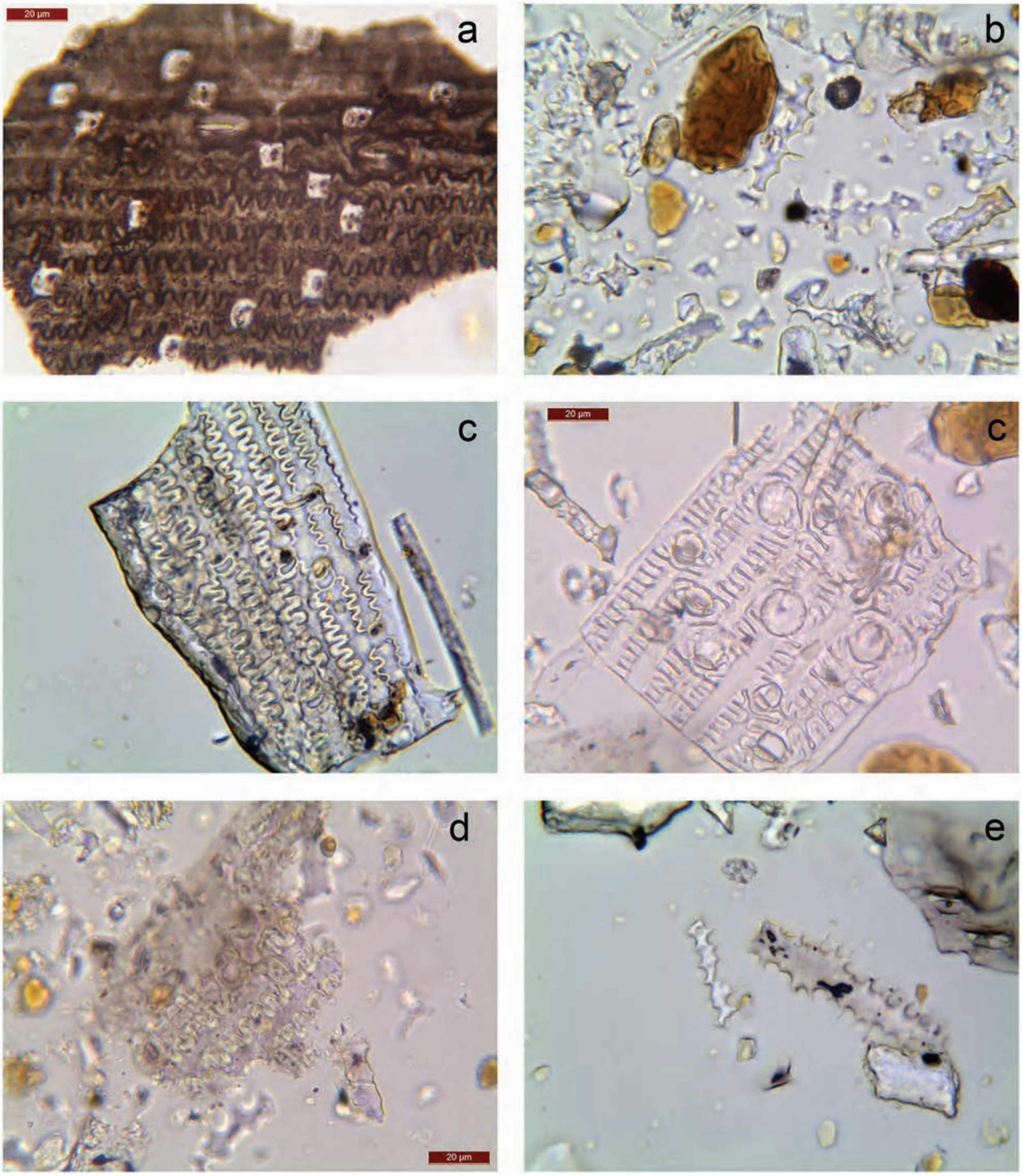


Figure 6.9. A selection of the phytoliths recorded during the assessment: (a) Multi-cell, long cell dendritic with short cells – c.f. phragmites culm (Ramsey et al. 2016); (b) Selection of dendritic long-cells from the husks of grasses. Potentially some rondel short cells which are generally formed in Pooid grasses (Twiss et al. 1969); (c) Multi-cell long cell dendritic with short cells, grass husk; (d) cereal-like – resemblance to c.f. Triticum sp. (Rosen 1992); (e) dendritic long-cells – grass husk.

the vicinity of the river the difference in colour may be because the deposit had been affected by fluvial activity or waterlogging from the nearby spring.

2. The sedimentary sequences from Neolithic levels identified in boreholes BH2, BH3, BH4, BH5, BH8 and BH9 surrounding the mound and in the monoliths include: a) deliberately laid silty clay-packing as a foundation for floors and levelling prior to construction; b) plastered floors; and c) accumulated occupation deposits as both thick, 0.50m, and thin, 0.13m, layers with highly variable anthropogenic inclusions, such as micro and macro-charcoal, burnt

aggregates, lithics and mollusc shells. The monolith samples have provided an important baseline for comparison to sediments from the boreholes.

3. The boreholes indicate that the proportions of packing/levelling and occupation deposit vary across the mound, with the highest number of deposits identified as packing/levelling/construction materials and occupation deposits in BH5. This aligns with the results of the excavation of Trenches 12 and 13.

4. No buried soil horizons were observed in Neolithic levels, indicating relatively continuous occupation. The deposits representing the interval between the Neolithic and Iron Age are at least 0.50m thick as evidenced in BH6 and BH7 with little occupation debris, suggesting a long period of abandonment of this site from *c.* 7000-900 BC. These boreholes show evidence of clay packing/levelling and occupation deposits. However, when considered in reference to Trenches 2 and 4 in the immediate vicinity it is most likely that these deposits represent later periods of activity.

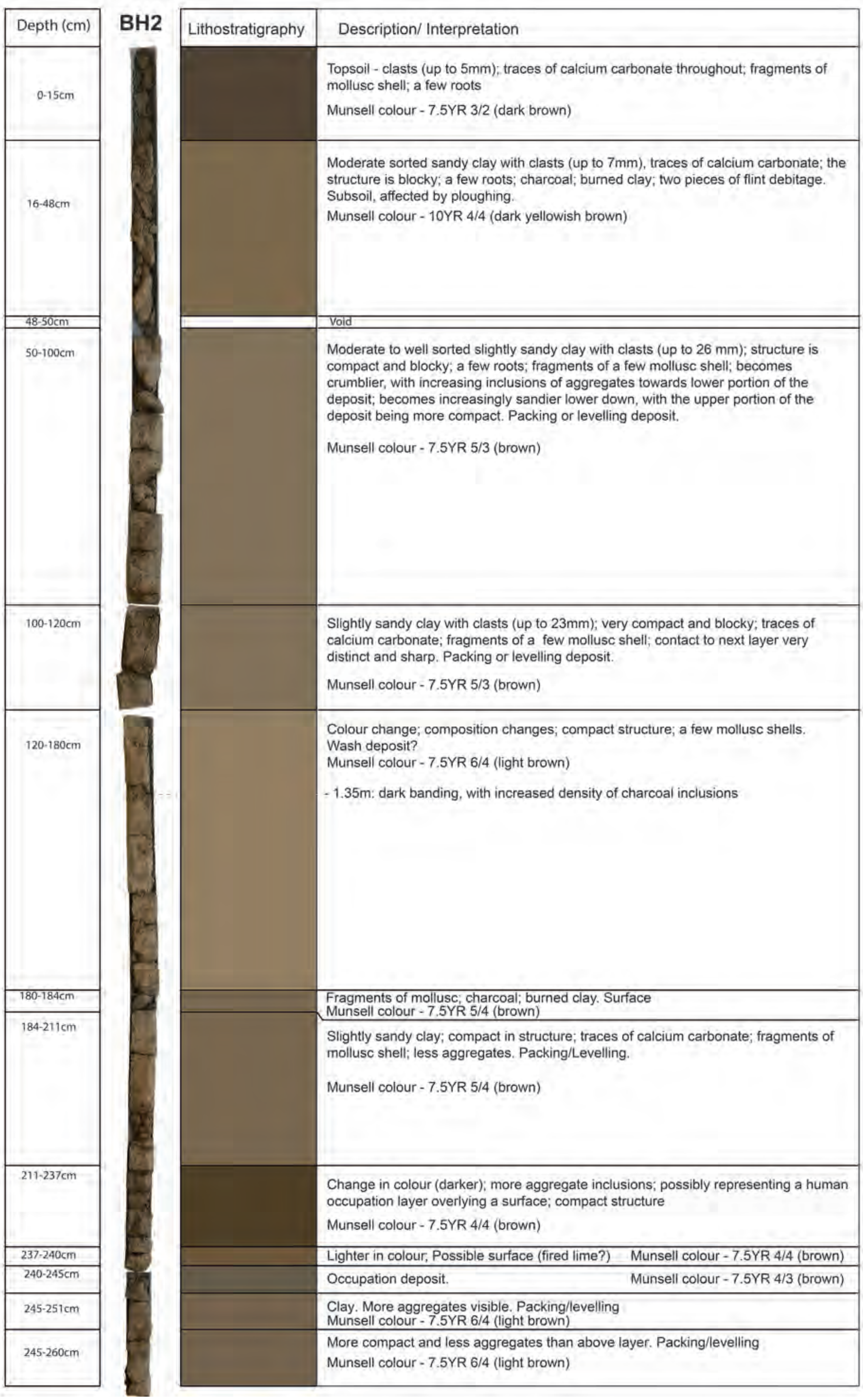
5. The evidence in topsoil of soil development associated with the present ground surface includes clay enrichment and calcium carbonate redistribution, indicating a substantial period of ground surface stability during the historic past.

Evidence from the borehole record relating to the vegetation and occupation histories of the site is limited but not without interest. The presence throughout the sediment sequence of phytoliths and spores of fungi that form symbiotic relationships with plants suggests more or less continuous vegetation cover during the period of sediment accumulation. The spores associated with herbivore dung correlate with the micromorphological evidence for widespread use of dung as fuel (Chapters 12 and 16). In addition, the presence of arboreal phytoliths at the bottom of the sediment sequence in the boreholes, as well as from elsewhere at the site (Chapters 12 and 13), suggests the possibility that there was woodland within the vicinity of the site, as also attested by the fauna (Chapter 15). The absence of microcharcoal at the same level may indicate that these deposits represent burning temperatures exceeding *c.* 500°C, as attested repeatedly in micromorphological samples of deposits rich in plant remains and hearth and oven fuel and rake-out (Chapter 13, see also Chapter 18).

Conclusions

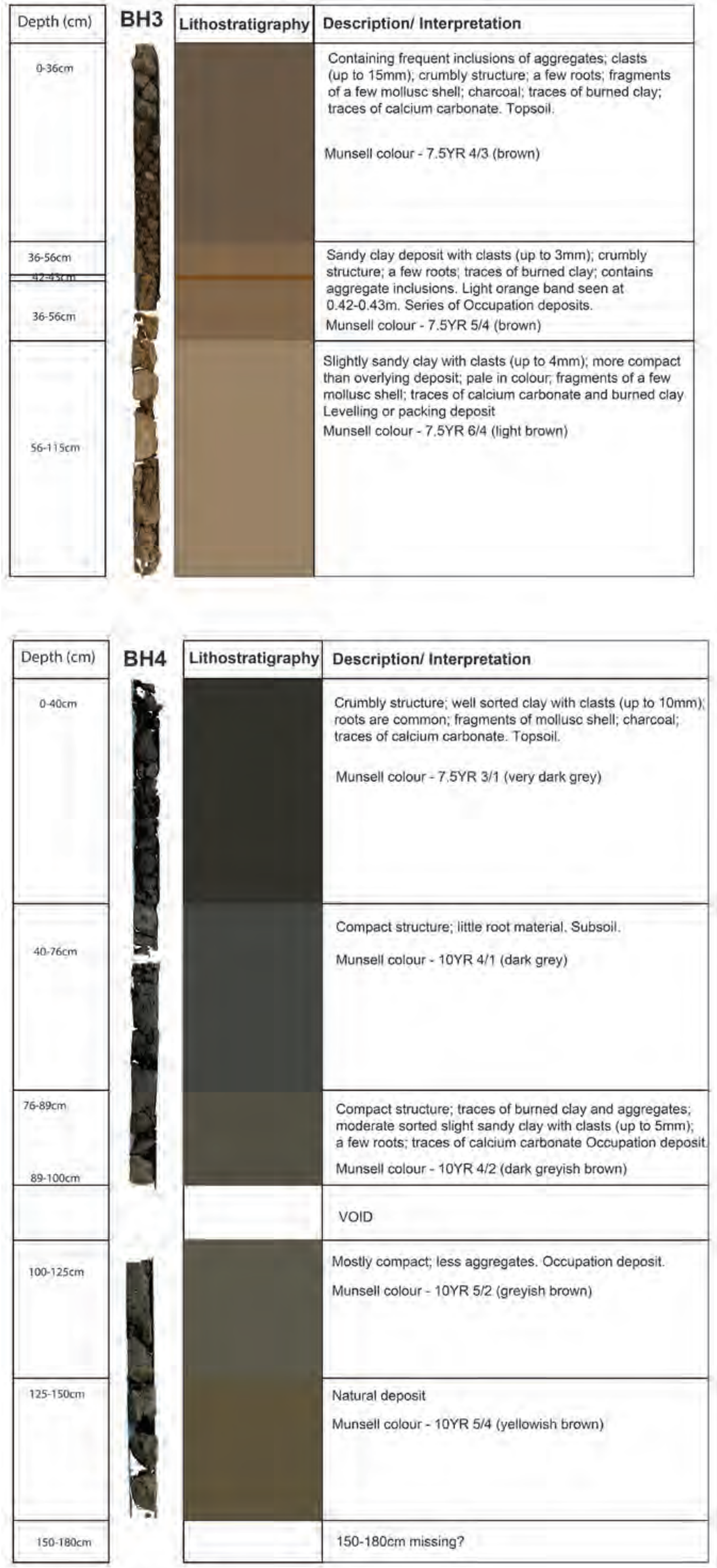
The natural sediments on the plain that surround the archaeological site today can be characterised as a deep phased chestnut soil type (Chapter 3; Buringh 1960; Zakaria *et al.* 2013) on a pale brown calcitic silty clay substrate that was only reached in Trench 4 and BH4. The absence of buried soil horizons within Neolithic levels suggests relatively continuous occupation. The total depth of Neolithic occupation is at least 2m deep across the mound, and up to 4m deep when Neolithic levels on the mound above the level of the plain are included (Chapter 24). The mound deposits comprise varying accumulations of packing/levelling, construction materials, and occupation deposits.

The pilot analytical studies have informed current and future research strategies. Although pollen preservation is limited in occupation deposits, pollen was better preserved in more organic deposits close to the spring and will enable an ongoing programme of palaeoenvironmental excavation to provide high-resolution local environmental data to complement the regional scale coring by Altaweel *et al.* (2013). Non-pollen palynomorphs are better preserved than pollen across the settlement and include *Sordaria* which is commonly associated with herbivore dung and provides additional evidence of the major importance of herbivore dung as a source of fuel and energy in the Neolithic, as independently attested in the zooarchaeological and micromorphological data (Chapters 12, 15 and 16). The identification of cereal-like phytoliths within BH9, as well as elsewhere within the settlement (Chapters 12 and 13) is particularly important, as few cereal or cereal-like grains have been recovered by water-flotation (Chapter 18). Explanations for this discrepancy include post-depositional bioturbation, as argued in Chapter 18, to sparse use of cereals and oxidation of carbon in high combustion temperatures >500–850^{o}C that are attested across the settlement based on analysis of >100 micromorphological thin-sections (Chapter 12, see also Chapter 15). This pilot study has laid the foundations for a more ambitious programme of environmental and geoarchaeological investigation at and around the Early Neolithic site of Bestansur, which we plan to build on there and at Shimshara in future seasons.



Depth (cm)	BH2	Lithostratigraphy	Description/ Interpretation
0-15cm			Topsoil - clasts (up to 5mm); traces of calcium carbonate throughout; fragments of mollusc shell; a few roots Munsell colour - 7.5YR 3/2 (dark brown)
16-48cm			Moderate sorted sandy clay with clasts (up to 7mm), traces of calcium carbonate; the structure is blocky; a few roots; charcoal; burned clay; two pieces of flint debitage. Subsoil, affected by ploughing. Munsell colour - 10YR 4/4 (dark yellowish brown)
48-50cm			Void
50-100cm			Moderate to well sorted slightly sandy clay with clasts (up to 26 mm); structure is compact and blocky; a few roots; fragments of a few mollusc shell; becomes crumblier, with increasing inclusions of aggregates towards lower portion of the deposit; becomes increasingly sandier lower down, with the upper portion of the deposit being more compact. Packing or levelling deposit. Munsell colour - 7.5YR 5/3 (brown)
100-120cm			Slightly sandy clay with clasts (up to 23mm); very compact and blocky; traces of calcium carbonate; fragments of a few mollusc shell; contact to next layer very distinct and sharp. Packing or levelling deposit. Munsell colour - 7.5YR 5/3 (brown)
120-180cm			Colour change; composition changes; compact structure; a few mollusc shells. Wash deposit? Munsell colour - 7.5YR 6/4 (light brown) - 1.35m: dark banding, with increased density of charcoal inclusions
180-184cm			Fragments of mollusc; charcoal; burned clay. Surface Munsell colour - 7.5YR 5/4 (brown)
184-211cm			Slightly sandy clay; compact in structure; traces of calcium carbonate; fragments of mollusc shell; less aggregates. Packing/Levelling. Munsell colour - 7.5YR 5/4 (brown)
211-237cm			Change in colour (darker); more aggregate inclusions; possibly representing a human occupation layer overlying a surface; compact structure Munsell colour - 7.5YR 4/4 (brown)
237-240cm			Lighter in colour; Possible surface (fired lime?) Munsell colour - 7.5YR 4/4 (brown)
240-245cm			Occupation deposit. Munsell colour - 7.5YR 4/3 (brown)
245-251cm			Clay. More aggregates visible. Packing/levelling Munsell colour - 7.5YR 6/4 (light brown)
245-260cm			More compact and less aggregates than above layer. Packing/levelling Munsell colour - 7.5YR 6/4 (light brown)

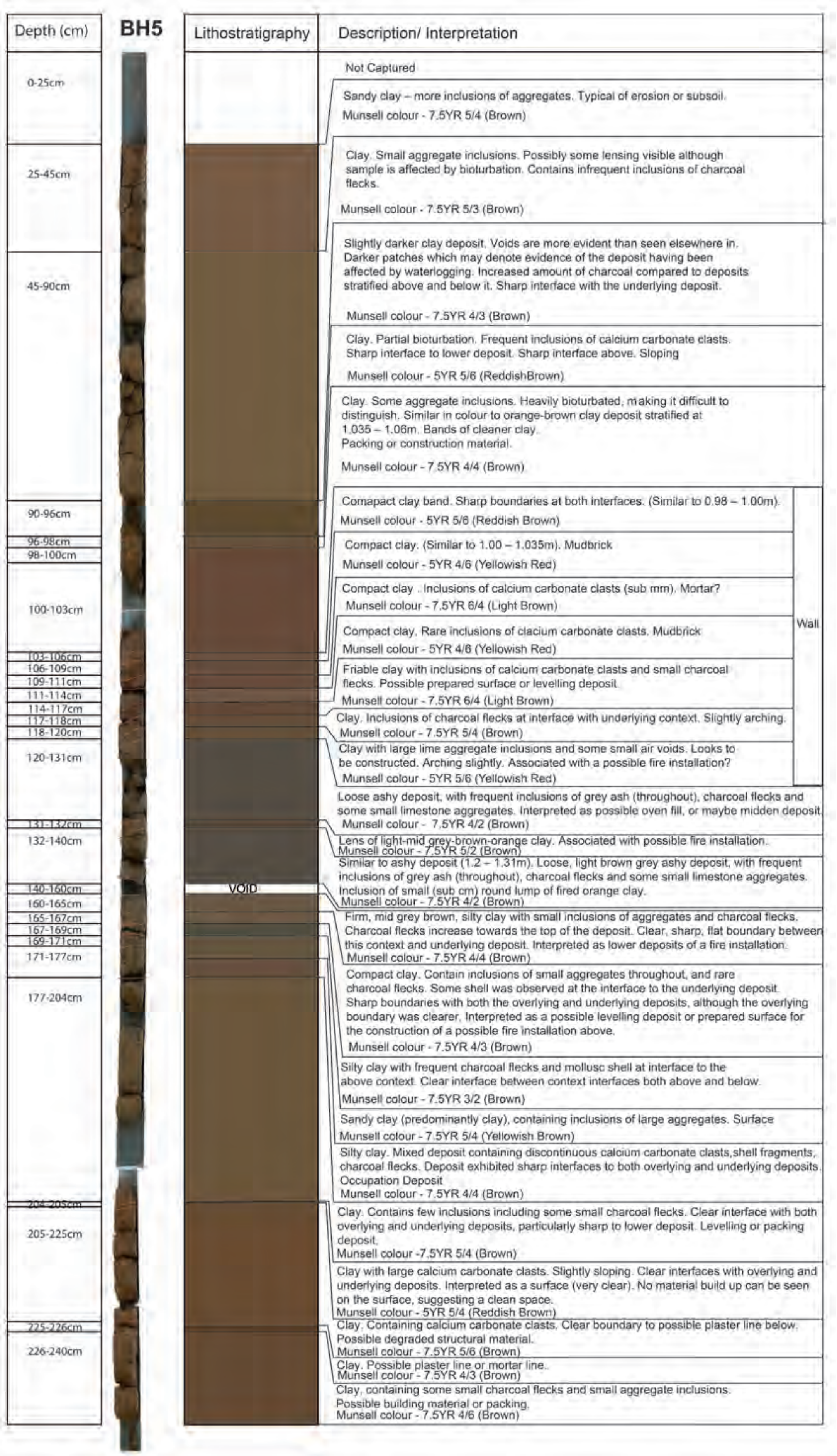
Figure 6.10. Analysis of borehole BH2.



Depth (cm)	BH3	Lithostratigraphy	Description/ Interpretation
0-36cm			Containing frequent inclusions of aggregates; clasts (up to 15mm); crumbly structure; a few roots; fragments of a few mollusc shell; charcoal; traces of burned clay; traces of calcium carbonate. Topsoil. Munsell colour - 7.5YR 4/3 (brown)
36-56cm 42-43cm 36-56cm			Sandy clay deposit with clasts (up to 3mm); crumbly structure; a few roots; traces of burned clay; contains aggregate inclusions. Light orange band seen at 0.42-0.43m. Series of Occupation deposits. Munsell colour - 7.5YR 5/4 (brown)
56-115cm			Slightly sandy clay with clasts (up to 4mm); more compact than overlying deposit; pale in colour; fragments of a few mollusc shell; traces of calcium carbonate and burned clay Levelling or packing deposit Munsell colour - 7.5YR 6/4 (light brown)

Depth (cm)	BH4	Lithostratigraphy	Description/ Interpretation
0-40cm			Crumbly structure; well sorted clay with clasts (up to 10mm); roots are common; fragments of mollusc shell; charcoal; traces of calcium carbonate. Topsoil. Munsell colour - 7.5YR 3/1 (very dark grey)
40-76cm			Compact structure; little root material. Subsoil. Munsell colour - 10YR 4/1 (dark grey)
76-89cm 89-100cm			Compact structure; traces of burned clay and aggregates; moderate sorted slight sandy clay with clasts (up to 5mm); a few roots; traces of calcium carbonate Occupation deposit. Munsell colour - 10YR 4/2 (dark greyish brown)
			VOID
100-125cm			Mostly compact; less aggregates. Occupation deposit. Munsell colour - 10YR 5/2 (greyish brown)
125-150cm			Natural deposit Munsell colour - 10YR 5/4 (yellowish brown)
150-180cm			150-180cm missing?

Figure 6.11. Analysis of boreholes BH3 and BH4.



Not Captured

Sandy clay – more inclusions of aggregates. Typical of erosion or subsoil.
Munsell colour - 7.5YR 5/4 (Brown)

Clay. Small aggregate inclusions. Possibly some lensing visible although sample is affected by bioturbation. Contains infrequent inclusions of charcoal flecks.
Munsell colour - 7.5YR 5/3 (Brown)

Slightly darker clay deposit. Voids are more evident than seen elsewhere in. Darker patches which may denote evidence of the deposit having been affected by waterlogging. Increased amount of charcoal compared to deposits stratified above and below it. Sharp interface with the underlying deposit.
Munsell colour - 7.5YR 4/3 (Brown)

Clay. Partial bioturbation. Frequent inclusions of calcium carbonate clasts. Sharp interface to lower deposit. Sharp interface above. Sloping
Munsell colour - 5YR 5/6 (ReddishBrown)

Clay. Some aggregate inclusions. Heavily bioturbated, making it difficult to distinguish. Similar in colour to orange-brown clay deposit stratified at 1.035 – 1.06m. Bands of cleaner clay.
Packing or construction material.
Munsell colour - 7.5YR 4/4 (Brown)

Comapact clay band. Sharp boundaries at both interfaces. (Similar to 0.98 – 1.00m).
Munsell colour - 5YR 5/6 (Reddish Brown)

Compact clay. (Similar to 1.00 – 1.035m). Mudbrick
Munsell colour - 5YR 4/6 (Yellowish Red)

Compact clay . Inclusions of calcium carbonate clasts (sub mm). Mortar?
Munsell colour - 7.5YR 6/4 (Light Brown)

Compact clay. Rare inclusions of clacium carbonate clasts. Mudbrick
Munsell colour - 5YR 4/6 (Yellowish Red)

Friable clay with inclusions of calcium carbonate clasts and small charcoal flecks. Possible prepared surface or levelling deposit.
Munsell colour - 7.5YR 6/4 (Light Brown)

Clay. Inclusions of charcoal flecks at interface with underlying context. Slightly arching.
Munsell colour - 7.5YR 5/4 (Brown)

Clay with large lime aggregate inclusions and some small air voids. Looks to be constructed. Arching slightly. Associated with a possible fire installation?
Munsell colour - 5YR 5/6 (Yellowish Red)

Loose ashy deposit, with frequent inclusions of grey ash (throughout), charcoal flecks and some small limestone aggregates. Interpreted as possible oven fill, or maybe midden deposit.
Munsell colour - 7.5YR 4/2 (Brown)

Lens of light-mid grey-brown-orange clay. Associated with possible fire installation.
Munsell colour - 7.5YR 5/2 (Brown)

Similar to ashy deposit (1.2 – 1.31m). Loose, light brown grey ashy deposit, with frequent inclusions of grey ash (throughout), charcoal flecks and some small limestone aggregates. Inclusion of small (sub cm) round lump of fired orange clay.
Munsell colour - 7.5YR 4/2 (Brown)

Firm, mid grey brown, silty clay with small inclusions of aggregates and charcoal flecks. Charcoal flecks increase towards the top of the deposit. Clear, sharp, flat boundary between this context and underlying deposit. Interpreted as lower deposits of a fire installation.
Munsell colour - 7.5YR 4/4 (Brown)

Compact clay. Contain inclusions of small aggregates throughout, and rare charcoal flecks. Some shell was observed at the interface to the underlying deposit. Sharp boundaries with both the overlying and underlying deposits, although the overlying boundary was clearer. Interpreted as a possible levelling deposit or prepared surface for the construction of a possible fire installation above.
Munsell colour - 7.5YR 4/3 (Brown)

Silty clay with frequent charcoal flecks and mollusc shell at interface to the above context. Clear interface between context interfaces both above and below.
Munsell colour - 7.5YR 3/2 (Brown)

Sandy clay (predominantly clay), containing inclusions of large aggregates. Surface
Munsell colour - 7.5YR 5/4 (Yellowish Brown)

Silty clay. Mixed deposit containing discontinuous calcium carbonate clasts,shell fragments, charcoal flecks. Deposit exhibited sharp interfaces to both overlying and underlying deposits.
Occupation Deposit
Munsell colour - 7.5YR 4/4 (Brown)

Clay. Contains few inclusions including some small charcoal flecks. Clear interface with both overlying and underlying deposits, particularly sharp to lower deposit. Levelling or packing deposit.
Munsell colour -7.5YR 5/4 (Brown)

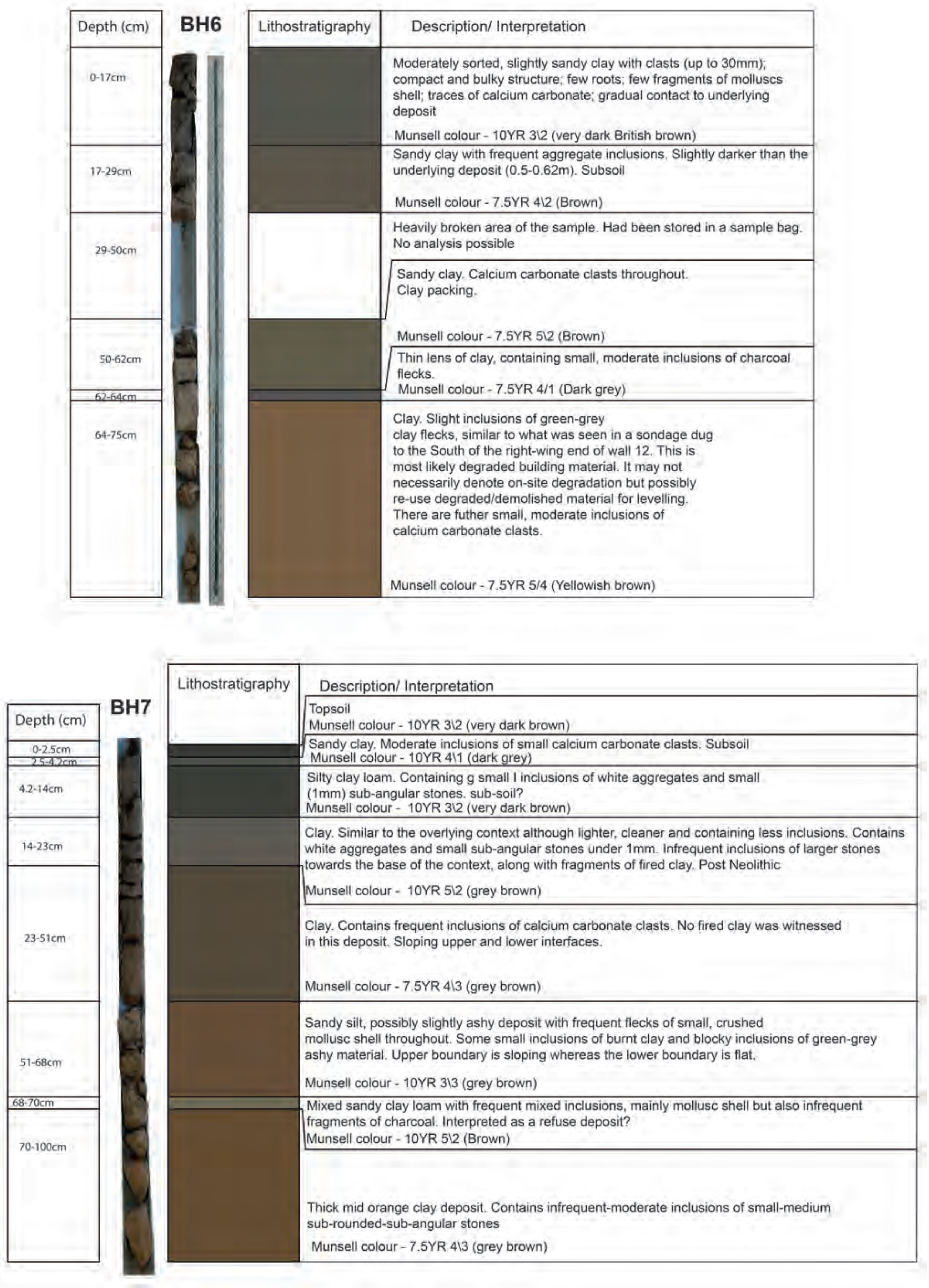
Clay with large calcium carbonate clasts. Slightly sloping. Clear interfaces with overlying and underlying deposits. Interpreted as a surface (very clear). No material build up can be seen on the surface, suggesting a clean space.
Munsell colour - 5YR 5/4 (Reddish Brown)

Clay. Containing calcium carbonate clasts. Clear boundary to possible plaster line below. Possible degraded structural material.
Munsell colour - 7.5YR 5/6 (Brown)

Clay. Possible plaster line or mortar line.
Munsell colour - 7.5YR 4/3 (Brown)

Clay, containing some small charcoal flecks and small aggregate inclusions. Possible building material or packing.
Munsell colour - 7.5YR 4/6 (Brown)

Figure 6.12. Analysis of borehole BH5.



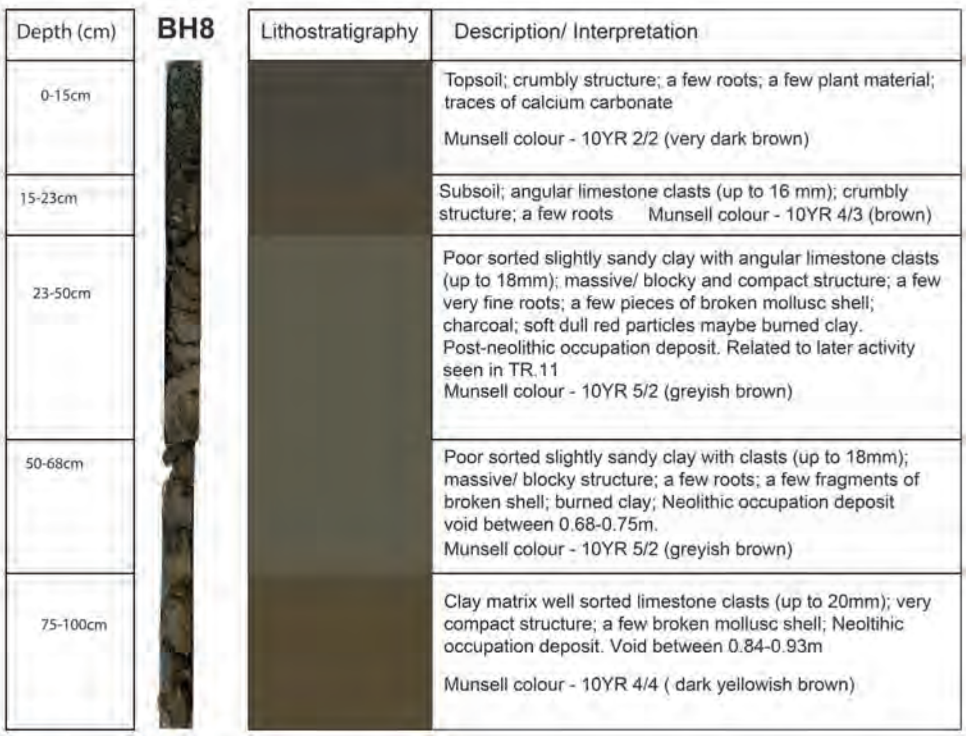
BH6

Depth (cm)	Description/ Interpretation
0-17cm	Moderately sorted, slightly sandy clay with clasts (up to 30mm); compact and bulky structure; few roots; few fragments of molluscs shell; traces of calcium carbonate; gradual contact to underlying deposit Munsell colour - 10YR 3\2 (very dark British brown)
17-29cm	Sandy clay with frequent aggregate inclusions. Slightly darker than the underlying deposit (0.5-0.62m). Subsoil Munsell colour - 7.5YR 4\2 (Brown)
29-50cm	Heavily broken area of the sample. Had been stored in a sample bag. No analysis possible Sandy clay. Calcium carbonate clasts throughout. Clay packing.
50-62cm	Munsell colour - 7.5YR 5\2 (Brown)
62-64cm	Thin lens of clay, containing small, moderate inclusions of charcoal flecks. Munsell colour - 7.5YR 4/1 (Dark grey)
64-75cm	Clay. Slight inclusions of green-grey clay flecks, similar to what was seen in a sondage dug to the South of the right-wing end of wall 12. This is most likely degraded building material. It may not necessarily denote on-site degradation but possibly re-use degraded/demolished material for levelling. There are futher small, moderate inclusions of calcium carbonate clasts. Munsell colour - 7.5YR 5/4 (Yellowish brown)

BH7

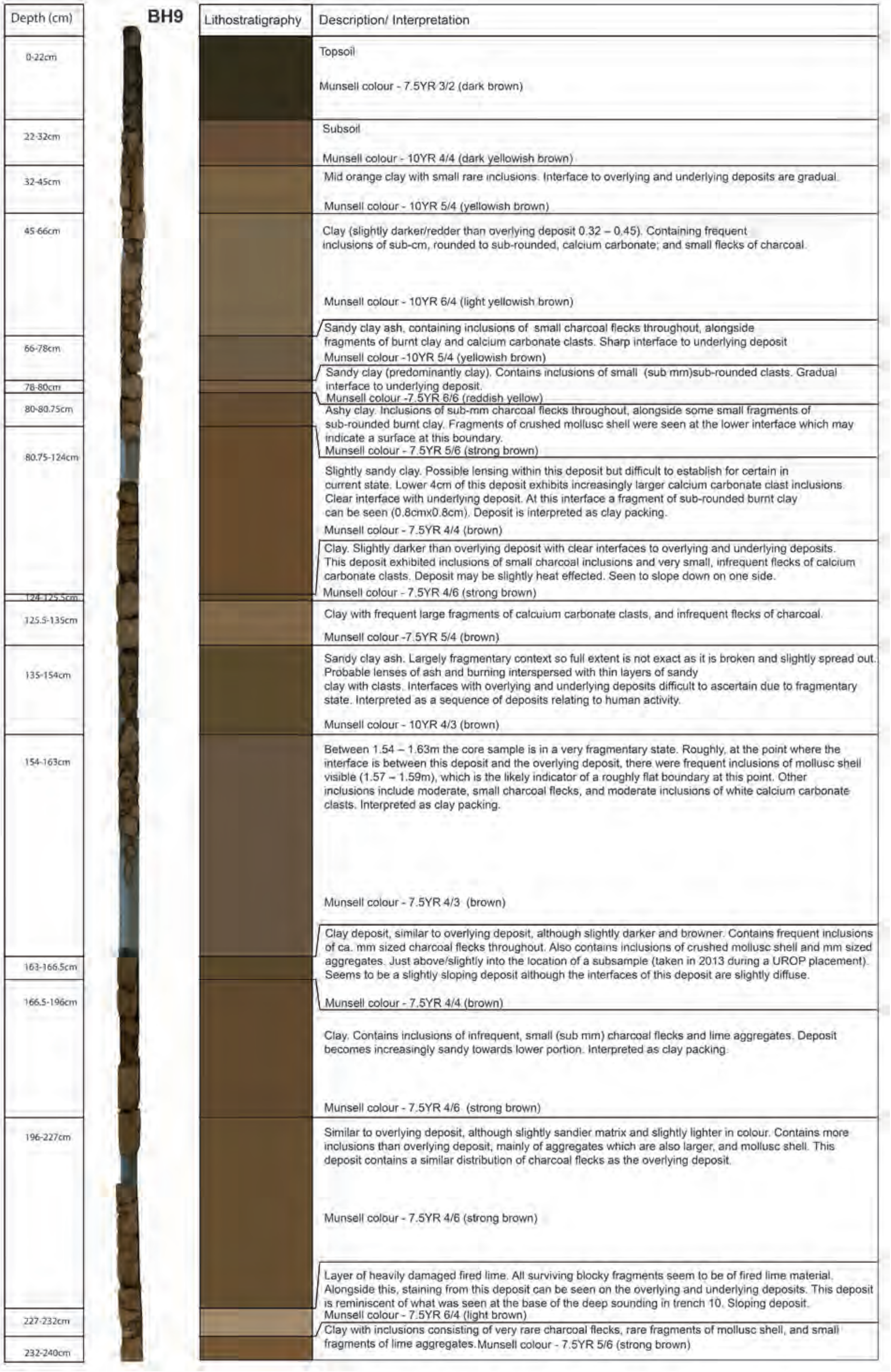
Depth (cm)	Description/ Interpretation
0-2.5cm	Topsoil Munsell colour - 10YR 3\2 (very dark brown)
2.5-4.2cm	Sandy clay. Moderate inclusions of small calcium carbonate clasts. Subsoil Munsell colour - 10YR 4\1 (dark grey)
4.2-14cm	Silty clay loam. Containing g small I inclusions of white aggregates and small (1mm) sub-angular stones. sub-soil? Munsell colour - 10YR 3\2 (very dark brown)
14-23cm	Clay. Similar to the overlying context although lighter, cleaner and containing less inclusions. Contains white aggregates and small sub-angular stones under 1mm. Infrequent inclusions of larger stones towards the base of the context, along with fragments of fired clay. Post Neolithic Munsell colour - 10YR 5\2 (grey brown)
23-51cm	Clay. Contains frequent inclusions of calcium carbonate clasts. No fired clay was witnessed in this deposit. Sloping upper and lower interfaces. Munsell colour - 7.5YR 4\3 (grey brown)
51-68cm	Sandy silt, possibly slightly ashy deposit with frequent flecks of small, crushed mollusc shell throughout. Some small inclusions of burnt clay and blocky inclusions of green-grey ashy material. Upper boundary is sloping whereas the lower boundary is flat. Munsell colour - 10YR 3\3 (grey brown)
68-70cm	Mixed sandy clay loam with frequent mixed inclusions, mainly mollusc shell but also infrequent fragments of charcoal. Interpreted as a refuse deposit? Munsell colour - 10YR 5\2 (Brown)
70-100cm	Thick mid orange clay deposit. Contains infrequent-moderate inclusions of small-medium sub-rounded-sub-angular stones Munsell colour - 7.5YR 4\3 (grey brown)

Figure 6.13. Analysis of boreholes BH6 and BH7.



Depth (cm)	BH8	Lithostratigraphy	Description/ Interpretation
0-15cm			Topsoil; crumbly structure; a few roots; a few plant material; traces of calcium carbonate Munsell colour - 10YR 2/2 (very dark brown)
15-23cm			Subsoil; angular limestone clasts (up to 16 mm); crumbly structure; a few roots Munsell colour - 10YR 4/3 (brown)
23-50cm			Poor sorted slightly sandy clay with angular limestone clasts (up to 18mm); massive/ blocky and compact structure; a few very fine roots; a few pieces of broken mollusc shell; charcoal; soft dull red particles maybe burned clay. Post-neolithic occupation deposit. Related to later activity seen in TR.11 Munsell colour - 10YR 5/2 (greyish brown)
50-68cm			Poor sorted slightly sandy clay with clasts (up to 18mm); massive/ blocky structure; a few roots; a few fragments of broken shell; burned clay; Neolithic occupation deposit void between 0.68-0.75m. Munsell colour - 10YR 5/2 (greyish brown)
75-100cm			Clay matrix well sorted limestone clasts (up to 20mm); very compact structure; a few broken mollusc shell; Neoltihic occupation deposit. Void between 0.84-0.93m Munsell colour - 10YR 4/4 (dark yellowish brown)

Figure 6.14. Analysis of borehole BH8.



Depth (cm)	Description/ Interpretation
0-22cm	Topsoil Munsell colour - 7.5YR 3/2 (dark brown)
22-32cm	Subsoil Munsell colour - 10YR 4/4 (dark yellowish brown)
32-45cm	Mid orange clay with small rare inclusions. Interface to overlying and underlying deposits are gradual. Munsell colour - 10YR 5/4 (yellowish brown)
45-66cm	Clay (slightly darker/redder than overlying deposit 0.32 – 0.45). Containing frequent inclusions of sub-cm, rounded to sub-rounded, calcium carbonate; and small flecks of charcoal. Munsell colour - 10YR 6/4 (light yellowish brown)
66-78cm	Sandy clay ash, containing inclusions of small charcoal flecks throughout, alongside fragments of burnt clay and calcium carbonate clasts. Sharp interface to underlying deposit Munsell colour -10YR 5/4 (yellowish brown)
78-80cm	Sandy clay (predominantly clay). Contains inclusions of small (sub mm)sub-rounded clasts. Gradual interface to underlying deposit. Munsell colour -7.5YR 6/6 (reddish yellow)
80-80.75cm	Ashy clay. Inclusions of sub-mm charcoal flecks throughout, alongside some small fragments of sub-rounded burnt clay. Fragments of crushed mollusc shell were seen at the lower interface which may indicate a surface at this boundary. Munsell colour - 7.5YR 5/6 (strong brown)
80.75-124cm	Slightly sandy clay. Possible lensing within this deposit but difficult to establish for certain in current state. Lower 4cm of this deposit exhibits increasingly larger calcium carbonate clast inclusions. Clear interface with underlying deposit. At this interface a fragment of sub-rounded burnt clay can be seen (0.8cmx0.8cm). Deposit is interpreted as clay packing. Munsell colour - 7.5YR 4/4 (brown)
124-125.5cm	Clay. Slightly darker than overlying deposit with clear interfaces to overlying and underlying deposits. This deposit exhibited inclusions of small charcoal inclusions and very small, infrequent flecks of calcium carbonate clasts. Deposit may be slightly heat effected. Seen to slope down on one side. Munsell colour - 7.5YR 4/6 (strong brown)
125.5-135cm	Clay with frequent large fragments of calcuium carbonate clasts, and infrequent flecks of charcoal. Munsell colour -7.5YR 5/4 (brown)
135-154cm	Sandy clay ash. Largely fragmentary context so full extent is not exact as it is broken and slightly spread out. Probable lenses of ash and burning interspersed with thin layers of sandy clay with clasts. Interfaces with overlying and underlying deposits difficult to ascertain due to fragmentary state. Interpreted as a sequence of deposits relating to human activity. Munsell colour - 10YR 4/3 (brown)
154-163cm	Between 1.54 – 1.63m the core sample is in a very fragmentary state. Roughly, at the point where the interface is between this deposit and the overlying deposit, there were frequent inclusions of mollusc shell visible (1.57 – 1.59m), which is the likely indicator of a roughly flat boundary at this point. Other inclusions include moderate, small charcoal flecks, and moderate inclusions of white calcium carbonate clasts. Interpreted as clay packing. Munsell colour - 7.5YR 4/3 (brown)
163-166.5cm	Clay deposit, similar to overlying deposit, although slightly darker and browner. Contains frequent inclusions of ca. mm sized charcoal flecks throughout. Also contains inclusions of crushed mollusc shell and mm sized aggregates. Just above/slightly into the location of a subsample (taken in 2013 during a UROP placement). Seems to be a slightly sloping deposit although the interfaces of this deposit are slightly diffuse. Munsell colour - 7.5YR 4/4 (brown)
166.5-196cm	Clay. Contains inclusions of infrequent, small (sub mm) charcoal flecks and lime aggregates. Deposit becomes increasingly sandy towards lower portion. Interpreted as clay packing. Munsell colour - 7.5YR 4/6 (strong brown)
196-227cm	Similar to overlying deposit, although slightly sandier matrix and slightly lighter in colour. Contains more inclusions than overlying deposit, mainly of aggregates which are also larger, and mollusc shell. This deposit contains a similar distribution of charcoal flecks as the overlying deposit. Munsell colour - 7.5YR 4/6 (strong brown)
227-232cm	Layer of heavily damaged fired lime. All surviving blocky fragments seem to be of fired lime material. Alongside this, staining from this deposit can be seen on the overlying and underlying deposits. This deposit is reminiscent of what was seen at the base of the deep sounding in trench 10. Sloping deposit. Munsell colour - 7.5YR 6/4 (light brown)
232-240cm	Clay with inclusions consisting of very rare charcoal flecks, rare fragments of mollusc shell, and small fragments of lime aggregates. Munsell colour - 7.5YR 5/6 (strong brown)

Figure 6.15. Analysis of borehole BH9.

Table 6.1. Lithostratigraphic description, borehole BH2.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
558.29–558.14	0–0.15	8	7.5YR 3/2 dark brown; moderate sorted slightly sandy clay with clasts (up to 5mm) which are probably limestone; traces of calcium carbonate throughout; the structure is bulky and slightly crumbly; fragments of mollusc shell (a few), probably *Helix Salomonica*; a few roots; gradual contact with:
558.14–557.81	0.15–0.48	7	7.5YR 5/4 brown; moderate sorted sandy clay with clasts (up to 7mm), traces of calcium carbonate; the structure is blocky; a few roots; charcoal; burned clay; two pieces of flint debitage; void between 0.48–0.50m.
557.81–557.31	0.50–1.00	6	7.5YR 4/3 brown; moderate to well sorted slightly sandy clay with clasts (up to 26 mm); structure is compact and blocky; a few roots; fragments of a few mollusc shell; gradual contact with:
557.31–556.51	1.00–1.80	5	7.5YR 4/4 brown; well sorted very slightly sandy clay with clasts (up to 23mm); very compact and blocky; traces of calcium carbonate; fragments of a few mollusc shell; well-marked contact with:
556.51–556.47	1.80–1.84	4	10YR 4/3 brown; moderate to well sorted sandy clay; compact structure; fragments of mollusc shells are common; charcoal; burned clay; gradual contact with:
556.47–556.04	1.84–2.27	3	7.5YR 5/4 brown; well sorted slightly sandy clay; compact in structure; traces of calcium carbonate; calcium carbonate nodule?; fragments of mollusc shell; gradual contact with:
556.04–555.86	2.27–2.45	2	10YR 4/3 brown; moderate sorted clay with clasts (up to 8mm); compact to slightly crumbly structure; fragments of mollusc shell are common; charcoal; traces of calcium carbonate; traces of burned clay; gradual contact with:
555.86–555.71	2.45–2.60	1	7YR 4/4 brown; moderate sorted slight sandy clay with clasts (up to 14mm); compact structure; fragments of a few mollusc shell; traces of calcium carbonate; reprecipitated calcium carbonate; top of the base is probably calcite.

Table 6.2. Lithostratigraphic description, borehole BH3.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
557.55–557.19	0–0.36	3	7.5YR 3/2 dark brown; well sorted sandy clay with clasts (up to 15mm); crumbly structure; a few roots; fragments of a few mollusc shell; charcoal; traces of burned clay; traces of calcium carbonate; gradual contact with:
557.19–556.99	0.36–0.56	2	7.5YR 4/3 brown; moderate sorted sandy clay with clasts (up to 3mm); crumbly structure; a few roots; traces of burned clay; gradual contact with:
556.99–556.40	0.56–1.15	1	7.5YR 4/4 brown; moderate sorted slight sandy clay with clasts (up to 4mm); fragments of a few mollusc shell; traces of calcium carbonate.

Table 6.3. Lithostratigraphic description, borehole BH4.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
556.72–555.98	0–0.74	3	7.5YR 3/2 dark brown; well sorted clay with clasts (up to 10mm); slightly crumbly but otherwise compact structure, roots are common; fragments of mollusc shell; charcoal; traces of calcium carbonate; gradual contact with:
555.98–555.83	0.74– 0.89	2	7.5YR 4/3 brown; moderate sorted slight sandy clay with clasts (up to 5mm); compact structure; a few roots; traces of calcium carbonate; Void between 0.89–1.00m.
555.83–554.92	1.00–1.80	1	7.5YR 4/2 brown; moderate sorted slight sandy clay with clasts (up to 6mm); compact structure; a few roots; fragments of a few mollusc shell; traces of calcium carbonate.

Table 6.4. Lithostratigraphic description, borehole BH5.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
560.54–560.29	0–0.25	8	Not captured
560.29–559.54	0.25–1.00	7	7.5YR 5/4 brown, moderate sorted clay with clasts (up to 5mm); compact blocky structure; charcoal; traces of calcium carbonate; a few pieces roots (wood?) between 0.52–0.54m, 0.67–0.69, 0.74–0.80m (root penetration downward) and 0.98–1.00m; void between 0.55–0.60m and 0.97–1.00m.
559.54–559.23	1.00–1.31	6	7.5YR 4/4 brown; moderate sorted slight sandy clay with clasts (up to 3mm); compact structure; traces of calcium carbonate; gradual contact with:
559.23–559.09	1.31–1.45	5	7.5YR 4/2 brown; moderate sorted sandy clay; compact structure; a few roots; a few fragments of mollusc shell; charcoal; traces of burned clay; gradual contact with:
559.09–558.94	1.45–1.60	4	7.5YR 4/3 brown; moderate to poor sandy clay with clasts (up to 27mm); compact structure; fragments of a few mollusc shell; a piece of bone at about 1.56m; void between 1.57– 1.60m.
558.94–558.74	1.60–1.80	3	7.5YR 4/4 brown to 7.5YR 3/2 dark brown; moderate to well sorted sandy clay; compact structure; fragments of mollusc shell are common; charcoal; traces of calcium carbonate; gradual contact with:
558.74–558.56	1.80–1.98	2	7.5YR 5/4 brown; moderate to well sorted slight sandy clay with clasts (up to 2mm); compact structure; fragments of a few mollusc shells; charcoal; traces of calcium carbonate; void between 1.98–2.00m.
558.56–558.16	2.00–2.40	1	7.5YR 4/4 brown, moderate sorted to well sorted very slight sandy clay with clasts (up to 3mm); compact structure; charcoal; light banding/layer between 2.05–2.06m; dark banding/layer between 2.26–2.27m; traces of calcium carbonate.

Table 6.5. Lithostratigraphic description, borehole BH6.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
560.45–560.28	0–0.17	3	10YR 3/2 very dark greyish brown; moderate sorted slight sandy clay with clasts (up to 30mm); compact and bulky structure; a few roots; a few fragments of mollusc shell; traces of calcium carbonate; gradual contact with:
560.28–559.95	0.17–0.50	2	7.5YR 4/2 brown; moderate sorted sandy clay with clasts (up to 8mm); partly broken (between 0.30–0.50m) but otherwise compact; a few roots; a few fragments of mollusc shell; traces of calcium carbonate; contact difficult to tell as it is broken into fragments.
559.95–559.59	0.50–0.86	1	7.5YR 5/4 brown; moderate sorted slight sandy clay; compact in structure; a few fragments of mollusc shell; traces of calcium carbonate.

Table 6.6. Lithostratigraphic description, borehole BH7.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
560.46–560.20	0–0.26	4	7.5YR 3/2 dark brown; poor to moderate sorted slight sandy clay with clasts (up to 15mm); compact structure; a few roots; a few fragments of mollusc shell; burned clay; traces of calcium carbonate; gradual contact with:
560.20–559.96	0.26–0.50	3	7.5YR 4/3 brown; poor to moderate sorted slight sandy clay; a few roots; a few fragments of mollusc shell; traces of calcium carbonate; gradual contact with:
559.96–559.86	0.50–0.63	2	10YR 3/3 dark brown; poor to moderate sorted slight sandy clay with clasts (up to 12mm); blocky structure and slightly crumbly; a few roots; fragments of mollusc shell are common; flint fragment; green/grey colour maybe plaster; a woody fragment maybe plant material; traces of calcium carbonate; gradual contact with:
559.83–559.46	0.63–1.00	1	7.5YR 4/3 brown; well sorted clay silt with clasts (up to 12mm); compact structure; a few roots; a few fragments of mollusc shell; traces of calcium carbonate.

Table 6.7. Lithostratigraphic description, borehole BH8.

Depth (m asl)	*Depth (cm bgs)*	*Unit number*	*Description*
560.08–559.93	0–0.15	6	10YR 3/3 dark brown; moderate sorted slightly sandy clay; crumbly structure; a few roots; a few plant material; traces of calcium carbonate; strong HCI reaction; gradual contact with:
559.93–559.85	0.15–0.23	5	10YR 4/3 brown; poor sorted sandy clay with angular limestone clasts (up to 16mm); blocky/crumbly structure; a few roots; charcoal?; small pieces of CBM or burned clay?; strong HCI reaction; gradual contact with:
559.85–559.58	0.23–0.50	4	10YR 4/3 brown; poor sorted slightly sandy clay with angular limestone clasts (up to 18mm); massive/ blocky and compact structure; a few very fine roots; a few pieces of broken mollusc shell; charcoal?; soft dull red particles maybe burned clay?; strong HCI reaction; gradual contact with:
559.58–559.40	0.50–0.68	3	10YR 4/3 brown; poor sorted slightly sandy clay with clasts (up to 18mm); massive/blocky structure; a few roots; a few fragments of broken shell; strong HCI reaction; void between 0.68–0.75m.
559.40–559.31	0.75–0.84	2	7.5YR 4/2 brown; matrix clay well sorted and sand grains and limestone clasts (up to 20mm); very compact structure; a few broken mollusc shell; strong HCI reaction; void between 0.84–0.93m with broken pieces as above.
559.31–559.24	0.93–1.00	1	0YR 4/3 brown; poor sorted slightly sandy clay with clasts (up to 18mm); massive/blocky structure; a few roots; a few fragments of broken shell; strong HCI reaction; void between 0.68–0.75m.

Table 6.8. Lithostratigraphic description, borehole BH9.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
558.99–558.76	0–0.23	6	10YR 3/3 dark brown; moderate to well sorted clay with clasts (up to 13mm); crumbly in structure; many roots; a few fragments of mollusc shell; well-marked contact with:
558.76–557.99	0.23–0.87	5	10YR 4/4 dark yellowish brown; moderate sorted clay; compact and crumbly structure; roots are common; a few fragments of mollusc shell; charcoal; burned clay; traces of calcium carbonate; void between 0.87–1.00m bgs.
557.99–557.65	1.00–1.34	4	7.5YR 4/4 brown; moderate to well sorted clay with clasts (up to 9mm); compact structure; a few roots; a few fragments of mollusc shell; large root between 1.14–1.17m (going downward); burned clay; gradual contact with:
557.65–557.46	1.34–1.53	3	10YR 4/3 brown; moderate sorted sandy clay with clasts (up to 10mm); crumbly/ blocky structure; a few fragments of mollusc shell; charcoal; burned clay; flint fragment; gradual contact with:
557.46–557.39	1.53–1.60	2	7.5YR 4/3 brown; moderate sorted clay; compact structure; a few fragments of mollusc shell; gradual contact with:
557.39–556.39	1.60–2.60	1	7.5YR 4/3 brown; well sorted clay with clasts (up to 5mm); compact structure; a few roots; charcoal; burned clay; green colour probably plaster at about 222cm; large piece of flint at 1.80m; large $CaCo_3$ nodules (up to 20mm); only 245cm captured.

Table 6.9. Lithostratigraphic description, columns SA1948 to SA1946 and SA2269.

Depth (m asl)	*Depth (m bgs)*	*Unit number*	*Description*
Column SA1948			
558.20–557.97	0–0.23	2	7.5YR 5/4 brown; poor to moderate sorted sandy clay; a few roots; a few fragments of mollusc shell; burned clay?; Plaster?; greyish surface; charcoal; gradual contact with:
557.97–557.70	0.23–0.50	1	7.5YR 5/4 brown; poor sorted sandy clay with clasts (up to 20mm); crumbly; stony and compact structure; traces of calcium carbonate.
Column SA1947			
557.88–557.38	0–0.50	1	7.5YR 4/3 brown; sandy clay with clasts (up to 1mm); compact to slightly crumbly structure; few fragments of mollusc shell; Charcoal; greyish surface (dots); traces of calcium carbonate
Column SA1946			
557.51–557.23	0–0.28	1	7.5YR 4/4 brown; well sorted sandy clay with clasts (up to 3mm); compact structure; a few fragments of mollusc shell; a few roots; charcoal; burned clay; traces of calcium carbonate; gradual contact with:
557.23–557.01	0.28–0.50	2	7.5YR 4/3 brown; moderate to well- sorted sandy clay with clasts (up to 2mm); crumbly to compact structure; large fragments of mollusc shell (up to 11mm) and smaller pieces; charcoal; burned clay; traces of calcium carbonate.
Column SA2269			
557.36–557.23	0–0.13	4	7.5YR 5/4 brown; poor to moderate sorted sandy clay with clasts (up to 15mm); very crumbly structure; a few fragments of mollusc shell; traces of calcium carbonate; well-marked contact with:
557.23–557.09	0.13–0.27	3	7.5YR 4/3 brown to 7.5YR 3/2 dark brown; moderate sorted sandy clay with clasts (up to 50mm); blocky and compact structure; a few fragments of mollusc shell; charcoal; small flint (6mm); traces of calcium carbonate; gradual contact with:
557.09–556.98	0.27–0.38	2	7.5 YR brown; moderate to well sorted sandy clay with clasts (up to 3mm); a few fragments of mollusc shell; traces of calcium carbonate; well-marked contact with;
556.98–556.86	0.38–0.50	1	7.5YR 4/3 brown; poor sorted clayey sand with clasts (up to 10mm); crumbly and stony structure; charcoal; traces of calcium carbonate.

Table 6.10. Lithostratigraphic description, borehole BH10.

Depth (m bgs)	*Unit number*	*Description*
0–0.11	3	7.5YR 4/1; As2 Ag2 Dh+ Gg+; dark grey clay silt with traces of detrital plant remains and gravel; gradual contact with:
0.11–0.26	2	10YR 3/1; As3 Ag1 Sh+ Dh+; very dark grey clayey silt with traces of organic matter and detrital plant material; gradual contact with:
0.26– 0.67	1	7.5YR 4/1; As3 Ag1 Dl+ Dh+ Sh+; dark grey clayey silt with traces of detrital wood and plant remains and organic matter.

Table 6.11. Lithostratigraphic description, borehole BH11.

Depth (m bgs)	*Unit number*	*Description*
0–0.06	6	7.5YR 3/1; Ag2 As1 Sh1 Dl+ Dh+; very dark grey silty clay with traces of detrital wood, detrital plant remains and organic matter; well- marked contact with:
0.06–0.20	5	7.5YR 4/1; Ag2 As2 Dh+; dark grey silty clay with detrital plant remains; gradual contact with:
0.20–0.40	4	7.5YR 3/1 ; Ag2 As2 Dh+ Sh+; very dark grey silty clay with detrital plant remains and organic matter; well-marked contact with:
0.40–0.46	3	7.5YR 3/1; Sh2 Th^{2}1 As1 roots+; very dark grey with high amount of organic matter; diffuse contact with:
0.46–0.49	2	7.5YR 3/1; Sh1 Th^{2}1 As1 Ag1 roots+ Gg+; very dark grey colour; well-marked contact with:
0.49–0.50	1	7.5YR 3/1; Ga1 Gg3; very dark grey colour with small pieces of gravel.

Table 6.12. Results of the pollen assessment from boreholes BH2, BH9 and BH11.

		BH2											*BH9*										*BH11*			
	Depth (m asl)	*557.88*	*556.17*	*556.09*	*556.24*	*556.2*	*556.16*	*556.08*	*556.05*	*556.01*	*555.87*	*555.69*	*558.51*	*558.31*	*558.19*	*557.74*	*557.63*	*557.6*	*557.49*	*557.41*	*557.39*	*556.61*	*0.26m bgs*	*0.42m bgs*	*0.46m bgs*	*0.50m bgs*
Latin name	*Common name*																									
Trees																										
Pinus	pine	1																								
Betula	birch					1																				
Shrubs																										
cf *Salix*																							1			
Herbs																										
Poaceae	grass family	1			1																		1			
Cyperaceae	sedge family																						1	1		
Chenopodium type	goosefoot family																						1			
Asteraceae	daisy family																						1		1	
Taraxacum	dandelion																						1			1
Unknown									1																	
Spores		1	1	1		26		4	33	2	5	1	71	21	54	2	11	7	11	1	3	1	74	46	73	25
Total Land Pollen (grains counted)		2	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	3	2	1
*Concentration**		1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
*Preservation***		4	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5	5
Microcharcoal concentration		0	0	1	0	4	0	1	1	0	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1

Table 6.13. Results of the non-pollen palynomorph assessment from boreholes BH2, BH9 and BH11.

Depth (m asl)	*BH2*											*BH9*										*BH11*			
Name	*556.17*	*556.09*	*556.24*	*556.2*	*556.16*	*556.08*	*556.05*	*556.05*	*556.01*	*555.87*	*555.69*	*558.51*	*558.31*	*558.19*	*557.71*	*557.63*	*557.6*	*557.49*	*557.41*	*557.39*	*556.61*	*0.26m bgs*	*0.42m bgs*	*0.46m bgs*	*0.50m bgs*
Dung/wood saprophytes																									
Chaetomium										cf 1															
Coniochaeta										1				1											
Sordaria cf *inequalis*																							1		
Aquatic?																									
Zygnema- type														1											
Unknown aquatic																							2		
Indeterminable/Unknown										3				1								3	4	3	1
Total counted Npp	1	1	1	0	26	0	4	33	2	5	1	71	21	54	2	11	7	11	1	3	1	74	46	73	25
Concentration*	1	1	1	0	1	0	1	1	1	1	1	3	1	2	1	1	1	1	1	1	1	3	2	3	1

Table 6.14. Results of the phytolith assessment from borehole BH9.

Depth (m asl)	*558.51*	*558.31*	*558.19*	*557.71*	*557.63*	*557.6*	*557.49*	*557.41*	*557.39*	*556.61*
Long smooth		12	5	7	13	12	4	6	13	
Dendritics		6	7	13	24	20	10	10	9	2
Sinuous							1	1		
Key stone		9	8	2	8	3	3	5	5	
Hair					1					
Bulliform			1	1						
Bilobes									1	
Multicells		3	1			3	1		1	
Phytoliths of inconsistent morphological shape (overall)		few	few			few		few	v. low	many
Total counted phytoliths	–	30	22	23	42	46	19	22	29	2
Concentration*		2	2	3	2	3	3	3	2	1
Preservation**		4	3	4	4	4	4	3	4	5

Table 6.15. Results of the diatom assessment from boreholes BH9 and BH11.

Depth m asl	*Concentration*	*Preservation BH9*	*Diversity*
558.99	0	0	–
558.91	0	0	–
558.83	0	0	–
558.27	0	0	–
557.71	0	0	–
557.49	0	0	–
557.39	0	0	–
557.08	0	0	–
556.7	0	0	–
m bgs		*BH11*	
0.38m bgs	1	4	1
0.42m bgs	0	0	–
0.46m bgs	1	3	1
0.5m bgs	1	2	1

7. ETHNOARCHAEOLOGICAL RESEARCH IN BESTANSUR: INSIGHTS INTO VEGETATION, LAND-USE, ANIMALS AND ANIMAL DUNG

Sarah Elliott, Robin Bendrey, Jade Whitlam and Kamal Raeuf Aziz

Introduction

We conducted an ethnoarchaeological pilot study in and around the modern village of Bestansur to contribute towards the framework of archaeological analyses being carried out at the Early Neolithic site during the field seasons in spring/summer 2012 and spring 2013. Preliminary results are reported in Elliott *et al*. (2015) and Bendrey *et al*. (2016). The aim of this chapter is to discuss the programme of research that was undertaken and its role in informing archaeological interpretation as well as to consider potential avenues of future research. Although a modern comparison cannot provide direct parallels for examination of Neolithic villages in this research, the selection for study of a modern village community in a rural setting in the same geographic area with traditional practices does enable exploration of similarities and differences in parameters and material characteristics to aid interpretation.

Ethnoarchaeology can contribute significantly to archaeological understanding and has been used in many studies to provide a basis for interpretations about past human behaviour and society (Gould 1978; Middleton and Price 1996; Tsartsidou *et al.* 2008; 2009; Jenkins *et al.* 2011; Gur-Arieh *et al.* 2013; Portillo *et al.* 2014). Ethnoarchaeological studies are not without limitations, however. Crucially, they cannot inform us about prehistoric behaviour patterns that have no modern counterpart nor analogue (Gould 1978: 254). Nevertheless, when modern societies are identified with apparently similar practices to the archaeological communities being examined, the information obtained may be highly valuable within archaeology. A contrastive approach to ethnoarchaeology should not replace analogy but be used to supplement and extend it (Gould 1978). Schiffer (1978) argues that participants from interviews in any behavioural system do not encode their memories in sufficient detail about all events and activities to form the basis of sound behavioural observations and generalisations. It is therefore difficult to make statements about the reliability of information gathered during interviews conducted in ethnoarchaeological research. In addition, the use of translation within the interviewing process highlights further issues regarding accuracy and detail, therefore adding to potential inconsistencies in information. Even with these limitations, however, there is an important place for ethnographic research within archaeology. Ethnoarchaeological research increasingly plays a key role in helping us understand and interpret archaeological signatures (David and Kramer 2001). Ethnoarchaeological research was a key component of previous research on the Neolithic in the highland Zagros in Iran and included the study of land, plant and animal resources and management (Watson 1979; Kramer 1982). Little ethnoarchaeological research, however, has been conducted in the lower Zagros in Iraq. A key aim in this research therefore is to conduct ethnoarchaeological research in this region of the lower Zagros and to develop the range of scientific techniques that are applied to analysis of ethnoarchaeological materials in order to aid and to test archaeological methodologies, data and interpretations of traces of activities and animal management practices, in order to provide greater rigour and insights into archaeological approaches (Portillo *et al.* 2014; Elliott *et al.* 2017; Jenkins *et al.* 2017).

Research rationale, aims and objectives

Living near the archaeological site of Bestansur and being embedded within the local community provided an opportunity to conduct ethnoarchaeological research within the small, rural village of Bestansur (Fig. 7.1). This situation gave us a unique insight into everyday lives and allowed us to observe first-hand the rural rhythms of the village as well as the nuances of the interactions between people, animals, plants and the environment (Bendrey *et al.* 2016). The inhabitants of Bestansur live mainly in houses of modern construction but they are connected to the land through their animals and plants as well as through familial and cultural traditions. Studying these interactions and the evidence they leave behind can, therefore, potentially provide information to help us interpret archaeological signatures within the same geographical context as the excavations.

The main aim of the pilot ethnoarchaeological study at Bestansur was to determine whether ethnoarchaeological studies of environment, ecology, modern animal management and husbandry can provide evidence to help interpret the archaeological datasets. The methodology included interacting with, observing and studying how families in the modern village used and managed their livestock within the local landscape to develop an understanding of locally contextualised animal and plant use and economies which might be compared to the Neolithic site of Bestansur. This involved investigating the interplay and impact of different environmental factors, at a local and regional level, to observe the influences that they have on animal husbandry, (Bendrey 2011) and arable farming practices (Dreslerová *et al.* 2013). This research uses a multi-proxy ethnoarchaeological methodology combining a range of interdisciplinary approaches to the study of modern rural societies, with a focus on vegetation, land use, animals and animal dung.

This chapter will introduce the main themes under two headings: vegetation and land use, and animals and dung. This will be followed by a section on the research approaches and methods and then the key results will be presented under three main headings; 1) interviews, observations and tracking herds, 2) kitchen gardens and 3) animal dung. The results are followed by discussion, conclusions and suggestions for future directions.

Vegetation and land-use

Most of the Zagros today is within the Zagros temperate zone with a mean annual temperature of between 15–25 ºC and considerable variability in modern annual rainfall with strong seasonal variations (Roustaei *et al.* 2006). The study area is within the semi-arid temperate zone. Iraqi Kurdistan today has a semi-arid climate with a strong continental component, characterised by cold, snowy winters and long, warm, dry summers (Maran and Stevanovic 2009). The environment around the village of Bestansur can be classified into different ecological and functional domains (Elliott *et al.* 2015). There are three distinct physical zones around Bestansur today within 3–5km: the river catchment area, the farmed alluvial plains and the limestone foothills (Fig. 7.1). There is one main water source in the village, a spring from the large karstic aquifer located directly below (Saeed Ali 2007). The immediate land around Bestansur consists of a gently sloping agricultural plain which now makes up the main cultivation land in this area.

The present-day vegetation of the study area is strongly influenced by environmental variables such as precipitation and temperature, with both the cold winter period and hot dry summer inhibiting plant growth (Zohary 1973: 35). In phytogeographic terms Bestansur falls into the Kurdo-Zagrossian sub-division of the Irano-Turanian region (Zohary 1973: 87), which is dominated by climax vegetation mostly in the form of steppe- or park-forests. On the foothills of the Zagros a dense ground cover of steppe vegetation is represented by pistachio–almond (*Pistacia*–*Amygdalus*) scrub, along with herbaceous communities largely dominated by *Astragalus* spp., and *Salvia* spp., and wild grasses. However, human activity, particularly agriculture, has significantly altered the natural vegetation of the study area in recent times.

Arable agriculture is a key economic activity in Iraqi Kurdistan and some 35% of Iraqi Kurdistan is currently used as arable land, covering substantial areas in the broad valleys and plains (Maran and Stevanovic 2009: 103–104). The average size of a single-family landholding is less than 10ha, with most households maintaining a kitchen garden in which some, or all, of the plants being cultivated are for household consumption. Winter crops are normally grown between October and May and summer crops from March to September. Fruit production is also widespread, due to favourable climatic conditions and most villages have orchards, which are typically irrigated during the summer. Poplar (*Populus* spp.) and willow (*Salix* spp.) plantations can also be found in many valleys and alluvial plains. The principal crops cultivated in northern Iraq today are summarised in Table 7.1. Forest and rangeland currently account for 40% of the land use in Iraqi Kurdistan, while altitudes higher than *c.* 1500m asl are mainly used for the grazing of sheep and goats in the summer. In the upland pastoral system, family-centered economies are based on the sale of meat, milk and wool products.

Figure 7.1. Top: Location of Bestansur modern village in relation to the archaeological site, river catchment area, the alluvial plains and limestone foothills of the Zagros Mountains. Bottom: Google Earth view with location of top map marked in hashed box.

Small-scale poultry production is also practiced in most villages. While tensions exist between the land use needs of plant and animal husbandry, these two practices are also closely linked within agricultural strategies and have been for millennia.

The primary aim of the plant-based component of this research was to gather information to enhance our understanding of how plant and animal management are integrated at the level of individual households through, for example, the provision of fodder and/

Table 7.1. Principal crops in northern Iraq today (Maran and Stevanovic 2009: 103–104).

Major crops	Wheat (*Triticum* spp.) and barley (*Hordeum vulgare)*, sunflower (*Helianthus annuus)* and sesame (*Sesamum indicum*), chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), broad beans (*Vicia faba)*, and sugar beet (*Beta vulgaris)*.
Vegetable crops (grown under irrigated or locally favourable conditions)	Tomato (*Solanum lycopersicum)*, cucumber (*Cucumis sativus)*, onions (*Allium cepa)*, eggplant (*Solanum melongena)*, and okra (*Abelmoschus esculentu*)
Crops grown under rotation in the summer growing season	Rice (*Oryza sativa)*, maize (*Zea mays)*, sunflower and cotton (*Gossypium hirsutum*)
Fruit trees	Apple (*Malus domestica*), pear (*Pyrus communis)*, cherry (*Prunus* spp.) and walnut (*Juglans regia)*, figs (*Ficus carica)*, apricots (*Prunus armeniaca)*, pomegranates (*Punica granatum)*, peaches (*Prunus persica*) and almonds (*Prunus amygdalus*)

or the use of manure on cultivated plots. To examine these inter-relationships, we focused on elucidating the role and function(s) of informants' kitchen gardens in order to explore how plant and animal husbandry relate to the village's structure and economy as part of a sustainable strategy operating at a household level. An additional aim of the plant-based research was to collect modern plant specimens from the surrounding environs for strontium isotope analysis and to create herbarium specimens for identification and curation in the UK (Table 7.2).

Animals and dung

Archaeologists are increasingly turning to ethnographic research to inform interpretations of different archaeological signatures, particularly with regard to dung studies (Hole 1978; Anderson and Ertug-Yaras 1998; Shahack-Gross *et al.* 2003; Lancelotti and Madella 2012; Wallace and Charles 2013; Portillo *et al.* 2014; Berna 2017; Morandi 2018). A crucial ethnoarchaeological line of investigation relating to archaeological analysis of faecal material is the creation of modern dung reference collections and examination of faecal contents (Brochier *et al.* 1992; Canti 1997; 1998; 1999; Anderson and Ertug-Yaras 1998; Chame 2003; Lancelotti and Madella 2012; Portillo *et al.* 2014; 2017). While dung studies are increasingly collecting reference samples, collections are often small and region or site specific. It is important therefore to produce reference collections in relation to the study area as previous studies have shown differences in dung signatures from different regions (Brochier *et al.* 1992; Portillo *et al.* 2014). Studies have shown that, for example, faecal spherulite production varies based on grazing locations particularly soil pH (Canti 1999) and therefore is likely to be linked to geology. Recent research has also related faecal spherulite production to diet (Dalton and Ryan 2018), which is therefore linked to grazing environment and vegetation and/or foddering practices. An important ethnoarchaeological approach to dung studies is the examination of animal diet through the analysis of macrobotanical, pollen or phytolith remains extracted from dung deposits (Charles 1998; Valamoti 2013; Wallace and Charles 2013; Portillo *et al.* 2014). Another ethnoarchaeological aspect of dung studies which is important for recognising early animal management and domestication is the identification of animal pens. Shahack-Gross *et al*. (2003) and other scholars have identified stabling or penning deposits which characteristically were dominated by organic material formed into layers (Anderson and Ertug-Yaras 1998; W. Matthews *et al.* 2000; Macphail *et al.* 2004: 189; Matthews 2005). By establishing the microscopic signatures from modern animal dung samples collected in Bestansur, the key aim of this ethnoarchaeological research was to provide modern faecal samples which would help in the interpretation of faecal material in archaeological samples (Chapter 16).

Research approaches and methods

The ethnoarchaeological programme implemented in Bestansur was carried out by a team of CZAP specialists and involved a multi-method interdisciplinary approach (Table 7.2). This methodology encompassed semi-structured interviews with local families, plant collection, personal observations/tracking the herds, dung and penning analysis, modern village soil sampling and finally environmental characterisation. The environmental characterisation included strontium isotope analysis of plants, elemental and mineralogical analysis of soils, and oxygen isotope analysis of water. The methods utilised in this research are presented in Table 7.2 with details of specific objectives, materials and methodologies.

Results

Initial data and interpretations have been published in Elliott *et al*. (2015) and Bendrey *et al*. (2016) and a summary of the main results is provided here.

Table 7.2. (continued overleaf) CZAP ethnoarchaeological methods, objectives and sample collection.

Method/Approach	*Objective*	*Materials*	*Specific methodology*	*Details*	*References*
Environmental characterisation		Water, plant and soil samples	Oxygen and nitrogen isotope analysis (water and plant samples), X-ray fluorescence and X-ray diffraction (soil samples)	Soil: ×6 soil samples *c.*10g collected from the alluvial plains and limestone foothills	Elliott *et al.* 2015
Interviews	The semi-structured interviews carried out on informants from Bestansur village were conducted to collect a multi-faceted dataset. The questionnaire was formatted to investigate modern use and management of livestock within the local landscape. A supplementary questionnaire focused on the role and function(s) of households 'kitchen gardens' with a specific focus on links between plant and animal husbandry (e.g. foddering, manuring)	Questionnaire-translated conversation	The interview framework used a questionnaire but allowed discussion to expand naturally when appropriate	×3 families interviewed (×2 families provided information on past and present activities, ×1 family provided information on present activities only). ×2 families provided information on kitchen gardens	Elliott *et al.* 2015
Plant collection	To collect plant (leaf) material for Strontium Isotope analysis and to contribute to environmental characterisation of the landscape	Plant specimens	For each collection 2–3 specimens were collected so that each part of the whole plant (e.g. roots, leaf, flowers etc.) was represented. Relevant notes (e.g. habitat, flower colour etc.), digital photographs and GPS readings were obtained for each collection. Fresh plant material was pressed until dry and exported to the UK. After the necessary material had been removed for isotope analysis the dried plants were deposited at the University of Reading Herbarium for identification and curation. Replicates were sent to Kew Herbaria	25 plant samples were collected from locations including, grazed fallow fields, margins of streams, the slopes of Bestansur and the edges of cultivated fields and track ways	Davis 1961; www.reading.ac.uk/herbarium

Table 7.2. (continued from previous page) CZAP ethnoarchaeological methods, objectives and sample collection.

Method/Approach	*Objective*	*Materials*	*Specific methodology*	*Details*	*References*
Tracking the herd and observing grazing patterns	This methodological approach was an extension to the interviewing aspect of the ethnoarchaeological methodology. The aim of this approach was to observe the diet of the animals and track their grazing location and duration, using hand held GPS	Observations, questions and *in situ* sample collection (dung as observed during grazing)	A period of time was spent tracking sheep/goat herds around Bestansur to observe their typical grazing patterns and diet	5 hours observing the herds and interviewing the herder. Grazing locations logged using handheld GPS. ×4 dung samples collected from known species.	Elliott *et al.* 2015
Dung collection	The modern comparative dung reference collection was designed to aid archaeological interpretations of potential ancient dung deposits. A range of information can be collected from the analyses of modern faecal material such as numbers of faecal spherulites and numbers and types of phytoliths which can be related to known animal diet	Dung samples (known species, animal pens). Spatial and vertical samples from animal pens	Micromorphology, spherulite analysis, portable X-ray fluorescence (pXRF), phytolith analysis	×8 dung samples collected during interviews, ×4 dung samples collected during herding. Spatial dung sampling ×7 dung samples. Vertical sampling ×11 dung/penning samples	Guilloré 1985; Courty *et al.* 1989; Katz *et al.* 2010; Canti 1997; Rosen 1999
Modern village surface soil sampling	The framework for sampling the modern soils was to investigate areas which potentially could include low traces of animal dung.	Loose soil samples taken from targeted areas within the modern village (roads, thoroughfares, peripheral areas etc)	pXRF, spherulite analysis and phytolith analysis	×10 loose soil samples taken	Katz *et al.* 2010; Canti 1997; Rosen 1999

Figure 7.2. Bestansur family being interviewed in their 'kitchen garden' plot.

Interviews, observations and tracking herds

Families were interviewed (Fig. 7.2) and herds observed (Fig. 7.3) to provide information on vegetation, land use and animals. Four families from Bestansur village were interviewed. Three families (Households 1, 2 and 4) provided information on present-day activities, one (Household 4) on past and present activities and the fourth (Household 3) gave information about activities *c.* 70 years ago in the recent past. The tracking of the herd provided vital first-hand observations of animal diet and offered an opportunity to observe their grazing habits (Fig. 7.4), collect plants (Fig. 7.5) and to collect dung directly from specific animals (Fig. 7.6). This activity gave us the opportunity to conduct more extensive interviewing. The grazing route during the spring involved visiting several fields to the east of the karst-spring in Bestansur (Fig. 7.7). The information gathered during this aspect of the ethnoarchaeological pilot study provided important additional insights into animal diet and helped to clarify the information we were given. The herders insisted, for example, that the animals did not eat the reeds (*Phragmites*). However, we observed that this was not the case, with many animals recorded as grazing on the reeds and bulrushes (*Typha*) along the edge of the spring (Fig. 7.8). As CZAP excavations were conducted in both the spring and summer we were able to conduct fieldwork during these key periods and therefore to observe Bestansur village and its animals in contrasting seasons and weather to examine the nature and impact of variation in environment on animal management, grazing and browsing and archaeologically detectable traces and faecal matter (Figs 7.4, 7.9 and 7.10).

Kitchen gardens

Although modest, our preliminary dataset clearly demonstrates that kitchen gardens serve several purposes for the villagers of Bestansur including provision of food, decoration and fodder, with both continuity and variation in practices observed between the two households interviewed (Elliott *et al.* 2015; Bendrey *et al.* 2016). The function(s) of these garden plots (Fig. 7.2) is linked to differences in plot size, household gender roles, personal preferences and family traditions, as well as the household's wider

Figure 7.3. Heading out with the herd. Observations of grazing route.

Figure 7.4. Goats browsing on shrubs and trees adjacent to the Neolithic archaeological mound.

Figure 7.5. Plants being collected while observing the herds on the grazing route.

Figure 7.6. Dung samples being collected while observing the herds on the grazing route.

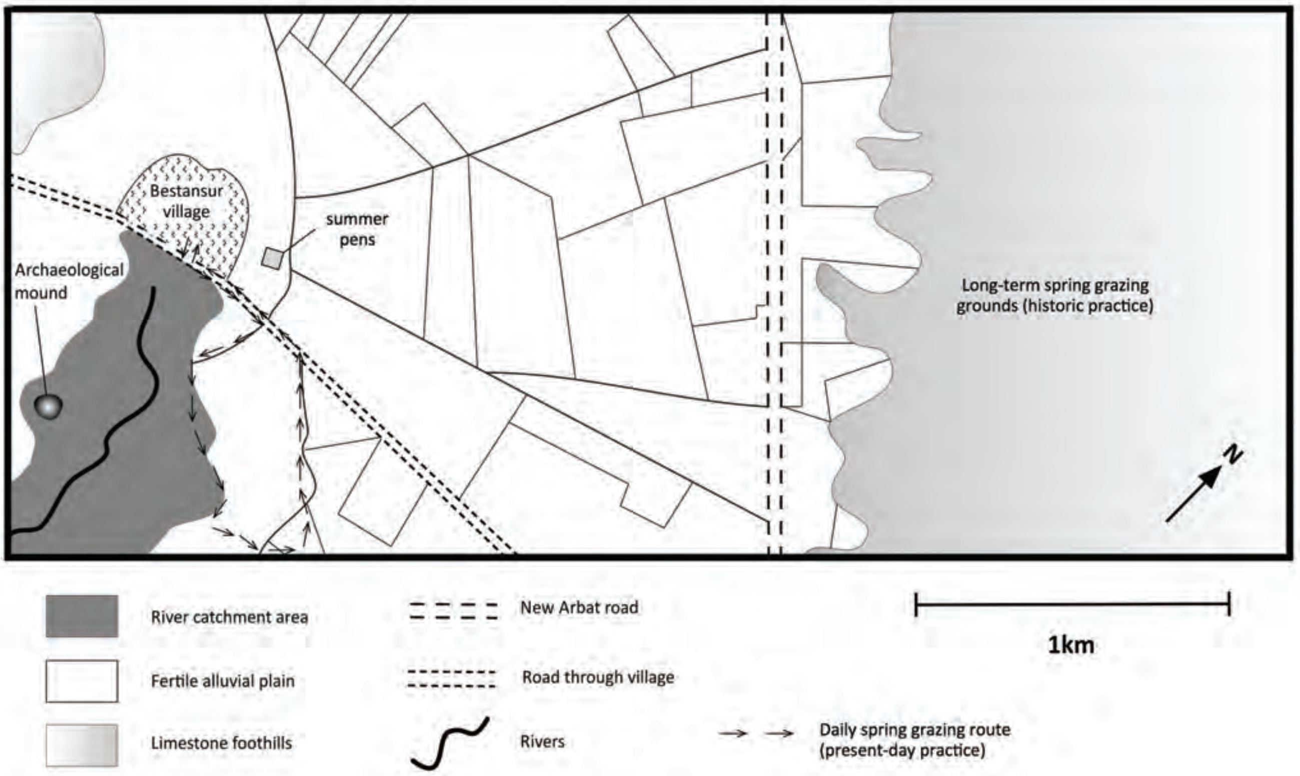


Figure 7.7. Grazing route taken daily by sheep and goat herders, east of the village to the agricultural fields adjacent to the river catchment area.

Figure 7.8. Sheep grazing on reeds alongside a spring.

Figure 7.9. Sheep and goat herds grazing on the lush vegetation around arable crop fields in the spring.

Figure 7.10. Sheep and goat herds grazing on the fallow fields in the summer.

Figure 7.11. Dung being collected from households and communal areas to be used as fertiliser on 'kitchen garden' plots.

agro-economic strategy. In both cases primary links with animal management, which are the main focus of this study, were expressed by (1) the collection and use of manure to fertilise garden plots, with dung being either collected from the households' own animals (Household 1), or from another household's livestock (Household 4, Fig. 7.11), and (2) through the production of fodder as a by-product of weeding and, in the case of Household 1, also by intention. It is clear even from this limited sample size that plant and animal management are closely linked at a household level and that this relationship extends beyond the sphere of the individual group, with dung and plant material being exchanged between households within the village.

Animal dung

Initial results from the dung reference collection have previously been published (Elliott *et al.* 2015). More extensive results from the reference collection will be compared in a separate publication to fully investigate the differences between all the dung samples studied. During the ethnoarchaeological fieldwork important details were collected from the two households relating to the diet of the animals which were later correlated with and compared to the microscopic dung analysis. Silica phytoliths (Fig. 7.12) extracted from the dung deposits provide an indication of diet and the interviews in the ethnoarchaeological pilot study supplied the information to establish a 'known diet' of the animals. Furthermore, both our personal observations and the information gathered from the shepherd during the tracking of the herds provides information which correlates with some of the dung samples.

The dung samples and the dung penning deposits (Fig. 7.13) collected from Bestansur were analysed using a combination of techniques. These samples were collected for a range of analyses that would enable the characterisation of the faecal material and could later be compared to the archaeological analyses. The dung reference collection compared animal dung samples with a 'known diet' against phosphorus values, spherulite numbers, phytolith assemblages and micromorphological results. Phosphorus is elevated in all dung samples and spherulites and phytoliths are also present in them

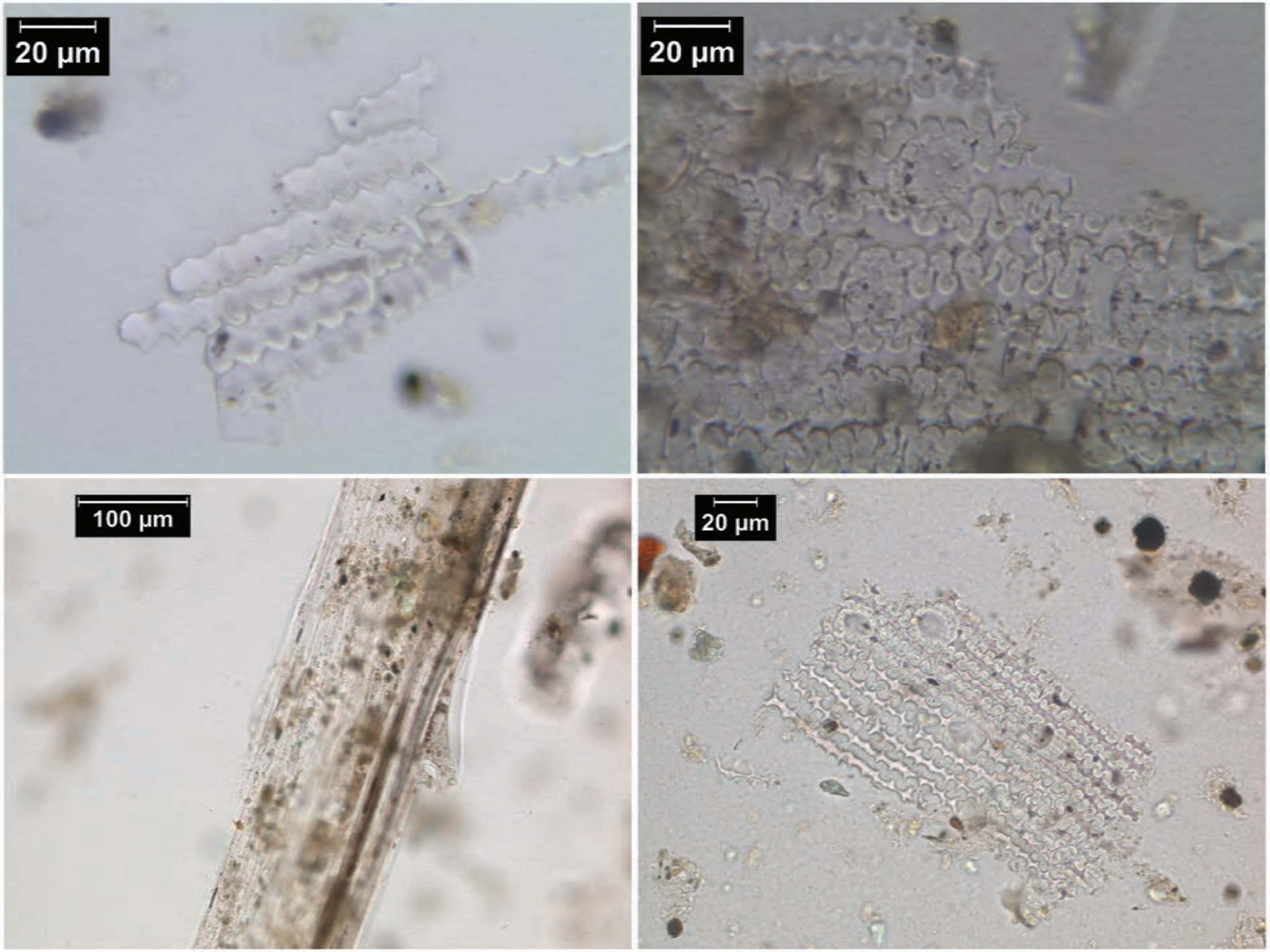


Figure 7.12. Silica phytoliths extracted from dung samples collected in Bestansur village. a) grass leaf/stem multi-celled phytolith, b) Triticum (wheat) multi-celled phytolith, c) awn multi-celled phytolith, d) Hordeum (barley) multi-celled phytolith.

Figure 7.13. Small trench dung into modern animal pen for sampling of dung deposits, Bestansur village (scale 15cm).

all (Elliott 2015; Elliott *et al.* 2015). Phytoliths were common in all dung samples and were dominated by grass phytoliths (monocotyledons, Fig. 7.12). Most samples contained low numbers of phytoliths from shrubs and trees (dicotyledons). Wheat (Fig. 7.12), barley husks (Fig. 7.12) and reed stems and leaves were identified in some of the dung remains (Elliott 2015; Elliott *et al.* 2015).

In the dung samples analysed from the animal pen (Fig. 7.13), phosphorus was elevated throughout the profile, in the dung deposits and in the sediment beneath. Spherulites in the animal pen deposits were abundant and highest in the fresh dung and slightly reduced in the older dung. The micromorphological thin section showed clear degradation of the animal dung with age, particularly a darkening in the colour and reduction in numbers of spherulites.

Discussion

The aim of this pilot study was to determine whether ethnoarchaeological studies of environment, ecology, modern animal management and husbandry can provide evidence to help interpret the archaeological datasets. Whilst we applied a standard methodology in the archaeological fieldwork each season, the ethnoarchaeological programme varied and was adapted and developed based on ongoing results obtained both archaeologically and ethnoarchaeologically. Modern ethnoarchaeological comparative datasets can provide important insights into materials, practices and environment for archaeological investigations (Kramer 1979; Brochier *et al.* 1992; Anderson and Ertug-Yaras 1998; Shahack-Gross *et al.* 2003; Lancelotti and Madella 2012; Portillo *et al.* 2014). Known information and scientific results from modern datasets can be compared against unknown archaeological results and can further aid archaeological interpretation by identifying and evaluating similarities and differences in signatures. One example where this approach was successful at a Neolithic site was at the site of Makri, Greece (Tsartsidou *et al.* 2008; 2009). This study specifically used ethnoarchaeological phytolith analysis in order to interpret use of space. Results suggested that the archaeological site was both a mixed pastoral and agricultural economy at a permanently occupied site. Another example of successful integration of scientific ethnoarchaeology with archaeological interpretation is from sites in Mexico analysed by Middleton and Price (1996). This study used modern floor deposits to examine geochemical signatures which enabled successful identification of archaeological floor deposits. In Syria, Portillo *et al.* (2014) used analyses of ethnoarchaeological phytoliths and dung spherulites to examine Neolithic household behaviour, specifically identifying domestic activities and spatial distributions. This study successfully identified activities such as storage and cereal processing, and they were able to identify room-use patterns and household behaviours (Portillo *et al.* 2014).

The ethnoarchaeological pilot study included in this research was carried out in the modern village of Bestansur 620m from the archaeological mound, and the selection of a modern village community in a rural setting with traditions and practices arguably similar to those of the Neolithic enables exploration of similarities and differences in parameters and material characteristics to aid interpretation. This investigation correlated what can be observed microscopically with known information from field observations and interviews. The overall aim was to develop scientific datasets from controlled sampling for comparison to ancient materials to provide a more robust framework for interpretation of archaeological deposits. However, a margin of error should be taken into account because all aspects of animal husbandry and animal practices such as foddering and grazing cannot be ascertained in the limited time of observation in this pilot study. Furthermore, the vegetation and crops grown will not directly represent the conditions in the Neolithic, especially with the introduction of newer domesticates such as tomatoes and watermelon.

Conclusions and future directions

The ethnoarchaeological methods used in this research were designed to test and help inform the archaeological analysis (Elliott 2015). In this pilot study we recognise the requirement for a combination of interviews and personal observations to compile the overall knowledge utilised as the foundation of the research. The information provided by the families and the observation of grazing herds provided a detailed account of the local environment and vegetation and animal diet, including foddering, grazing and browsing practices. A cycle of plant growth, animal foddering and application of manure as fertilisation was observed. Obtaining an informed and contextualised account of the modern plant, environment, animal and human interactions enables us to consider wider research questions regarding interactions between these elements in the past. Examining these relationships today allows us to develop interpretations on how people and animals might have interacted with the surrounding environments in the past, and how everyday life and habituation practices may have left signatures which can be identified and interpreted today. By analysing modern signatures of both human and animal activity we can successfully integrate scientific methodological results into archaeological interpretation in order to address questions such as plant and animal domestication, animal diet, foddering and grazing regimes, village structure, use of space and identification of different activities (Elliott *et al.* 2015; Bendrey *et al.* 2016).

In this study evidence for animal diet was observed in the dung samples, and animal penning deposits were documented in micromorphological thin sections which provided evidence to interpret penning deposits archaeologically (Chapter 16). Different environmental and ecological zones were recognised around Bestansur and these were also recognised in the strontium isotope results conducted on soil samples collected from around Bestansur (Elliott *et al.* 2015).

This ethnoarchaeological dataset at Bestansur highlights the value of integrated interdisciplinary ethnoarchaeological approaches that link the study of environment, plant and animal management and socio-economic and cultural practices, and the need for further work that extends the household data-set and conducts a similar seasonal approach, to visit the study area in all four seasons and obtain yearly rhythms and patterns. Additional interdisciplinary ethnoarchaeological and experimental combustion research on animal management, diet and dung fuel use was conducted in 2017 by Portillo and Matthews (Chapter 13) focusing also on sustainable architecture materials, construction and the built environment and building on the studies here.

8. CONSERVATION

Jessica S. Johnson

Conservation at Bestansur

Artefact conservation as an integrated element of excavation activities helps to ensure better recovery of fragile items, careful reconstruction of broken artefacts for documentation and analysis, and support for materials identification. Some of the earliest techniques and ideas about the importance of 'field conservation' were developed in the Middle East, and the field of conservation, particularly in the UK, has been heavily influenced by concern about immediate preservation during and after excavation (Petrie 1888; Sease 1992).

Conservation and preservation of the site and the finds are given careful consideration at Bestansur. Numerous simple but thoughtful practices are part of the day-to-day work and help to ensure that the site and the finds are kept as stable as possible during on-going excavations. These include shade cover over the entire site (Fig. 8.1), covering the site with plastic each evening, and making suitable supplies

Figure 8.1. View of Trench 10, with shelter and coverings to slow drying of excavated areas and artefacts.

and materials such as plastic boxes, Japanese tissue and aluminium foil available for storage of fragile finds immediately upon excavation. At the end of the season, walls are given physical support with plastic woven bags filled with soil and the site is backfilled (Chapter 2). All of these practices are part of normal excavation practice of Bestansur and should serve as a model for other excavations.

This chapter discusses observations and work undertaken on-site as well as ideas for how excavation projects such as Bestansur can help support the future of heritage conservation in Iraq. The chapter specifically documents activities carried out at Bestansur, Sulaimaniyah, Iraq, 1–21 April 2014, highlights the conservation challenges encountered at sites such as this, and provides recommendations on this basis. Further conservation treatments and training were conducted by Julie Unruh in April 2017 and are detailed in the open access CZAP archive report: https://www.czap.org/archive-reports .

Artefact conservation in Iraq

The field of conservation developed early in Iraq with a laboratory established at the Iraq Museum in Baghdad in 1932 (Al-Naqshbandi 1973). To highlight the early significance of this, the first laboratory in the UK opened at the British Museum in 1920 and the first laboratory in the US opened at the Fogg Museum at Harvard in 1928. The Baghdad laboratory still exists, and until recent years was the only active conservation laboratory in the country.

In 2009 a new conservation education facility opened as a partnership between the US State Department, the State Board of Antiquities and Heritage and the Kurdistan Regional Government. Based in Erbil, the Iraqi Institute for the Conservation of Antiquities and Heritage (IICAH) is now managed by a five member Iraqi Board of Directors with an international Advisory Council. Programmes in artefact conservation, architectural conservation and archaeological site preservation, sponsored by the US State Department and managed by the University of Delaware, have developed since its foundation, led by Executive Director Brian Lione. A variety of shorter courses have also been offered by a number of other international academic and non-governmental institutions (Johnson *et al.* 2014). At least two museums in the Kurdistan Regional Government have now opened conservation labs staffed and supported by graduates of IICAH programs (at the Slemani Museum and the Erbil Civilizations Museum). However, there is a dearth of opportunities for practical, hands-on experiences for students trained at the IICAH – a standard part of conservation training. The 2014 CZAP field season was an opportunity for three young Kurdish archaeologists and conservators, staff of the Slemani Museum, to gain some knowledge and experience in archaeological field conservation techniques through both observation and participation, as described below. Kamal Raeuf Aziz, Nyan Nasser and Hero Salih were exemplary in their work and their help in the field.

Conservation on-site

The majority of time was spent working on site lifting a number of very fragile artefacts. These included woven material at first thought to be textile (later identified as degraded matting), small clay balls and shapes that may be figurines, a large fragment of burnt or bitumen-lined matting, and a few other materials. Two basic methodologies were used – facing with Japanese tissue and block lifting, or careful excavation of soil away from the edges of artefacts, with or without consolidation, and then removal. Because of the damp soil conditions, maintained during excavation by the shade cover and daily covering of the site with plastic, fragile artefacts are kept physically supported by the clayey soil until it dries (Roth and Tsu 2002).

Fragile in situ *materials*

Three block lifts were undertaken on areas of fragile organic remains in C1771 (Fig. 8.2). A block lift is a method of removing a fragile artefact while keeping it supported by the surrounding soil (Payton 1992). *In situ* macro-shots of the artefacts were taken by project photographer Chris Beckman before lifting, in case the block failed. Viewing these images after excavation at the laboratory, it became clear that, though at first glance the first two artefacts lifted had a woven structure of fine threads, in fact there was no place where a finely divided weave pattern could be discerned. The fibres were not twisted which would have indicated that they were spun. Instead, the interwoven structure seems to be composed of fine fibres that are the remains of wider grasses or reeds. A third, separate area of interwoven material in C1781 is a better-preserved black area where complete elements of the interwoven material are visible – either as carbonised material or perhaps bitumen lining and white traces of phytoliths preserving the surface shape of the material (Fig. 8.3).

In each case the organic material was faced with Japanese tissue using Paraloid B-72 (see information on materials below) to keep it from shifting and then block lifted. Antiquities Directorate Representative Kamal Raeuf Aziz did much of the physical removal of soil for all the blocks and was assisted by conservation intern Nyan Nasser (Fig. 8.4). After excavation, all blocks were taken back to the laboratory and given additional physical support around the base using several layers of aluminium foil strapped tight with locally purchased tape (which will not be stable long term). Each was then inserted into a support cut into polyethylene foam inside a plastic box for drying and storage.

Figure 8.2. Organic materials in situ, before lifting, C1771 Sp50 B5 T10.

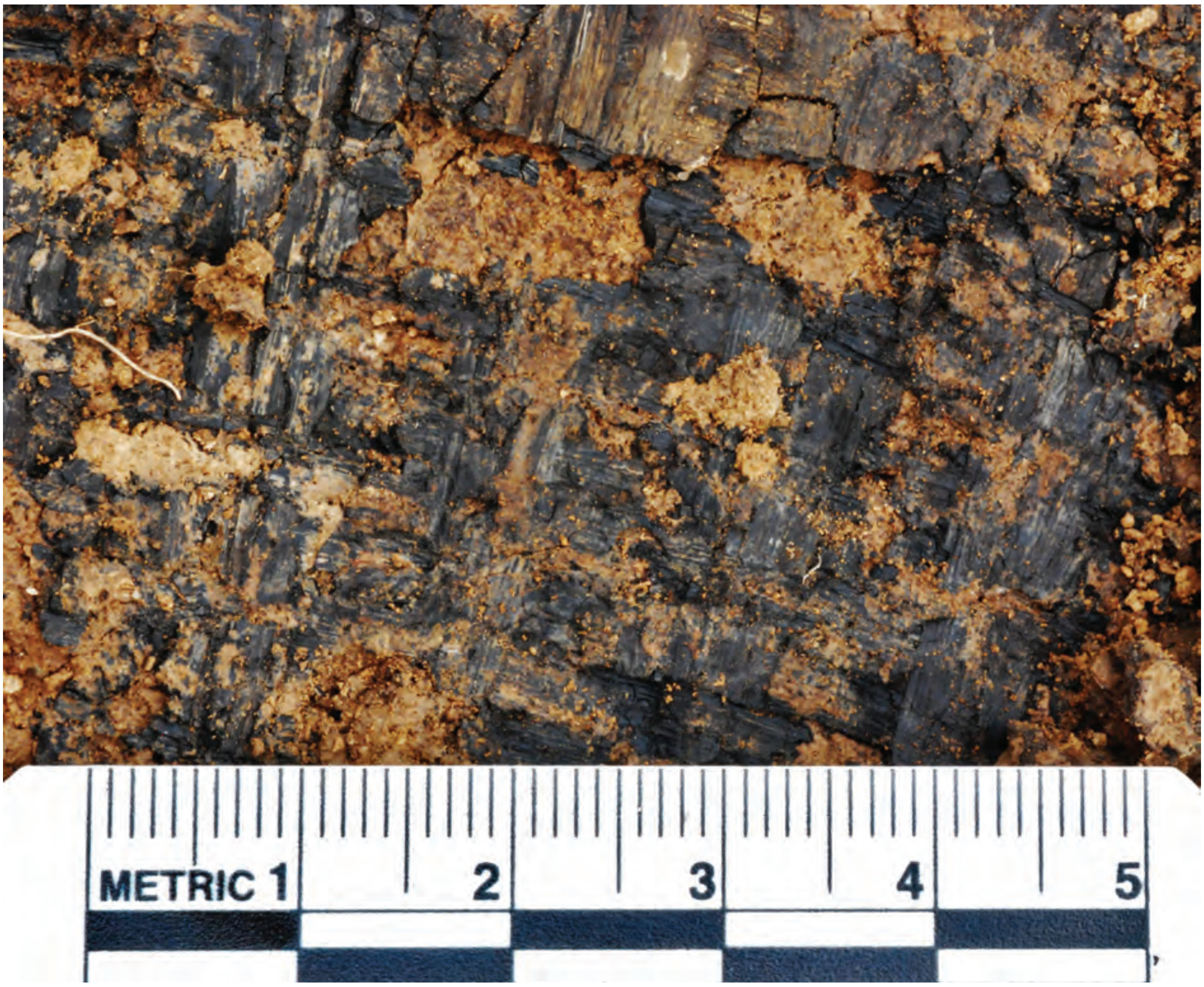


Figure 8.3. Grass or split-reed matting, C1781 Sp50 B5 T10.

Figure 8.4. Kamal Raeuf Aziz (left) and Nyan Nasser removing a block with matting stabilised with Japanese tissue and adhesive.

There was not time to remove the facings, and a stable reversible adhesive was used, so they can be removed in the future if desired. The black matting (Fig. 8.3) in particular, would make an informative example for display if treated in the future.

Small unfired and low-fired clay objects

A number of small clay objects were uncovered in several places during the site visit (Fig. 8.5; Chapter 21). They are often partially burnt, but rarely fired (though one unmistakable fired clay figurine was recovered from the site during our time on site: SF532, Fig. 8.8). Because of their fragility, usually from cracking throughout the structure, a methodology of facing the artefacts with Japanese tissue and Paraloid B-72 after applying ethanol to the surface was devised and shared with several excavators. Application of the ethanol was an attempt to push some of the water out of the surface of the clay so the Paraloid B-72 would not emulsify. This technique gave some support to the objects allowing them to be excavated in some cases. The facing is removable with acetone – and several objects were treated back in the laboratory to remove the facing.

Humic material

One morning was spent excavating an area of dark 'humic' material found under a stone mortar in C1773 (Fig. 8.6). This black material had no identifiable structure that could be seen in the field. The material was curved in the shape of the stone, but discontinuous. The edges found under the stone were clarified, but the material continues into the profile so the total extent could not be defined. It was

Figure 8.5. Clay shapes in situ in the field, C1772 Sp27 T10.

photographed *in situ*. Four samples (SA2239-SA2242) were taken of the material for further study.

Human remains

We assisted physical anthropologist Sam Walsh in her work uncovering human remains as so many partial skeletons were found in Space 50 of Building 5. In particular, one skull was thought to have a black material applied on the temple and forehead area. It was cleaned in the field using mini cotton swabs and water to clarify this hypothesis. However, with removal of overlying dirt and pXRF analysis, it was confirmed to be manganese staining (Chapter 19) and no further treatment was applied.

Laboratory conservation treatments

Fifteen small artefacts (clay disc, low-fired figurine, small clay artefacts, block lifted woven materials) were given treatment in the laboratory (Table 8.1). Documentation photography before and after treatments was carried out by Amy Richardson. All treatments were documented in an Excel spreadsheet which was provided to add to the excavation database. The table includes the following information:

- Tracking number (small find number, bulk find number, or sample number)
- Context
- Material
- Description
- Problem

- Treatment
- Conservator
- Date treatment finished

In general, treatments included removal of facings or clean-up of consolidant applied in the field (Fig. 8.7), basic cleaning to uncover surface detail, restoration of fragments of broken artefacts (Fig. 8.8). and in some cases specialised packing to ensure stability in storage. Details of treatments are documented in the archival records of the project.

Table 8.1. Bestansur artefacts treated in the laboratory, spring 2014.

SF no.	*SA no.*	*C no.*	*Material*
329		1548	clay token
333		1550	clay object
359		1554	clay lump
370		1564	clay object
470		1731	cowrie
468		1731	cowrie shell
532		1781	clay figurine
	2175	1771	4 clay lumps
	2163	1771	woven fibres
	2317	1771	woven fibres
	2318	1771	woven fibres

Materials used in treatments

- Paraloid B-72: clear, colourless, thermoplastic acrylic resin. Paraloid B-72 is composed of an ethyl methacrylate (70%) and methyl acrylate (30%) copolymer.
- Japanese tissue: Mulberry fiber tissue used applied with glue to stabilize surfaces during excavation
- Ethanol, acetone, white spirit – solvents purchased at pharmacies in Iraq

Conservation student practice

Thanks to the support of excavation co-director Kamal Rasheed Raheem, Director-General of Antiquities for the Sulaimaniyah Province, and Slemani Museum Director Hashim Hama Abdullah, Ms Nyan Nasser, a 2013 graduate of the IICAH Advanced Conservation program participated as an intern on-site during the week. Since graduation from the Institute, Nyan has been working in the small conservation laboratory

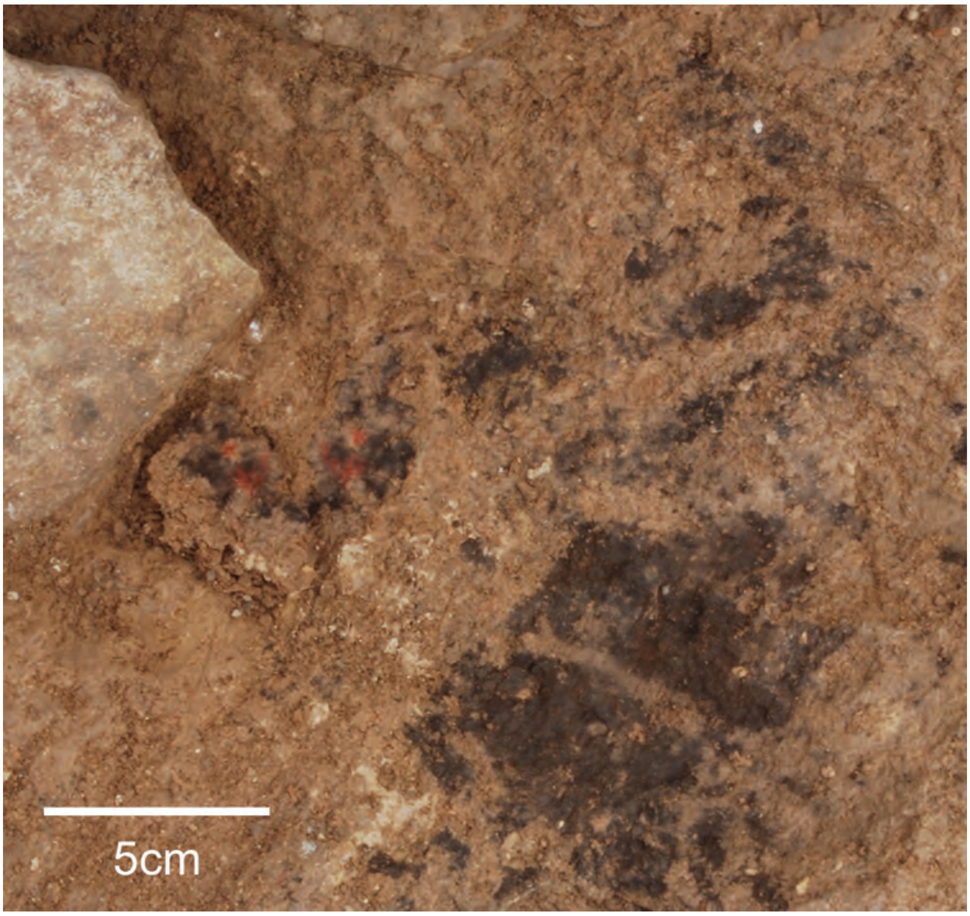


Figure 8.6. Dark deposit and red pigment under stone mortar, C1773 Sp53 B9 T10.

Figure 8.7. Conservation intern removing a facing applied in the field.

at the Slemani Museum. Examples of her work there include upgrading mounts for display and restoration of ceramics.

Though Nyan has a degree in archaeology from Salahaddin University, this was her first opportunity to actively participate in an on-going excavation. This is typical of many archaeology students in Iraq. Mock-up excavation and survey experiences take place as part of IICAH educational programs, but only real on-site experience gives people a nuanced understanding of preservation issues, limitations of recovery from the field, and new excavation methodologies currently being used. Nyan assisted with several different projects in the field, to remove very fragile materials from the soil including assisting with block lifting and facing and lifting fragile unfired clay objects. In the laboratory, Nyan learned how to consolidate fine cracks in clay artefacts, removal of facings applied in the field, and practised repair of low fired clay artefacts.

Conclusion: ideas for the future

A week on site with the Central Zagros Archaeological Project demonstrated future opportunities for collaboration and to integrate conservation in future excavations, including:

1. To continue to invite Iraqi museum staff and students with an interest in conservation to

Figure 8.8. Conserved and restored clay figurine, SF532 C1781 Sp50 B5 T10.

participate in the excavation and laboratory analysis that takes place on-site. Even if there is not a conservator on-site, the understanding of excavation and analysis is vital to ensure conservation decisions made in the museum laboratory take into account new research agendas that could be affected by conservation treatment.

2. To pair IICAH graduates with US or European conservation interns on-site, to share theoretically-informed knowledge and practical approaches, to encourage Iraqi students with continued education and to develop on-the-ground skills for the interns. This will ensure conservation issues are tackled in real-time on-site throughout each season.

Incorporation of ideas of preservation and conservation of artefacts and architecture in such projects that are investigating the development of the earliest agricultural communities ensures better recovery and preservation for analysis and reanalysis in the future. Constant awareness of preservation also saves architecture and artefacts that can be utilised for more public use in museums and archaeological site tourism attractions. Some of these ideas are under discussion for the future of the site. The CZAP project can serve as a model for other excavations to consider preservation and conservation throughout the project to allow what is recovered to have the widest possible impact in the scholarly and public arenas.

9. EXCAVATIONS AND CONTEXTUAL ANALYSES: BESTANSUR

Amy Richardson, Roger Matthews, Wendy Matthews, Sam Walsh, Kamal Raeuf Aziz and Adam Stone

Introduction to the excavations

The Central Zagros region was one of the first in which pioneering interdisciplinary investigations were conducted to investigate the origins of the Neolithic in the Eastern Fertile Crescent (EFC). In the lower Zagros in Iraq, excavations at Jarmo revealed a long-lived settlement with domesticated plants and animals spanning *c.* 7000–6000 BC (Braidwood *et al.* 1983). Since the 1960s, however, no excavations had been conducted in this region on a Neolithic site. The identification of a previously unknown Neolithic site near the modern village of Bestansur by the Shahrizor Plain Survey (Altaweel *et al.* 2012) therefore provided the opportunity for analysis of local and regional variation in sedentism and resource management by comparison with the results from Jarmo and previous excavations in highland Zagros by the Central Zagros Archaeological Project (Matthews *et al.* 2013a). The site promised to be important as the surface scatter extended over 4ha and the site is located next to a major spring with access to a rich range of environmental zones on the western side of the Shahrizor Plain, in a cluster of multi-period mounds that indicate long term settlement and sustainability in this locale.

The mound of Bestansur first came to archaeological attention in 1927 when 'Persian period' pottery was noted, and the site was subsequently recorded in the Iraq Atlas of Archaeological Sites (Speiser 1926–1927: 10–11; Directorate General of Antiquities 1970). Prehistoric occupation at the site was detected in 2009 when the German/Iraqi Shahrizor Survey Project identified Late Neolithic pottery at Bestansur (Altaweel *et al.* 2012: 21). Bestansur was included in the CZAP exploratory survey of Epipalaeolithic and Neolithic sites in 2011, which aimed to identify sites that would provide new insights into early settlement and resource use in Sulaimaniyah Province in the Kurdistan Region of Iraq in which Jarmo is located, 65km to the northwest of Bestansur. In September 2011 and January 2012, we conducted surface collection on the mound and in the surrounding fields at Bestansur (Fig. 9.1). Analysis of the recovered artefacts indicated the presence of Neolithic materials in the fields to the west, south and east of the mound. In particular, significant quantities of Early Neolithic chert and obsidian stone tools and working debris, including bullet cores, were recovered (Fig. 9.2). Surface collection of ceramic sherds on the mound itself indicated that later periods of occupation overlay the Neolithic occupation. Much of the raised mound is Iron Age, Sasanian and Ottoman in date, with abundant pottery from these periods but no evidence for Chalcolithic or Bronze Age occupation.

In order to assess the extent of preservation of the Early Neolithic levels and examine the range of activities conducted across different sectors of the settlement, locations for test trenches were selected based on the density and diversity of the surface finds and the mound's topography. Ten 2 × 2m trenches were excavated at locations on the lower slopes of the mound and in the surrounding fields from March 2012, following the excavation and sampling strategies established at Sheikh-e Abad (Fig. 9.3; Chapter 2). Subsequently, three additional areas of Neolithic activity were selected for more extensive and intensive investigation based on these results.

Surface survey at Bestansur identified evidence for Neolithic materials over an area of 4ha. The subsequent excavations established that intact

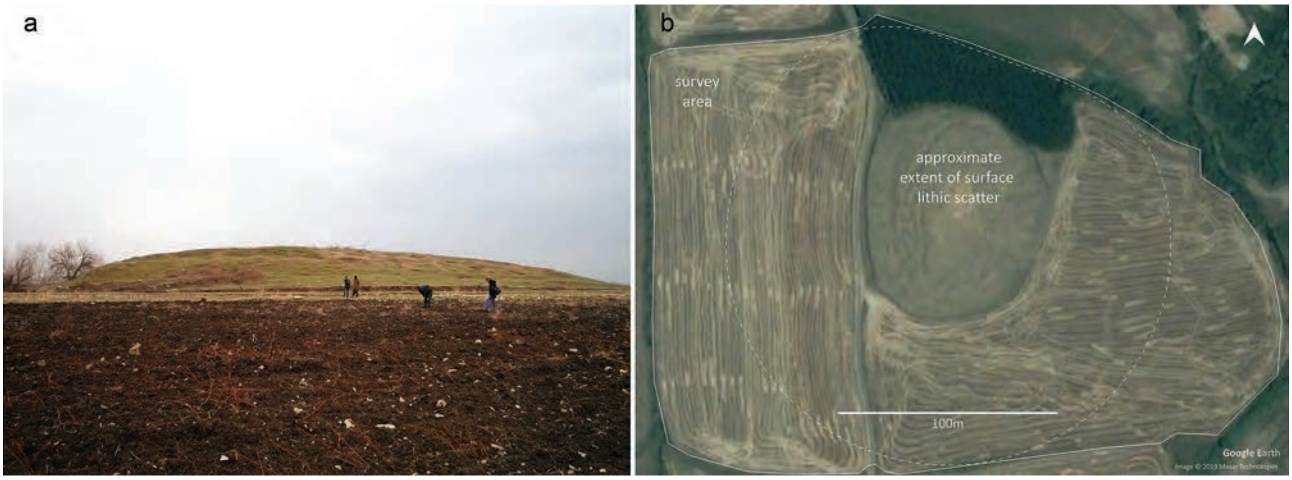


Figure 9.1. Survey of the field: a) to the west of the mound at Bestansur; b) area of the survey and approximate extent of the Neolithic settlement.

Figure 9.2. Chert cores and obsidian from surface collections.

Neolithic architecture is preserved across an area of more than 100m north–south and 100m east–west. This extent of occupation indicates a Neolithic settlement at least 1ha in size and it is likely that the Neolithic site and its environs are significantly larger. The modern field surface slopes gently down from northwest to southeast, and intact Neolithic levels correspond with this slope, being consistently preserved at *c.* 30–50cm below the modern plough depth and topsoil in the fields surrounding the mound. In the excavated trenches, intact levels of Neolithic architecture are preserved at *c.* 559m asl to the east of the mound (Fig. 9.4a) and at *c.* 560m asl to the west (Fig. 9.4b). The Neolithic settlement at Bestansur appears to follow a northwest–southeast slope and is likely situated on a low natural eminence overlooking the nearby spring. Erosion of the Neolithic settlement by levelling for construction in later periods and

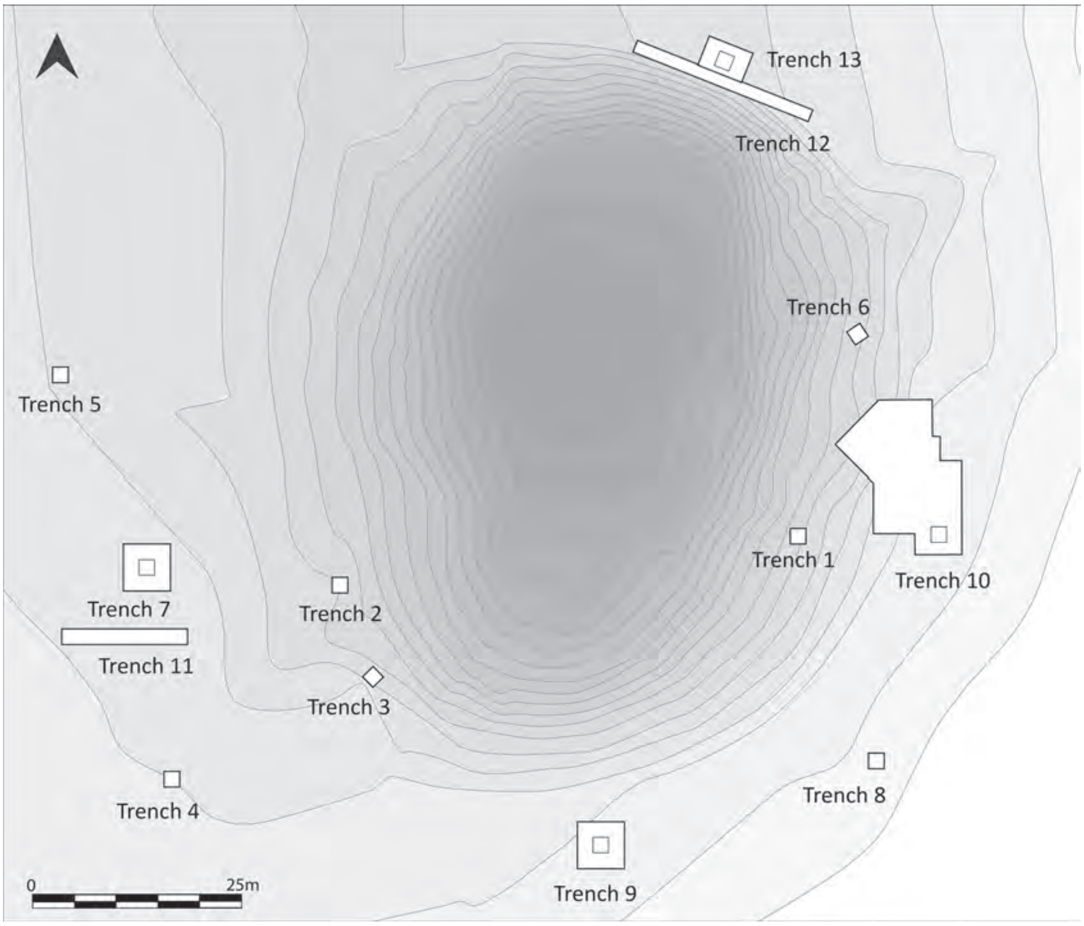


Figure 9.3. Contour plan of Bestansur mound, showing location of Trenches 1–13.

modern ploughing have contributed to truncation of the Neolithic architecture and subsequent activity in the surrounding fields, although later Neolithic levels are preserved beneath the mound itself, to heights of at least 561.50m asl in Trench 12.

In this chapter we examine the structures, features and deposits in their stratigraphic order of deposition from the base of excavations to the modern surface across the different sectors of the mound, by trench number. A summary contextual analysis in the concluding discussion of each trench examines the key finds and interpretations of each area. All heights, unless otherwise stated, refer to the uppermost level of the feature or deposit in metres above sea level (m asl), and were taken from a Datum situated on a concrete platform located on the summit of the mound (567.98m asl). At the end of each field season we produced full archive reports which provide detailed information on all trenches and materials excavated at Bestansur and Shimshara. These reports are freely available at: https://www.czap.org/archive-reports. In-depth discussion of the materials from these different trenches are presented in specialist chapters and the characteristics of each sector of the site summarised by ordinal location in Chapters 12 and 24. Radiocarbon dating indicates that Neolithic occupation at the site spans at least 7660–7000 BC, with the latest Neolithic levels excavated so far investigated in Trench 12.

Trench 1

Selection of location and excavation strategy

In order to identify the depth and nature of Neolithic sequences within the mound, Trench 1 was located on the lower slopes of the eastern side of the mound, approximately 10m from the field edge (Figs 9.3–5). Laid out as a 2 × 2m trench, the sections were stepped out as a safety precaution as the excavations progressed beyond a metre in depth. Investigations identified two phases of stone walls above a deep deposit of anthropogenically sterile material. Investigations progressed beneath this level in a 1 × 2m area in the east of the trench and located Neolithic architecture 2.35m below the surface of the slope.

Sequence of deposits, features and structures

Neolithic levels

The earliest levels investigated in Trench 1 are associated with Building 2, which was constructed from yellowish red brown mudbrick walls (W3, W4)

Figure 9.4. View of the trench locations: a) trenches on the eastern slopes looking west towards the mound; b) trenches on the western slopes looking southwest from the top of the mound.

aligned northwest to southeast at 559.78m asl and which extends beyond the trench edges (Fig. 9.6). The surfaces of the wall faces in Sp3 had been burned to a reddish orange colour (Fig. 9.6).

Space 3 was excavated to a depth of 559.48m asl, to a firm brown silty clay loam packing C1107, over which a contiguous surface of flat unworked stones had been laid C1105, C1103 and C1102 (Fig. 9.6). Within this material small quantities of animal bone, chipped stone tools and a small hammerstone were recovered. Heavy residue analysis revealed only low levels of all types of material. Overlying and sealing the stone surface was a firm dark yellowish brown silty clay loam C1100, which was the last remaining deposit within walls W3 and W4. A burnt clay ball SF15 was found adjacent to the burnt wall surface in Sp3, like those found at Neolithic sites across the region (Chapter 21). Other redeposited burnt material within Sp3 was detected in micromorphological thin-sections (Chapters 12 and 16).

No distinct features nor deposits were identified in the area southwest of W3 (Sp4). A series of units C1106, C1104 and C1101 was excavated with the aim of revealing further features in this area. The brown silty clay loam deposits had a very low density of material, below that expected of an external area. Overlying and sealing W3, W4 and deposits in Sp3 and Sp4, an area of possible *in situ* burning C1013 extended across all of Trench 1.

All these deposits were devoid of pottery and are

Figure 9.5. Trench 1: a) as the initial 2 × 2m trench; b) with stepped sections.

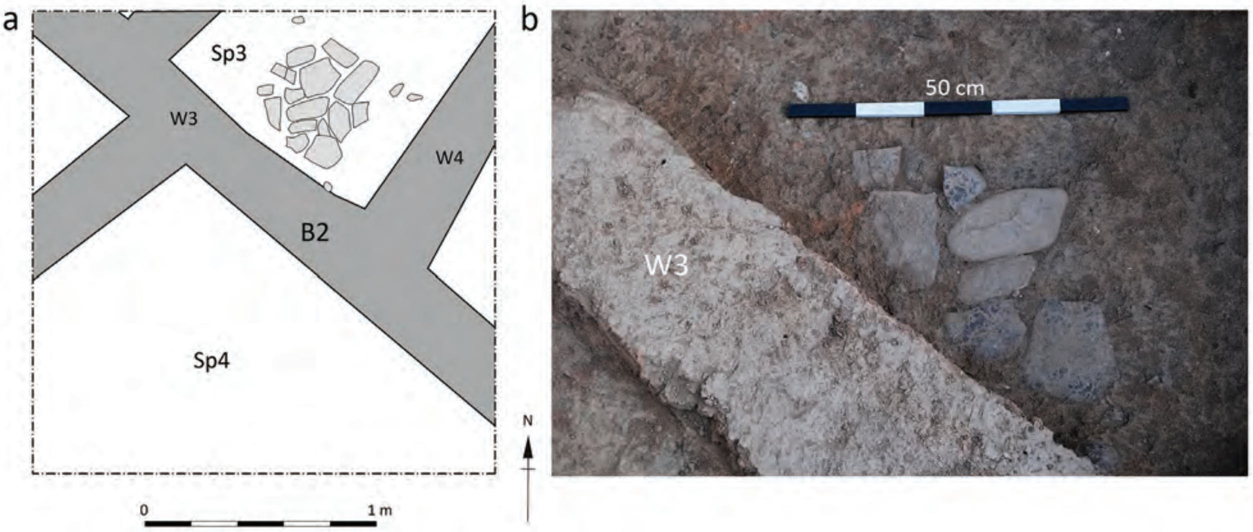


Figure 9.6. Trench 1: a) multi-context plan of Neolithic levels; b) burnt wall face of W3.

considered to represent Early Neolithic activities underlying the later period occupation of the mound. The chipped stone in both Sp3 and Sp4 comprises mixed chert and obsidian tools and debitage and is typical of the broader assemblage from the other Early Neolithic deposits across the site (Chapter 20). Overall, the zooarchaeological remains from the Neolithic levels of Trench 1 were very small in number, weighing only 31.7g, and heavy residue analysis revealed a low-density of material of all types, suggesting that many of these deposits are located within a building.

Post-Neolithic levels

Sealing C1013 was an anthropogenically clean and moderately firm dark greyish brown silty clay C1011, *c.* 20cm thick, which spanned the extent of the trench. Above C1011, a small patch of ashy dark greyish brown silty clay C1010 5cm thick was identified in the southeast corner of Trench 1. Above this level, a thick deposit C1009 devoid of any visible stratigraphy was excavated as a single 60cm unit across the trench. This deposit clearly separates prehistoric from historic levels and represents a hiatus in occupation in this area of the mound. Constructed directly on C1009 (560.68m asl), with no indication of a foundation trench, was a stone wall C1008, at least 2.4m in length from the southwest corner of the trench to the northeast (Fig. 9.7). It was 0.86m in height and 0.84m in width, and the stones were of irregular size and shape, showing little obvious coursing or internal organisation. The stones were set in a thick and muddy dark yellowish brown mortar. Above this, a much higher course of stones C1004 was set above a 0.12cm thick deposit of a similarly mud-like mortar C1006 (561.43m asl). A break in the wall and the large end stone, approximately half-way along its length, forms a possible entranceway.

To the northwest of Walls 1 and 2 in Sp1, a moderately loose dark greyish brown silty loam C1002 overlay C1009, within which was a bronze nail SF3. To the southeast of the wall in Sp2 was

Figure 9.7. Post-Neolithic architecture C1008: a) looking north, scale = 50cm; b) plan of C1008 Walls 1 and 2.

first a 3cm thick deposit of a mixed greyish green and orangish brown silty clay C1007 which stretched across the entire trench, again above C1009. Above C1007, a defined area of ashy material C1005, 5–10cm thick, had been dumped in the entranceway and spread *c*. 30cm to the southeast into Sp2, perhaps representing material swept out of the internal area to the northwest of Sp1. Above C1005, a further deposit of loose greyish brown silty clay loam C1003, around 0.6m deep, covered the full extent of Sp2 to the southeast of the wall. This deposit extended through the doorway between walls W1 and W2 and was possibly equivalent to C1002.

Overlying these deposits, across the 2 × 2m extent of Trench 1, was *c*. 40cm of topsoil covered by turf, excavated as C1001 and C1000 (562.13m asl). For safety and access, once a depth of 1.2m had been reached in Trench 1, the four sides of the trench were stepped (Fig. 9.5b). Each step consisted of an area of 2 × 2m taken down *c*. 1–1.5m depending on the slope of the mound: northern extension C1015, eastern extension C1017, southern extension C1016 and western extension C1018. In the northern extension, the continuation of W2 C1012 was identified.

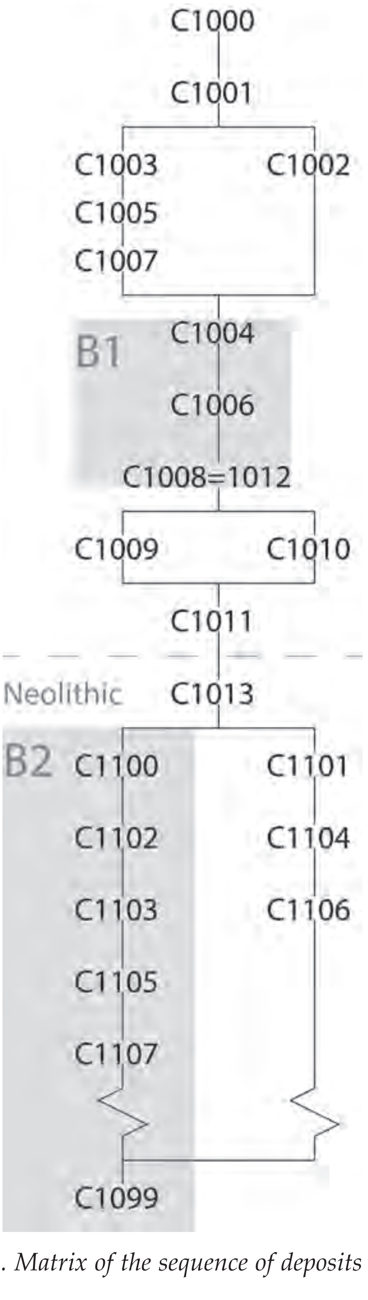


Figure 9.8. Matrix of the sequence of deposits in Trench 1.

Contextual analyses and interpretation

Investigations in Trench 1 and the identification of mudbrick architecture in the lowermost levels provide a crucial window into the depth of deposits 2.35m below the modern surface and the topography of the Neolithic settlement. Neolithic activity in Trench 1 is represented by low volumes of material, and there is no evident differentiation between Sp3 and Sp4 in Building 2. Walls W3 and W4 therefore probably define interior spaces. Space 3 appears to have an earlier phase of use associated with burning attested by the burnt wall faces, which perhaps are part of a large rectilinear fire installation, similar to Sp48 in B5 T10. Building 2 will be re-investigated in the next phase of the project as part of new analyses of a neighbourhood of buildings in one large trench that conjoins Trenches 1, 6 and 10.

The post-Neolithic deposits in Trench 1 contained mixed artefact assemblages, including ceramic material and a number of Çayönü tools in the topsoil deposits, perhaps from the later phase of Neolithic activity eroded by subsequent occupation on the mound (Chapter 20).

Trench 2

Selection of location and excavation strategy

A 2 × 2m trench was located on the southwest side of the mound in order to explore the depth and extent of the Neolithic levels within the lower slopes of the mound on the opposite side of the mound to Trench 1 (Figs 9.3 and 9.9). In contrast with the sterile deposits and stone architecture in Trench 1, excavation in Trench 2 identified continuous lenses of slope wash, pits and a tannur above a dense terrace of stone and pottery. Investigations continued beneath this surface in a 2 × 1m area and identified it to be immediately overlying a thin layer of deposits sealing Neolithic material *c.* 2m below the surface of the mound.

Sequence of deposits, features and structures

Neolithic levels

Neolithic deposits were encountered in Trench 2 at the base of a 1 × 1m sounding in the southwestern quarter of the original 2 × 2m excavation, at a maximum depth 559.34m asl, 2m below the surface of the mound. Excavations in the southwest revealed an *in situ* Neolithic surface, C1039, with scattered shell, bone and chipped stone, which sloped down to the west. Overlying this were two thin occupation deposits, C1037 and then C1035 each *c.* 5cm thick. These brown silty clay deposits included stone, shell, mollusc shell and bone fragments. The deposits were devoid of pottery or later material and appear to represent an undisturbed area of Early Neolithic activity.

Post-Neolithic levels

A dense layer of pottery and stone 10cm deep, C1038 and C1036, mixed with shell, bone, and chipped stone, was deposited only 20cm above the Neolithic deposits (Fig. 9.10; 559.54m asl). Deposits above the stone surface C1036 contained a high density of pottery belonging to a mix of periods, as a result of slope wash from the upper levels of the mound to the northeast of Trench 2.

Directly overlying C1036 and C1035, lenses of mixed slope wash *c.* 70cm thick were excavated as C1034, C1031=C1032 across the southern half of Trench 2 (2 × 1m). Above this level, deposits in Trench 2 were excavated across the full extent of the 2 × 2m area. The deposits extend across the whole area and comprise a *c.* 5cm deep layer of stones C1030 (560.29m asl), possibly a disturbed surface, covered by a *c.* 10cm thick mixed deposit of slope wash similar to C1034. In the northeastern corner, C1029 was cut by a shallow pit C1028, the fill of which contained a fragmentary human mandible. In the northwestern corner of

Figure 9.9. Excavation of Trench 2 on the south-west slope of the mound.

Figure 9.10. Neolithic deposits C1039 (east) and overlying sloping layers of dense pottery and stones C1038 and C1036. Looking south, scale = 50cm

Trench 2 and constructed on the upper horizon of C1029, was a small, round tannur C1027, 36cm wide and standing 25cm high, containing ashy burnt fills C1026, sealed by C1025.

Surrounding the tannur C1027, sealing the pit C1028 and overlying deposit C1029 were layers of slope wash excavated in 10cm units: C1024, C1023 and C1022 (560.74m asl). Overlying C1022 were *c.* 40cm of subsoil C1021 and 25cm of topsoil C1020 (561.39m asl).

Contextual analyses and interpretation

Excavations in Trench 2 yielded a large volume of pottery in addition to stone, bone, and shell. Most of the deposits represent mixed post-Neolithic slope wash. The presence of Early Neolithic deposits provides evidence for intact activity areas *c.* 2m below the slope of the mound in the southwest. The lowermost deposits C1039 (559.34m asl) are located 12cm deeper than the base of the Neolithic walls investigated in Trench 1 (559.48m asl), indicating that a Neolithic horizon is very likely to be preserved throughout the mound on a low natural rise. These excavations established that any future investigation of Neolithic levels within the mound would require excavation of at least 2m of overlying slope deposits and later levels.

Trench 3

Selection of location and excavation strategy

A small step trench, 2m (N–S) by 1.5m (E–W), was excavated on the edge of a modern irrigation ditch along the southwest edge of the mound in order to assess the potential for stepped investigations to obtain a rapid insight into the nature and date of deposits at the base of the mound (Figs 9.3, 9.12). As deposits in the southern half of the trench were less well-preserved and potentially disturbed, excavations were stepped down to reveal the base of the mound and the modern plain.

Sequence of deposits, features and structures

Neolithic levels

No intact Neolithic deposits were reached in this trench. The lowest levels C1047 were excavated at a depth of 1.51m below the modern mound surface at its northern edge and 20cm beneath the irrigation ditch to the south (560.47m asl) and contained pottery of a late date. Excavations were halted at this depth as excavations in Trenches 2 and 4 were proving more productive and had greater potential for more extensive and deeper excavations into the Neolithic.

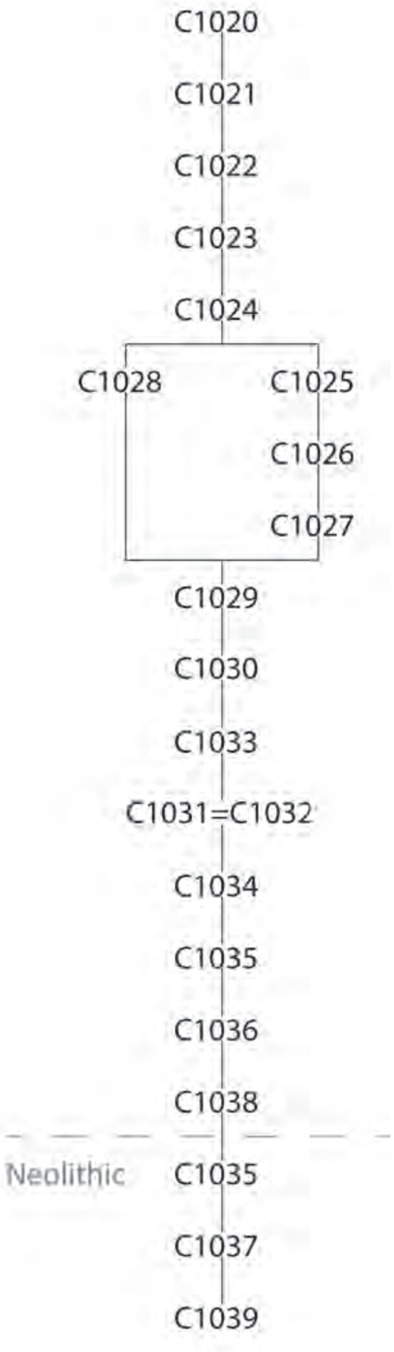


Figure 9.11. Matrix of the sequence of deposits in Trench 2.

Post-Neolithic levels

The earliest levels excavated in Trench 3 consisted of *c.* 5–10cm of distinct ashy lenses in a greyish brown silty clay loam. The ash lenses were present throughout occupation deposits C1047 possibly associated with an irregular line of stones identified along the western edge of the trench, forming a linear feature or wall. Overlying C1047 and the associated linear stone feature, a 15–20cm thick deposit of a brown silty clay loam C1046, was rich in broken brick. This bricky deposit was sealed by a 10cm thick layer of brown silty clay C1044, rich in stone, pottery and animal bone fragments, and included a sherd of plastic. A further 10cm of mixed occupation deposit, C1043, overlay C1044, and was similar in colour and consistency to the material below. Above C1043, up to 45cm of topsoil was removed across the trench as C1040, C1042, and C1045.

Contextual analyses and interpretation

This investigation of the southern extent of the mound has demonstrated the consistent depth and preservation of post-Neolithic deposits across the site. The lowermost levels, *c.* 1m above projected Neolithic activity identified in Trenches 1 and 2, contain mixed later material and disturbed post-Neolithic activity and represent considerable depths of later accumulation deposits from subsequent occupation. These investigations in the southern slopes of the mound at Bestansur (T1, T2 and T3) indicate that the Neolithic settlement occupied a low natural rise, above and terraced into which subsequent activities formed the upper slopes and summit of the mound, up to 8.6m above the intact Neolithic levels in the southern sector.

Trench 4

Selection of location and excavation strategy

Trench 4, a 2 × 2m trench, was excavated to investigate the depth and nature of Neolithic activity in the flat area to the southwest of the mound, close to where several Neolithic bullet cores were found in the surface survey (Fig. 9.3, Fig. 9.14). Possible Neolithic activity surfaces were detected immediately below topsoil. The trench was divided in half, and a 2 × 1m trench excavated in order to provide a profile view of deposits and leave a sequence for future sampling. At 1m below the modern surface, deposits became lighter in colour and only contained sparse anthropogenic inclusions. In order to investigate more rapidly whether these pale deposits were natural and to step the trench for safety, the excavated area was reduced to a 1 × 1m trench to a depth of 1.9m below the modern surface.

Sequence of deposits, features and structures

Natural deposits

At the base of Trench 4, 1m below the modern surface, probable natural deposits of a firm silty clay loam were investigated to a depth of 40cm (558.74m asl) in the southwest quadrant of the trench (Fig. 9.15). The lowermost natural deposits C1088 were distinguished by an increase in carbonate inclusions. Overlying this deposit were 20cm of reddish brown clay loam excavated as three units C1087, C1086

Figure 9.12. Excavations in Trench 3. Looking northeast, scale = 50cm.

and C1085, containing occasional anthropogenic material (chipped stone and bone). Above this accumulation, 17cm of deposits were excavated across the 2 × 1m western half of Trench 4 C1084 and C1083 (559.11m asl). These deposits had very low levels of fragmentary anthropogenic material, likely moved down by bioturbation: these finds decreased with depth.

Neolithic levels

The boundary between the natural deposits and the overlying levels, which had clear traces of human activity, was gradual and affected by bioturbation. Overlying the uppermost natural deposits C1083, the first layer of Neolithic deposits in this area of the mound comprised a dark brown silty clay C1082 with a sequence of discontinuous lenses of mollusc shells (*Helix salomonica*), heavily abraded bone, flat-lying chipped stone blades, patches of ash, charred plant remains and burnt aggregates. This sequence of lenses was sampled as a micromorphology block SA352 (Chapter 12) and revealed low levels of dung and faecal spherulites (Chapter 16) with secondary ash deposition, indicative of proximity to a primary area of external burning. Heavy residue analysis of these lenses, and all Neolithic contexts from this trench, indicate high levels of molluscs but with otherwise average quantities of other artefacts.

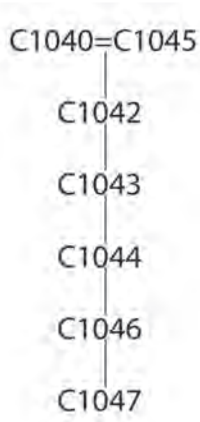


Figure 9.13. Matrix of the sequence of deposits in Trench 3.

Above this initial layer was a series of at least seven surfaces and accumulated deposits in a sequence *c.* 70cm thick from 559.23 to 559.93m asl: C1081, C1080, C1069–C1062. These deposits comprise a dark brown (10YR 4/3) fine silty clay loam with mollusc lenses 1–2cm thick at *c.* 4–10cm intervals over an area of 0.3–2m in extent (Fig. 9.15b). The presence of surfaces was marked recurrently by bones and chipped stone blades lying flat, suggesting a sequence of consistent activities and repeated use of this area. A single rim sherd SF23 from C1081 was of coarse low-fired pottery, and may potentially be of Neolithic date, rather than intrusive. Contexts below C1064 (C1067–C1069, C1080, and C1081) were excavated only in the western half of the trench to speed up investigation of the nature of the Neolithic deposits, C1062W=C1065E and C1063W=C1066E, and to use the resultant section to follow the slope and extent of surfaces more precisely. The Neolithic deposits were encountered below *c.* 30cm of topsoil, which

Figure 9.14. Excavations in Trench 4. Looking northeast, scale = 50cm.

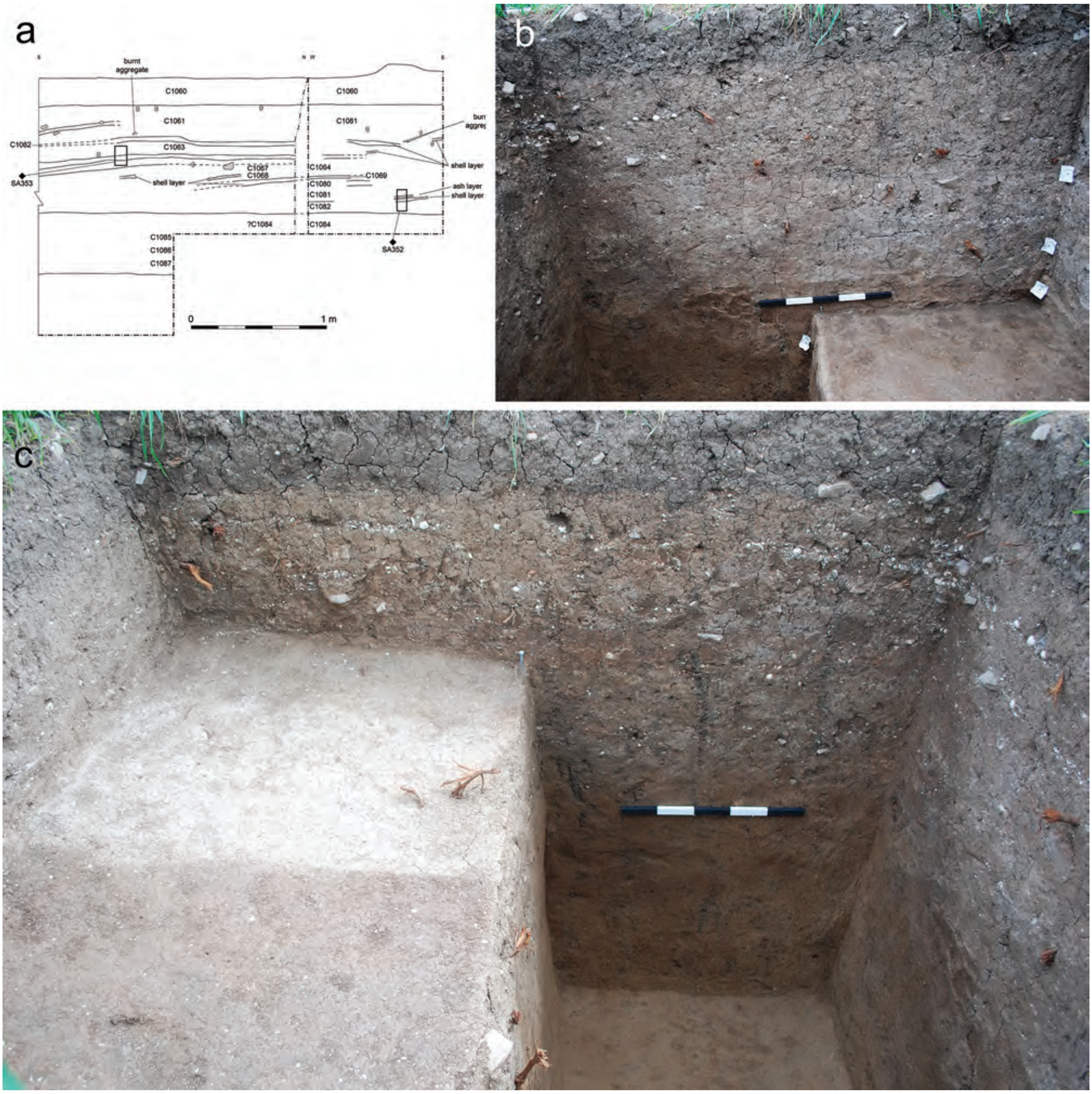


Figure 9.15. Trench 4 sections, a: section drawing; b: photo through mollusc lenses and surfaces, looking west, scale = 50cm; c: sounding into natural deposits, looking south, scale = 50cm.

was heavily ploughed and cultivated and excavated as C1061 and C1060.

Contextual analyses and interpretation

No traces of *in situ* architecture were detected in this trench. Deposits appear to represent a sequence of accumulated trampled surfaces in an external area. There was remarkable consistency in the types of accumulated deposits and materials, which suggests considerable repetition and long-term continuity in the types of activities in this area of the site.

Many of the activities in this area were associated with deposition of mollusc shells, chipped stone and bone, and occasional patches of ash and burnt aggregates and red pigment flecks. These materials suggest activities associated with processing of molluscs, most likely as a food source since they predominantly comprise the edible *Helix salomonica* (Chapter 17). Food production is supported by the associated activities of fire and lithic production, as well as the number of bone fragments. The zooarchaeological assemblage across the Neolithic levels in Trench 4 was low in density and very fragmented, although C1063 contained a notably higher proportion than the other contexts, with all

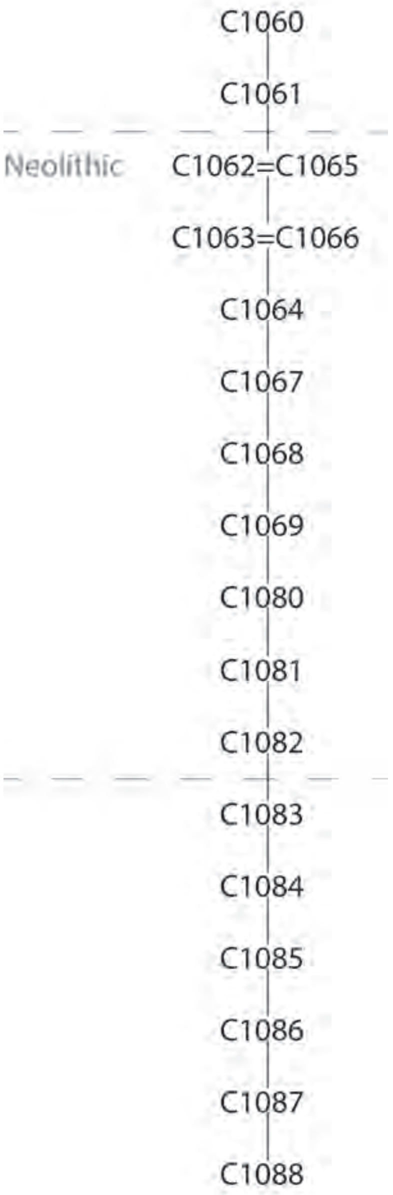


Figure 9.16. Matrix of the sequence of deposits in Trench 4.

pieces showing signs of abrasion through exposure and trampling, as may be expected in an actively used external area.

The chipped stone assemblage in Neolithic levels in Trench 4 has a below-average density of debitage for the site, but a number of tools lying flat on surfaces and a high ratio of obsidian to chert, with diagonal-ended bladelets, shouldered drills, notched blades and sickle blades occurring with an unusually high frequency. All the obsidian may be attributed to Nemrut Dağ with the exception of one obsidian blade, Tool 374 in C1069, which appears to come from an unusual source and suggests wider networks or material experimentation (Chapter 20). The chipped stone artefacts indicate a concentration on the tool-specific working of perishable materials, requiring sharp obsidian above chert. Diagonal-ended bladelets may have been used as arrow barbs, an explanation also consistent with wood shaft smoothing using notched blades. Interestingly no ground stone nor small-finds were present in this external area.

Of further significance is the presence of traces of dung spherulites in spot samples of the ashy patches from C1081-C1082 (Chapter 16). The presence of dung in ash suggests use of dung as fuel in this area of the site. A section of human femur and a deciduous human molar were found at the base of C1067. Such low-density distribution of human bone across Neolithic surfaces is in keeping with the site-wide pattern (Chapter 19).

Trench 5

Selection of location and excavation strategy

In the field to the west of the mound at Bestansur (Fig. 9.3) surface survey yielded several chert bullet cores and possible very early ceramics. Trench 5, 2x2m, was located to establish the extent of the spread of material directly to the west of the mound and to explore activities in this area of the site, including the possibility of flint knapping areas (Fig. 9.17). Initial spits through the topsoil and subsoil revealed that the eastern and western sides of the trench were displaying markedly different artefact patterns: a mollusc midden in the west of the trench, cut by a deep pit in the east. The dense mollusc deposit was column-sampled at its maximum depth (Chapter 17).

Sequence of deposits, features and structures

Neolithic levels

Deposits of grey brown silty clay containing sparse anthropogenic material were reached and excavated as C1140 at a depth of 1.3m below the modern field surface (559.38m asl). Immediately overlying this horizon, the earliest human activity was indicated by a few isolated chert and obsidian blades within *c.* 30cm of dense pale reddish brown silty clay, C1079. This deposit became increasingly sterile with depth. Following continuous low-level activity in this area, a substantial mollusc midden C1078 (559.78m asl) was piled on to the uppermost surface of C1079. The midden was located across the northwest of Trench 5, with its full extent clearly extending beyond the limits of the excavation. Within the trench the midden measured 2m N–S and 1.6m E–W, approximately 7–10cm deep. Based on a column sample density estimate, the area in Trench 5 alone contained *c.* 8000 molluscs (Fig. 9.18). The midden took the form of a low heap built up on the underlying surface. Samples taken for micromorphology (SA122 and SA123) have revealed at least two phases of shell deposition, and confirmed that this midden-like deposit largely

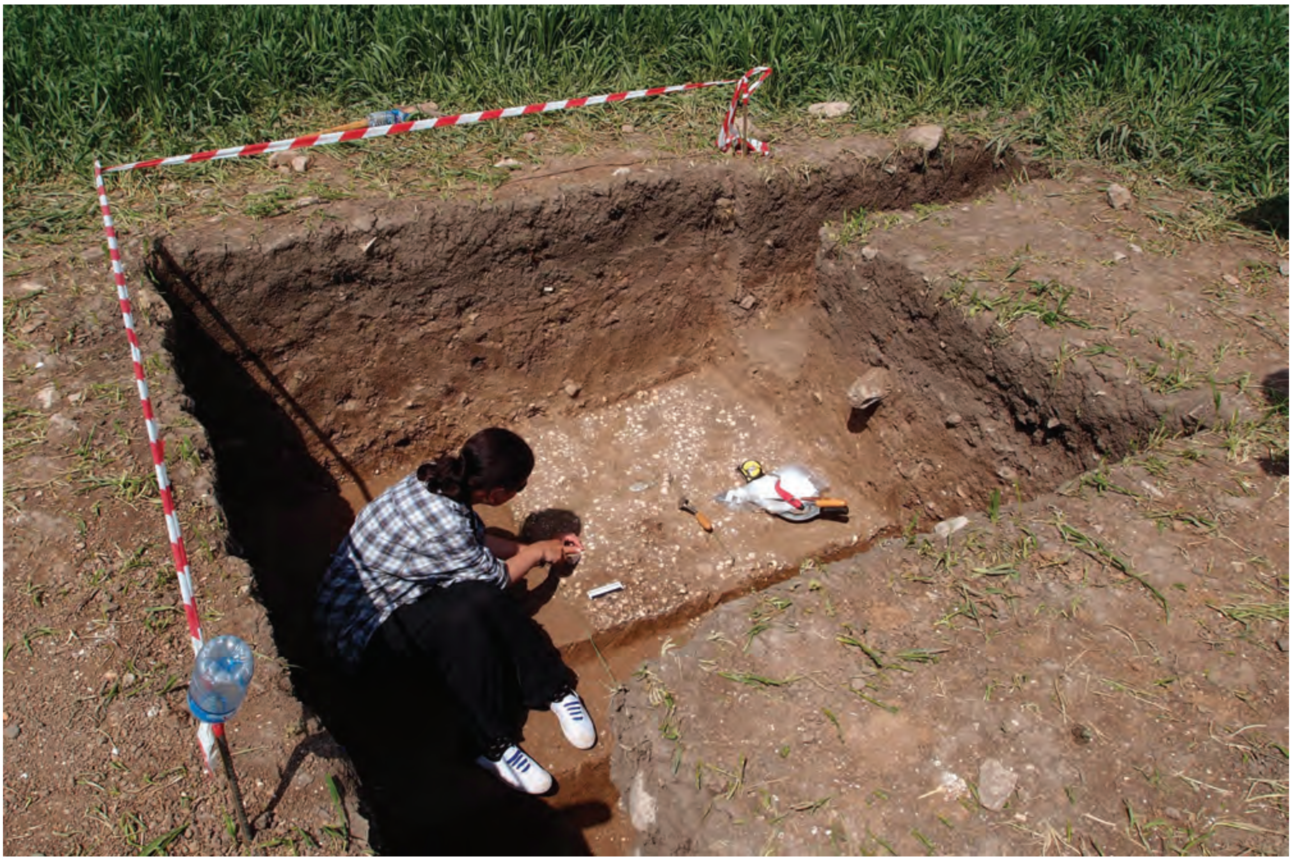


Figure 9.17. Excavation of Trench 5. Looking northwest, scale = 10cm.

Figure 9.18. Sectioned midden C1078 showing depth to underlying surface C1079 and cut by C1076. Looking north, scale = 50cm.

represents mollusc discard with only sparse charred flecks, ash and coprolite aggregates, which suggest a range of other activities were conducted nearby (Chapter 12).

Within the mollusc midden were small quantities of animal bone and fired clay, and a range of artefacts, notably a hammer stone with percussion marks, and obsidian and chert blades, including a blade of pale grey obsidian SF13 between layers of shell (Fig. 20.46). In total, eight Çayönü tools were recovered from Trench 5, including two from C1078. This is a dense concentration of these tools when compared to occurrences across the rest of the site, and is likely indicative of a specific activity requiring a non-standard tool type as well as providing evidence for the approximate date of the deposition, between 7600 and 7000 BC (see Table 20.26). Analysis of the mollusc shells within the midden revealed that the molluscs have been size-selected, with larger molluscs picked preferentially over smaller members of the species, a characteristic of the selection of molluscs for food (Chapter 17).

Post-Neolithic levels

Sealing the midden was a deep deposit (15cm) of firm very dark greyish brown silty clay C1075 (559.93m asl). Dense chipped stone (both obsidian and chert) and bone, with some small quantities of pottery, suggest either bioturbation or a later and mixed origin. This was sealed by a deposit containing abundant pottery C1074, 20cm deep. Cut into the mixed deposits was a later pit C1076 (Fig. 9.18, bottom), which dominated the east side of Trench 5 and extended beyond the limits of the trench. Within the trench the pit was 1.27m N–S and 0.57m E–W. The pit fill was a dark greyish brown silty clay loam packed with mixed deposits of pottery, stone, lithics and shell. The pit was excavated to a depth of 1.5m but was not bottomed. Sealing the pit and extending over the full width of Trench 5 was a 20cm thick deposit of packing material rich in stone and broken mudbrick C1073 (560.25m asl). This deposit was in turn overlain by 10cm of a mixed deposit C1072, containing stone, baked brick and thick-walled ceramics, and glass, disturbed by ploughing. Above this, 10cm of subsoil C1071 and topsoil C1070 were very churned and contained material from all periods (surface 560.68m asl).

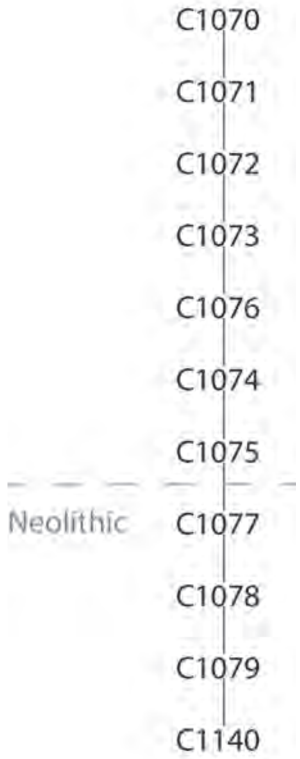


Figure 9.19. Matrix of the sequence of deposits in Trench 5.

Contextual analyses and interpretation

The earliest phase of activity in Trench 5 is represented by sparse chipped stone tools, including chert and obsidian blades, and *Helix salomonica* shell. This low-level activity is followed by the deposition of a midden of mollusc shells, comprising predominantly land snails with occasional freshwater molluscs. The mollusc midden represents possibly two deposition phases although the absence of a clear boundary suggests these were close together in time. The frequent association of blades with this substantial deposit suggests preparation and, most likely, consumption of molluscs in the immediate vicinity although this area does not appear to have been used for intense activity otherwise. The consumption of molluscs is attested at other Neolithic sites throughout the region (Reed 1962; Lubell 2004b) although they have not previously been the subject of systematic study until now (Iversen 2015; Chapter 17). Mollusc clusters and spreads have been recorded across the trenches at Bestansur, but this deposit represents one of the most significant episodes of preparation and processing of molluscs. The implications of the collection of such a large quantity of molluscs, estimated at >8000, in a single season may have had significant impact on the local ecology. In the subsequent deposits, chipped stone, shell and bone are present but appear to demonstrate no further feasting events in this area.

The seasonality of mollusc activity in the region and the cohesive nature of the deposit suggest that the deposit represents a single event or season of consumption. A ^{14}C date has been obtained on one shell sample from deposit C1078 which gives a conventional radiocarbon age of 9570±40 BP (Beta-326883), calibrated with 95% probability at 2 sigma to 9160–8780 BC. This date is considered unreliable due to the old carbon effect (Chapter 11) and conflicts with the evidence from the Çayönü tools, which indicate deposition at least 1500 years later.

Trench 6

Selection of location and excavation strategy

In order rapidly to determine the depth and type of archaeological deposits on the eastern side of the mound, a 2 × 3m step-trench (Trench 6) was located at the edge of the cut section of an existing drainage channel (Figs. 9.3 and 9.20). The stepped excavations identified deep deposits of slope wash, disturbed and bioturbated material above a significant burnt destruction level. Further investigation in a 1 × 2m area in the south of the trench located traces of Neolithic activity below the burnt building.

Sequence of deposits, features and structures

Neolithic levels

At the base of Trench 6, the very top of the Neolithic levels was reached, indicated by traces of an earthen wall (Fig. 9.21) and absence of pottery sherds at 560.13m asl. The excavation of this section indicated that future investigation of the Neolithic levels in this area of the site would be accessible beneath 1m of deposits.

Post-Neolithic levels

Overlying the Neolithic layer of brown silty clay, a sloping deposit of grey clay C1201 containing dense pottery was more apparent in the northern half of the trench. On the upper boundary seven stones were lying flat, possibly the remains of a disturbed and truncated surface (560.22m asl). Constructed on top of this was a layer of packing and multiple sequences of floor plasters associated with a post-Neolithic building that was destroyed by an extensive conflagration. The floors and building collapse were heavily burnt and baked hard in places. This fill was levelled and a later floor was constructed and also destroyed by fire. These two layers of burnt brick with ash and charred wood were excavated as C1200 in the northern half and C1117=C1019 in the southern half of Trench 6 (Fig. 9.20). This area was heavily truncated by a modern drainage cut, with evidence of bioturbation burrows at the edge of the mound. In the south, the remains of a fire installation *c.* 5cm in height, indicated the truncated remnants of a tannur 35cm in diameter (560.89m asl), filled with an ashy deposit. These deposits were covered with a sloping topsoil C1014 up to 40cm in depth (561.18m asl).

Figure 9.20. Trench 6. Looking southwest, scale = 50cm.

Figure 9.21. Trench 6 Neolithic levels. Viewed from southeast corner. Looking northwest, scales = 50cm.

Contextual analyses and interpretation

Particularly interesting was the discovery of Neolithic architecture 1m below the lower slope of the mound, and a later historical period destruction level. The presence of possible burnt surfaces and associated overlying destruction debris and a fire installation in the lower deposits, and below this a cluster of flat-lying stones, indicate that intact post-Neolithic archaeological deposits are present below the eastern slopes of the mound. Very few diagnostic pottery forms were collected from Trench 6. These activities truncate the Neolithic horizon, possibly deliberately cutting into and terracing the earlier levels.

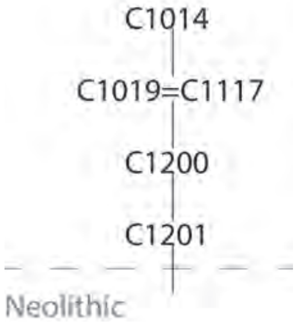


Figure 9.22. Matrix of the sequence of deposits in Trench 6.

Trench 7

Selection of location and excavation strategy

Trench 7 was located *c.* 15m west of the southwest edge of the mound at Bestansur, to investigate the accessibility, nature and preservation of Neolithic levels away from the mound in the fields and to study ecology and community in this sector of the site. Trench 7 was one of three trenches (Trenches 4, 5 and 7) excavated in the large field located in this area (Figs 9.3–9.4). All the trenches in this field were positioned based on chipped stone recovered from intensive field-walking survey.

Evidence for a diverse range of activities was uncovered within the original 2 × 2m area of Trench 7, including earthen architecture and an external area with a sequence of surfaces with ground stone, flint knapping debris and substantial quantities of edible land snail (*Helix salomonica*) in discrete clusters. At the end of the 2012 spring season, as with all trenches, Trench 7 was covered in sacking and back-filled

Figure 9.23. Location of initial 2 × 2m trench (centre), excavation of 6x6m extension and sampling of grid squares in Building 3. Looking northwest.

with excavated soil. In order to investigate the wider context of the above activities, the following season we expanded the 2 × 2m trench into a 6 × 6m area, with the original trench at its centre (Fig. 9.23).

Sequence of deposits, features and structures

Neolithic levels

Across the base of the northern half of the original 2 × 2m area, the lowermost deposits were excavated to a depth of *c.* 8cm (559.20m asl). The deposits comprised a light brown silty clay loam C1273 with very few inclusions of shell and chipped stone which may represent packing and levelling material as seen elsewhere across the site, in advance of construction. Overlying C1273 was a darker brown silty clay loam C1264 with anthropogenic material including sparse shell, white aggregates and bone fragments in the upper lens (559.29m asl).

Building 3

The excavation area revealed a large external area and the western portion of Building 3 on a northwest to southeast alignment with at least four rooms: Sp9/12, Sp10/16, Sp19 and Sp20 (Fig. 9.24). The spaces partially excavated are connected through Sp16 at the western edge of Building 3 (*c.* 1.5 × 2.3 m). To the north and west of Building 3 was a large contemporary external area with a sequence of abutting surfaces.

The earthen walls of Building 3 were constructed on top of surface C1264 and made from compacted reddish brown silty clay loam with white carbonate inclusions, with no traces of wall plaster (Chapter 12). The walls were of a variable width – up to *c.* 50cm wide for external walls and as narrow as *c.* 30cm wide for internal divisions – and survived to a maximum height of *c.* 70cm. The earthen material used in the construction of Building 3 has a high proportion of carbonate rock fragments and sparse plant material incorporated into the silty clay matrix with visible staining from organic matter (Chapter 12).

Space 10/16

Space 10/16 was a rectilinear room, *c.* 1.5 × 2.3 m, at the western extent of Building 3. The northwest corner, Sp10, was revealed by investigations in the 2 × 2m sounding. The earliest investigated internal surface (C1191–C1199) associated with the Building 3 walls was excavated in 1m grid squares to aid distinction of specific activity areas. This surface was laid 29cm above the lowest extent of the wall construction, at 559.62m asl. Finds on the surface included an *in*

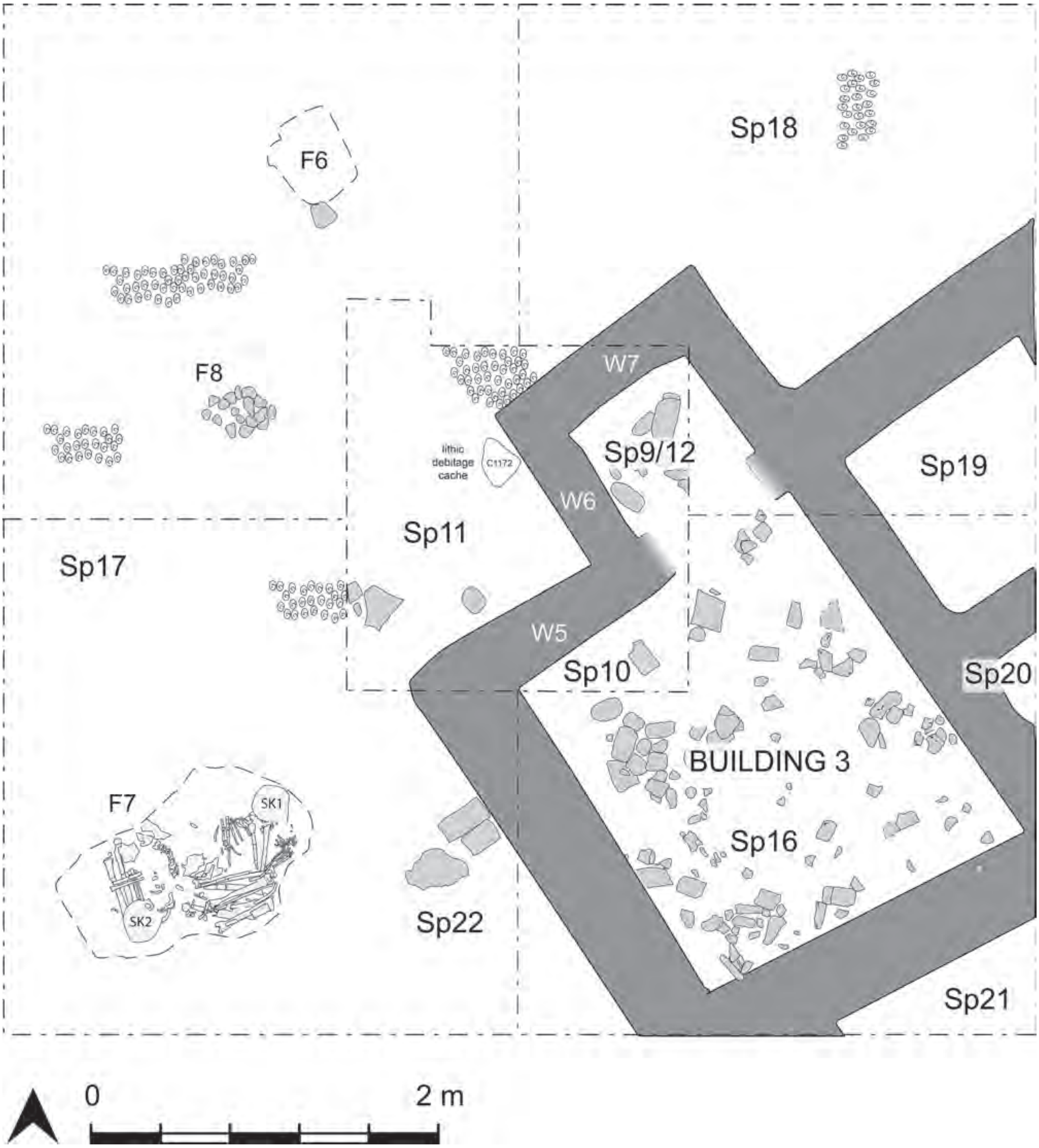


Figure 9.24. Multicontext plan of Trench 7 Building 3 and external areas, including shell clusters.

situ 30 × 20cm large saddle quern SF29, which had been ground smooth with use. Two flat-lying querns SF27 and SF28 were found at the same level lying on exterior surface C1191-C1196 (559.62m asl), in Sp11 on the north side of Wall 5, indicating that contemporary activities associated with ground stone may have been conducted both inside and outside Building 3.

Excavations in the rest of room Sp16 focused on the latest surface C1281 (559.83m asl) which also included traces of activity relating to ground stone tools, suggesting continuity in activities over time within Building 3. Discrete clusters of 98 ground stone tools (Figs. 9.24 and 9.25), had been placed on the upper horizon of C1281, and arranged in seven or eight groups of between five and 15 stones. These clusters represent distinct sets each of which had one or more percussion tools, a coarse grinding tool and other blanks/preforms and unworked stone

Figure 9.25. Trench 7 Building 3 Space 16 grid squares and external areas. Looking south, scales = 2m and 50cm.

(Chapter 22). Also in some sets were pounding tools, occasional fine abraders and polishers, small quantities of debitage, chipped stone tools and a broken thick-walled stone bowl base SF167 from the southeast of Sp16. The greyish brown occupation deposits between and surrounding the ground stone tools are *c.* 10cm in depth with sparse shell inclusions C1243=C1255=C1280. This surface and deposits were excavated and sampled in a further grid of nine squares in order to detect patterns of activity in micro-debris.

The groups of ground stone tools appear too close together to resemble individual working areas, but may represent storage since there was a lower density of debitage than would be anticipated in a working space. Analysis of the heavy residue from the sampling grid yielded a low density of micro-residues, in line with the density values for internal spaces elsewhere on the site (Chapter 14). However, the deposits in Space 16 contained a concentration of stone tools, particularly of obsidian, in contrast to the general pattern where such tools are more commonly found across external spaces. Seventeen obsidian tools from C1243=C1255=C1280 include two Çayönü tools, possibly used for working marble bracelets (Chapter 20). Chert tools from the same contexts include six unretouched blades and one serrated blade. The high proportion of obsidian in Sp16, and across all deposits in Trench 7, highlights the significance of obsidian tools within the range of activities carried out by the Early Neolithic occupants of Building 3. These activities appear to have been abandoned in this area, and the ground stone tools and surrounding sediment in Sp16 were sealed by a mixed fill of compact brown silty clay loam C1229, *c.* 6cm in depth. These clusters of finds therefore likely represent the remains of caches of tools from craft-working and processing that were safe-guarded within Sp16, and probably used in both interior and exterior areas associated with Building 3.

Space 9/12

In the northeast corner of Sp10/16, a break in Wall 5 leads to a smaller square room, Sp9/12, outlined by the Building 3 walls C1230 (Fig. 9.24). The earliest deposit excavated in this space was a *c.* 20cm deep light grey brown silty clay deposit overlying a circular arrangement of overlapping flat stones C1094 between 10cm and 35cm in width (559.48m asl). The deposit contained unworked sandstone and limestone fragments, and 16 flat river cobbles, possibly blanks for tools or for a surface. The majority of Sp9/12 was excavated in the 2 × 2m original test trench, and at a time in the excavation when the walls had not yet been recognised at their full heights. The contexts within Sp9/12 which directly overlay C1094 were excavated as mixed deposits C1093 and C1092 across the entirety of the 2 × 2m excavation. In the subsequent expansion of Trench 7, the southeast corner of Sp9/12 was investigated and a later phase of use of Sp9/12 identified, including a second surface of flat stones C1272 *c.* 20cm above C1094 (559.70m asl). An occupation deposit, C1252, directly on the stone surface included discarded lithics and was covered by brown silty clay loam fill C1251 and packing C1231.

Spaces 19 and 20

Exploratory investigations through 12-15cm of room fill were made in the suite of rooms adjoining the east wall of Sp10/16 Building 3: Sp19 and Sp20 (Fig. 9.24). In Sp19 the upper silty clay fill was excavated as C1253, but without reaching clear floors or surfaces. In the limited available segment of Sp20, deposits with distinctive greenish clay patches and with sparse shell inclusions had accumulated, C1266 (559.91m asl). A denser lens of shell was exposed in the extraction of a micromorphology block SA817 from the section face, suggesting the presence of underlying surfaces contemporary with the late occupation surfaces in Sp10/16 and Sp9/12.

External area, Space 11

Excavation of the external deposits to the north and west of the building was divided into quadrants to aid identification and separation of specific activity areas and conducted separately in each of the excavation spaces: Sp18 in the northeast quadrant, Sp17 in the northwest, Sp22 in the southeast, and Sp11 in the original 2 × 2m trench (Fig. 9.24). In places, there was some clear overlap and attempts were made to define related levels and stratigraphically equivalent deposits.

The earliest external deposits revealed were within the original excavation area, Sp11. Here, the excavations were restricted at this depth to the northern half section, a 2 × 1m area. After the construction of Building 3 and respecting the lowest levels of the external northeast faces of the walls, there was a sequence of surfaces with overlying occupation deposits with anthropogenic material comprising surface C1264 and accumulated deposits C1262, and surface C1260 and overlying deposits C1256. These deposits of brown silty clay loam on fugitive undulating surfaces were only 10cm in depth (559.29–559.39m asl). All three deposits included trampled lenses of shell and bone fragments, including a large cattle rib in C1260. A small pit, *c.* 30 × 20 × 8cm in size, was cut into C1256 in Sp11, the fill of which, C1172, contained a cache of lithic debitage (Fig. 9.26; 559.39m asl). The cache contained 838 fragments of chert including a single core (Chapter 20; Figs 20.25–20.26).

Overlying this cache was a 15cm deep deposit of brown silty clay C1171 (559.53m asl), laid as packing across the excavations in the northern half of the 2 × 2m trench. The upper horizon of this deposit formed a burnt surface C1170 upon which was a discrete concentration of edible snail shells C1097=1098 covering an area of 30 × 35 × 10cm. The dense cluster of shells was markedly different from other scatters observed across Neolithic external surfaces as no associated material other than shell was recovered from this deposit. It may represent a single episode of heating *Helix salomonica* for consumption, and more closely resembles mollusc rich deposits in Trench 5. Following this event, there was a steady accumulation of occupation debris and external surfaces, C1096 and C1095, which abutted

Figure 9.26. Cache of lithic debitage C1172 in Sp11, Building 3, Trench 7. Looking northwest, scale = 25cm.

Figure 9.27. Querns SF27 and SF28 in external Space 11, SF29 in Sp10/16 inside Building 3, Trench 7. Looking southeast, scale = 50cm.

the walls of Building 3. Lenses of burning are present throughout the reddish brown clay silt and burnt sheep/goat metacarpals indicate that this burning may have been to extract marrow.

The upper surface of C1095 is contemporary with that in the gridded space C1191–C1196 in the southern area of the 2 × 2m trench, on which rested two large flat-lying querns (Fig. 9.27): SF27 in C1176 and SF28 in C1177. These stones were placed at the same level as SF29 in Sp10/16 inside Building 3 and further attest that a range of particular activities were not confined to internal or external spaces, perhaps moving with daily cycles or seasons.

The walls of Building 3 were not identified in the phases above this surface in the 2 × 2m original excavation. The deposits were excavated as single units comprising patches of surfaces and occupation deposits: C1174=1093 and C1173=C1092, the latter of which contained a small alabaster tool SF16, suitable for reworking chipped stone tools. These contexts may include mixed material from internal and external areas broadly contemporary with the latest deposits excavated to the north and west of Building 3 in Sp17 and Sp18, as well as from the walls of Building 3 itself. Overlying this fill and the walls of Building 3, the subsoil C1091 (560.10m asl) contained two pestles and a quern, which may have been brought to the surface by deep ploughing or represent a later, truncated phase.

External area, Space 17

The lowermost external area deposits excavated across the southern half of Sp17 respect the exterior walls of Building 3. These deposits comprise a 10cm sequence of reddish brown silty clay lenses C1270=C1274 (559.80m asl), inter-bedded with finely stratified fugitive surfaces with rich lenses of ash, spherulites and trampled shell, and discrete clusters of molluscs, stones, lithics, and burnt animal remains (Fig. 9.28).

In the south of Sp17, we identified a cut C1269 containing the remains of two humans C1228, which clearly disturbed C1270=C1274 just below topsoil and which may have been cut from a higher level. The burial fill comprised a greyish brown silty clay loam C1224. The burial was of an adolescent female aged 14–20 years, SK1, and an adult male 30–40 years old, SK2 (Fig. 9.24; Chapter 19). The bodies were positioned on their sides, lying head to toe, with the male (SK2) in a tight foetal position, thus possibly bound (559.84m asl; Fig. 9.29).

Overlying C1270=C1274 lenses of greyish brown fugitive surfaces and shell scatters C1254 and C1223 were deposited across the south of Sp17, and contained

Figure 9.28. Clusters of molluscs and stones F8 (replaced) on surfaces with bone and lithics in external working area Space 17 Trench 7. Looking east, scales = 50cm.

Figure 9.29. Excavation of SK1 and SK2 in C1228, in Sp17, Trench 7. Looking southwest.

chipped stone tools, including four Çayönü tools, which suggest a later eighth millennium BC date to these deposits. Contemporary activity in the north of Sp17 was represented by dark greyish black lenses with patches of burning, C1261, followed by mixed occupation deposits with reddish brown bricky material that may have been the remains of a slumped northern wall of Building 3, and shell scatters C1259 and C1248 (559.87m asl).

A small fire installation was identified on

Figure 9.30. Half-section of clay-lined cooking pit C1218, F6 in Sp17, Trench 7. Looking southwest, scale = 10cm.

occupation surface C1248, in a 6cm depression. The base of this fire installation was charred and covered with a dense cluster of *c.* 10cm-sized stones, C1244, that had been used in heating or cooking. Micromorphological analysis has confirmed the presence of dung spherulites and charred material within this deposit. Further occupation lenses of similar colour and consistency to C1248 included residues from discrete activities in the form of clusters of shells and small stones, C1220. At the northern extent of Sp17, a further fire installation (F6, Fig. 9.30) was cut, C1238, into external deposit C1220. This small pit, *c.* 50 × 40 × 15cm, was lined on the base and sides with 1–2cm of reddish yellow fire-baked clay, C1237. The fills within the fire-installation, C1226 and C1218 (559.98m asl), were dark greyish brown with charred flecks and included a dense cluster of *Helix salomonica* shells, with fragments of animal bone, a serrated blade and fire-cracked ground stone debitage. This important cluster of finds within an FI provides insights into the diversity of diet, food preparation and cooking technologies that included molluscs and meat, and the use of custom-designed small installations with hot rock technology, similar to cooking methods attested at other Neolithic sites such as Çatalhöyük (Atalay and Hastorf 2006).

External area, Space 18

Space 18 is an external area in the northeast of Trench 7, north of Building 3 (Fig. 9.24). The lowermost deposits excavated in Sp18, C1249, respected the northern faces of the walls of Building 3, contemporary with C1270=C1274 in Sp17. These deposits comprised 10cm of reddish brown silty clay with lenses of shells and chipped stone tools on fugitive surfaces (559.83m asl). Activities in this external area were repeated through time suggesting long-term structured practices, attested by residues in *c.* 25cm of occupation lenses C1225=C1227, rich in snail shells. A small cache of distinctive red chert knapping debitage in C1225=C1227 provides evidence for tool production in this external area (Chapter 20; Fig. 20.23). In the subsequent external activity deposits, C1221, further evidence for tool knapping was present in the form of obsidian debitage (Chapter 20; Fig. 20.24). An area of burning to the north of Sp18, C1257, contained spherulites from dung probably used as fuel (Chapter 16). The deposits in Space 18 are approximately equivalent to the similar lenses of surfaces and occupation material excavated in adjacent Sp17.

External areas, Spaces 21 and 22

Space 21 to the southeast and Sp22 to the southwest of Building 3 (Fig. 9.24) include external activity

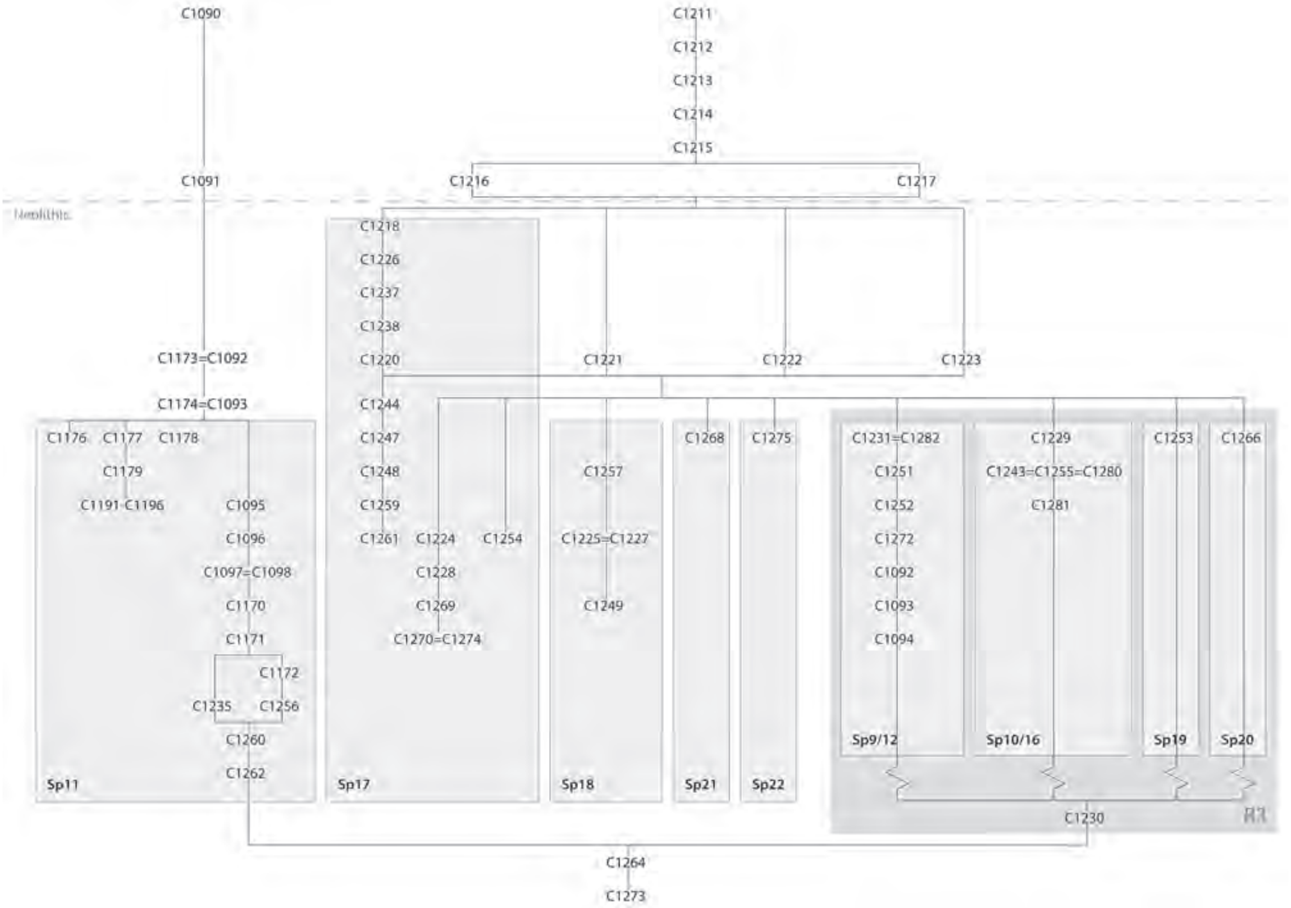


Figure 9.31. Matrix of the sequence of deposits in Trench 7.

residues composed of pale reddish brown silty clay with sparse shell fragments. Both C1268 in Sp21 and C1275 in Sp22 were similar in composition to Sp11, Sp17 and Sp18, and likely represent a similar use of outside space.

Overlying the walls and internal and external surfaces of Building 3, a series of disturbed deposits contained Neolithic material and occasional areas of undisturbed activity. The subsoil across the 6 × 6m extension of Trench 7 was divided into 3 × 3m quadrants around the original 2 × 2m excavation: C1220 in the northwest, C1221 in the northeast, C1222 in the southeast, and C1223 in the southwest, equivalent to C1092 and C1173 in the 2 × 2m sounding.

Post-Neolithic levels

The overlying deposits represent the transition between the Neolithic and later periods and were excavated across the northern half C1216 and the southern half C1217 of Trench 7, and C1091 in the sounding. Above these, a 50cm layer of greyish brown colluvium and disturbed plough soil deposits were excavated in five units across the whole 6 × 6m trench: C1215, C1214, C1213, C1212, C1211; equivalent to the sounding C1090 (560.58m asl).

Contextual analyses and interpretation

A range of activities may have been conducted both inside and outside buildings, based on the presence of ground stone in both context types. The accumulation of residues within these areas, however, differed markedly, suggesting greater care was made to maintain interior surfaces and to keep these clean, as commonly observed across the site. Heavy residue analysis (Chapter 14) has confirmed that the internal spaces in Trench 7, like those across the settlement, consistently contained densities of material far below the levels found in external spaces. The chipped stone data (Chapter 20) also demonstrates that there were low quantities of lithic debris in internal spaces, in contrast to the external surfaces and occupation deposits, which have high quantities of chert and obsidian debitage and ground stone debitage. This contrasting deposition of lithic residues points to extensive tool making in the outside spaces close to Building 3. Notched blades of both chert and obsidian occur exclusively in external deposits and thus relate to activities taking place on these surfaces, where food residues and fire installations are present.

The ground stone tools from Space 16 appear to represent storage of tool sets that were subsequently abandoned *in situ*, rather than use of these in this working or living space, as there are few traces of activity residues or working debris, and little working space between the clusters (Chapter 22). Building 3 and its associated external areas have yielded much repeated evidence for tool production and food preparation, cooking and consumption suggesting that this building and area may have been a focus for group activity. The building was constructed from the same reddish brown silty clay as many others at the site and was clearly integrated within the wider community (Chapter 12). As the plan of Building 3 is incomplete, it is less clear how similar the layout was to other structures like those in Trench 10. The more extensive excavation of external areas in Trench 7 has provided insight into the location and diversity of activities in external areas and repeated continuity in these, suggesting stable roles and relations and well-established practices related to craft and food preparation and consumption.

Both the chipped stone and animal bone distributions represent discrete activity locales and episodes, in the form of localised knapping and disposal, and butchery, as illustrated in Figure 20.55. The frequent presence of groups of small stones, broken tools of chert and obsidian, and animal bones fragmented for the extraction of marrow and grease, suggest that cooking and eating activities were taking place repeatedly here, with rapid disposal of discarded food debris close to the place of preparation and consumption, sealed by successive layers of packing. Low-level dung traces were also recorded across the trench, from the burning of dung as fuel and perhaps occasional presence of livestock in the area (Chapter 16).

The broad range of species represented in Trench 7 indicates that the diet was biodiverse, and included the consumption of fish, although the density of the remains is low, suggesting maintenance of the area and discard of a range of items elsewhere (Chapters 12 and 15). The presence of winter birds and snails provides consistent evidence for some of these activities taking place in the wet seasons. As these sequences of deposits in the external areas are more than 1m deep, they may thus represent long-term seasonal-cycles that took advantage of spring-time availability of land snails and the many other natural resources of the region in the Early Neolithic.

Trench 8

Selection of location and excavation strategy

Trench 8 was excavated in a 2 × 2m area in order to investigate the context of a concentration of chipped stone tools on a gentle slope to the southeast, which suggested a focus of Neolithic activities in this area (Figs 9.3–9.4, 9.32). Below the topsoil, an extensive layer of unoriented stones, lithics, and abraded pottery was uncovered across the trench. Deposits without pottery were uncovered immediately below this layer. Rapid assessment was conducted in a 1 × 1m sounding in the southeast quadrant of the trench, which encountered a grey ashy deposit with Neolithic lithics at a depth of *c.* 1.17m below the modern surface. Further investigations across the trench revealed clear wall lines, marked by the reddish brown colour and white carbonate inclusions of the wall make-up. These wall-lines could be traced in the edge of the section profile of the 1 × 1m sounding. The room fill and an ephemeral surface were excavated, but investigations were halted due to time constraints.

Sequence of deposits, features and structures

Neolithic levels

The earliest deposits excavated in this trench, C1180 at 557.46m asl, lie *c.* 1.35m below the modern surface. These deposits were exposed in a 1 × 1m sounding (Sp57) in the southeast corner of the trench (Fig. 9.33) and comprise a 5cm thick layer of greyish brown ashy material with burnt aggregates. Sealing C1180 a 5cm thick layer of almost sterile reddish brown silty clay packing, C1138, was laid in advance of the construction of the walls of Building 4 (Fig. 9.34; 557.58m asl).

Building 4 was not fully excavated but included a set of three walls: W8 to the north, W9 to the east, and W10 to the south. The walls clearly define an internal area Sp14 (0.7 × 1 m) that likely continued beyond the western limit of the trench (Fig. 9.33). The walls, which remain to a height of *c.* 20-25cm, are *c.* 50cm wide and formed of a reddish brown silty clay loam with white calcareous aggregates (Chapter 12).

Within internal Space 14, excavations halted at the uppermost floor layer, constructed from a 5cm thick surface of stony packing material (557.79m asl) sampled in micromorphology block (SA450, Chapter 12). On this surface in Sp14, *c.* 5cm of more sterile occupation material of brown silty clay loam, C1185, was overlain by mixed occupation deposits, C1184, rich in ash, burnt aggregates, dung spherulites and flecks of ochre. Overlying these occupation deposits, 4cm of mixed silty clay loam, C1183, represents a late accumulation of material in the west of Sp14. To the northeast of Building 4 W9, in Sp13 a blackened surface was covered by a dark brown silty clay rich in charred plant remains (>10%) and burnt aggregates, C1182. Together these deposits represent an activity area associated with this building, one which is possibly external when compared with the clean deposits observed inside other buildings across the settlement.

Sealing the structure of Building 4 and the

Figure 9.32. Trench 8 showing thick silty clay layer C1136 that overlay Building 4, and sounding in southeastern quadrant C1138. Looking southeast, trench = 2m

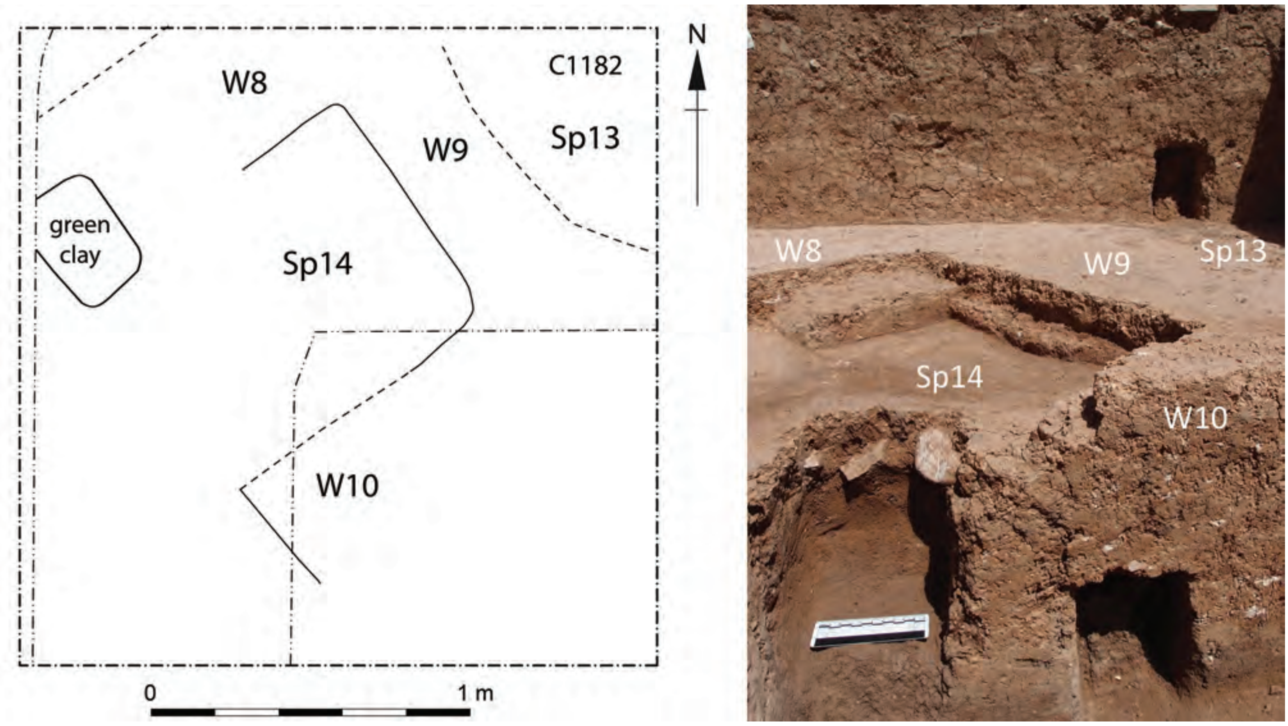


Figure 9.33. Trench 8 Neolithic architecture and spaces: a) multicontext plan; b) looking north, scale = 10cm.

Figure 9.34. Trench 8 south-facing section of the sounding showing Building 8 wall 10 (left) and earlier layer of grey ash. Looking west, scale = 25cm.

associated deposits, 5cm of light brown firm silty clay, C1181, were equivalent to C1137. The upper horizon of this layer (557.96m asl), which formed a poorly preserved surface, bore traces of ash and burnt aggregates. Overlying C1181, C1136=C1139 covered the entirety of Trench 8 and comprised 10cm of mixed deposits of orangish brown clay loam with white aggregate flecks. Throughout this deposit were further traces of surfaces, and lenses of shell, and a large well-preserved red deer bone that formed the majority, by weight, of the zooarchaeological remains from this trench (Chapter 15). Heavy residue analysis has identified a low density of all material from all deposits, including chipped stone, with only one sample producing any lithics (Chapter 14).

Post-Neolithic levels

The upper 45–50cm of deposits, from 558.08m asl, represent disturbed Neolithic deposits mixed with post-Neolithic material. A 10cm thick layer of reddish brown silty colluvium, C1135, and the subsequent 15cm thick layer of dark brown silty clay, C1134, both contained abraded pottery and large stones. The only piece of ground stone from Trench 8 came from C1134, likely not *in situ* (Chapter 22). Çayönü tools occurred in the uppermost disturbed deposits C1133. Above the subsoil, 40cm of ploughed topsoil, C1131 and C1130, covered the extent of Trench 8 (surface 558.81m asl).

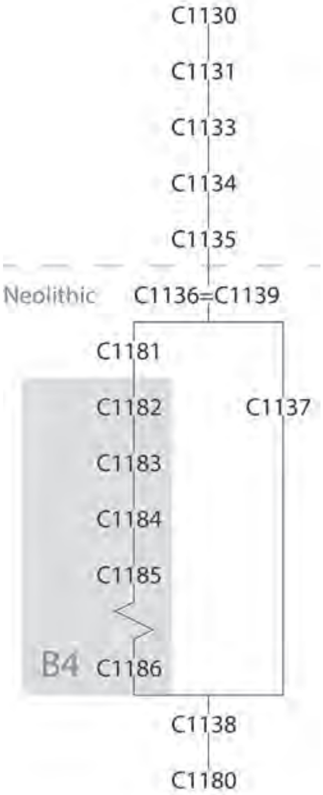


Figure 9.35. Matrix of the sequence of deposits in Trench 8.

Contextual analyses and interpretation

Of particular significance in this trench is the long sequence of occupation, which appears to continue below the current limit of excavation. There are at least two phases of Early Neolithic activity in this area of the site, the earliest represented by the well-preserved grey ash layer C1180, which may be associated with possible walls or features at the base of the 1 × 1m sounding in the southeast. The second is the overlying building with a small defined space in the centre of the trench and associated external spaces. The deposits on the floors of Building 4 are mixed and include ash, charred plant remains, lithics and flecks of ochre, attesting a range of activities associated with burning or heating. The external surface was blackened by residues of ash and charred flecks, suggesting presence of a fire-installation nearby.

Trench 9

Selection of location and excavation strategy

Trench 9 was laid out *c.* 7m south of the southern edge of the mound at Bestansur, aimed at exploring the extent of the archaeological deposits beyond the slope of the mound itself (Figs 9.3-4). In 2012 the trench originally comprised a 2 × 2m excavation, which located Neolithic deposits immediately below the plough soil, including a cluster of three small fire installations cut by the eastern edge of the trench and sequences of large ashy deposits across surfaces. Returning to these deposits in 2013, the 2 × 2m trench was expanded to a 6x6m trench, with the original sounding at the centre of the new excavation (Fig. 9.36). Investigations focussed on areas of ashy spread in the southern and western sectors of the trench, finding further fire installations and the edge of a Neolithic wall in the southwest corner of the trench.

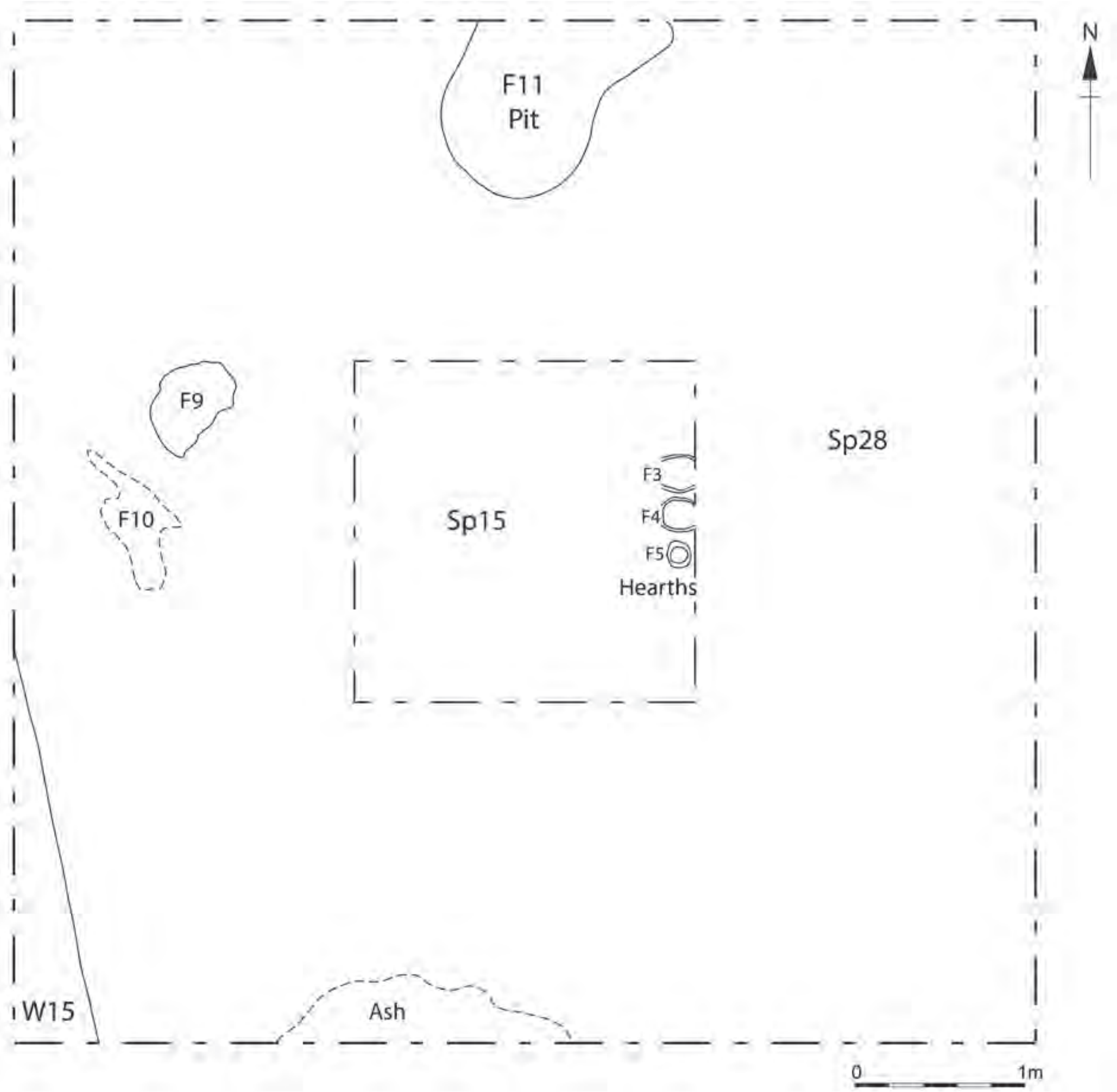


Figure 9.36. Multicontext plan of Trench 9 spaces.

Sequence of deposits, features and structures

Neolithic levels

The earliest excavated deposits in Trench 9 represented an exterior surface, C1435, with areas of *in situ* burning in the east, ashy lenses in the west, and a white gritty area in the southeast area (558.73m asl). This deposit extended across the entirety of the 6 × 6m trench and was equivalent to the lowest extent reached in the original 2 × 2m excavation. An Iron Age pit F11 cut through this surface from later levels revealed at least 50cm of finely stratified Neolithic deposits extending below this level (558.24m asl).

External surface C1435 was laid up to the exterior face of a wall, W15 C1433 and C1432. Excavations partially exposed a 2.3m section of W15 in the southwestern corner of Trench 9 and revealed it to have been constructed on the same southeast to northwest axis observed in buildings across the settlement (Fig. 9.36). W15 is made from unplastered red silty clay with white aggregate inclusions and stands to a height of 12cm above the surface of C1435.

The source of the sloping ashy deposits spread across C1435, and equivalent ashy layer C1158 in the original 2 × 2m sounding, is likely the substantial evidence for fire installations across this external area. These include four clay-lined fire installations, F3, F4, F5 and F9 (Figs 9.36–9.37) and two further possible fire installations. The three small clay lined hearths, F3, F4 and F5, were constructed as a unit on the earliest external surface C1158=C1435 (Fig. 9.37). A small patch of white plaster, C1159, was uncovered beneath F5 and may have been the remains of an earlier surface or feature in this area.

In the eastern area of the excavation, a poorly preserved small oval feature of burnt clay containing burnt deposits, C1437 (558.75m asl; Fig. 9.37), had been cut into external surface C1158=C1435. In the southwest of Trench 9, near to the southern end of W15, was a shallow clay-lined feature C1436 (Fig. 9.37), which extends beyond the southern limit of the excavation and measured more than 40 × 60 × 4cm deep. C1436 was lined with a yellowish red clay and contained *in situ* burning, C1434, and a small assemblage of fragmentary and burnt animal bones. This fire installation may be an oven associated with W15.

The overlying external surface sealed this fire installation and comprised a diffuse accumulation of dark brown occupation deposits, C1364 *c.* 8cm deep, that covered the entirety of the 6 × 6m excavation and is equivalent to C1156 in the 2 × 2m excavation. These deposits contained over 200 small fragments of animal bone of sheep/goat, pig, red deer and bird, as well as molluscs and chipped stone. On the upper horizon, discrete regions of activity included traces of heavy burning, burnt bone and ash, C1361, and discarded deposits of bone and shell, C1362 and C1359.

A thick deposit of clay C1155=C1157=C1357 covered these deposits across the entirety of Trench 9, sealing the fire installations F3, F4 and F5. Compared with the extensive evidence for occupational activity and refuse disposal in the levels below, this layer had far fewer indications of human activity and few inclusions for a deposit of this size, and probably represents thick packing laid as a foundation for subsequent activities, as observed in a range of other sectors of the site in Trench 10 and Trenches 12/13 for example (Chapter 12).

The following occupation deposits are similar to earlier deposits and attest continuity in activity in this area and respect the line of W15. Bone discard C1344 (Fig. 9.38) and C1350, and ash lenses C1346, C1349 and C1358, indicate the continuation and intensification of butchery and burning in discrete areas. In the south, bone spread C1344 had dense animal bone fragments from pig and sheep/goat (Chapter 15), including the occipital elements of the skull of a male, morphologically wild, sheep skull placed face down with the horns protruding upwards. In the southeast of Trench 9, a brown clayey silt C1347 contained a large number of bone fragments from sheep/goat, pig, equids, cervids, birds and microfauna, and dense molluscs, and two halves of two separately broken grindstones (Chapter 22). These deposits, including W15, were sealed by a thick layer of dense occupation activity, C1154=C1339=C1340, indicating further continuity in the same outdoor activities in this area, including primary butchery.

Neolithic activities on the external surfaces in this area continued, although the subsequent deposits are likely disturbed by later activity, in particular modern ploughing of the field. C1153=C1333=C1335=C1336 was similar to the previous deposits in having localised areas of shell, burnt aggregates and ash, as well as bone fragments, chipped stone tools, and a shell bead (SF207). Overlying this deposit, activity continued and is evident through further patchy surfaces, C1152=C1305, heavily bioturbated and affected by modern ploughing, C1307 and C1309.

Post-Neolithic levels

Five Iron Age or later pits cut through the Neolithic deposits, including C1337, C1338, C1355, C1341 and C1365. No Iron Age surfaces or occupation levels were recorded in either the 6 × 6m or 2 × 2m excavation. Overlying these final contexts were the ploughed subsoil and topsoil, C1151=C1304 and C1150=C1300=C1301=C1303, amounting to *c.* 45cm in depth.

Contextual analyses and interpretation

The earliest deposits of Trench 9 attest the presence of a structure represented by wall W15 and intensive fire-related activity in the form of three small adjacent contemporary fire installations or hearths and two further fire installations. The evidence from T9

Figure 9.37. Fire installations in Trench 9. Looking north, scale = 10cm.

Figure 9.38. Excavation of a morphologically wild male sheep skull, Trench 9 C1344.

indicates an external working area where butchery and cooking took place, and refuse was freely discarded across open surfaces. The zooarchaeological material has some bias towards heads and feet suggestive of primary butchery, and freshly fragmented and burned limb bones indicate marrow and grease processing (Chapter 15). Additionally, weathered and trampled bones were left on surfaces, often prior to

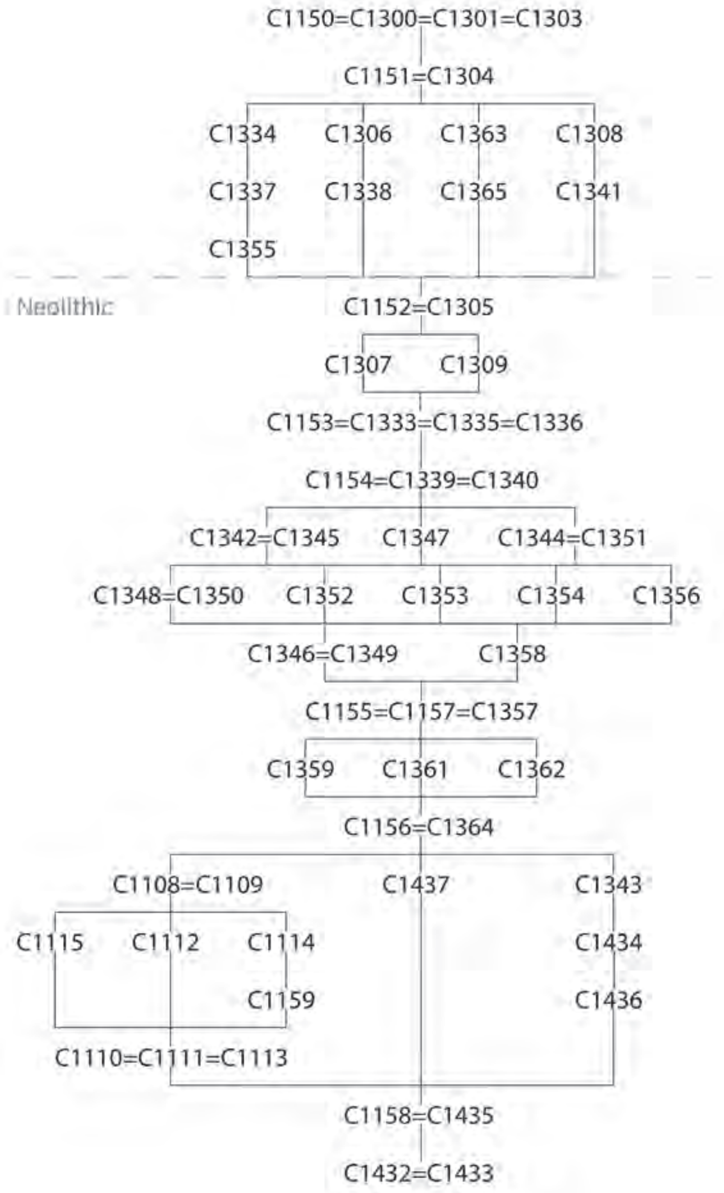


Figure 9.39. Matrix of the sequence of deposits in Trench 9.

laying of layers of packing such as a thick deposit of clay C1155=C1157=C1357. This accumulation of discard and activity residues in external areas contrasts markedly with the clean internal spaces investigated across the site. Analysis of the heavy residue indicates that the density of all types of material in T9 was higher than the site average, as almost all the excavated area was of external spaces (Chapter 14). The density and degree of fragmentation of chert and obsidian is characteristic of external spaces at the site (Chapter 20). The relatively high quantities of notched blades as well as awls/drills are also suggestive of external activities. Very few Çayönü tools were recovered in T9 in contrast to T7, and those that were occur in disturbed upper layers, as is the pattern in several other trenches at Bestansur.

Trench 10

Selection of location and excavation strategy

The location of Trench 10 was selected to investigate a scatter of particularly diverse chipped stone tools observed during surface survey at Bestansur. An initial 2 × 2m trench was laid out in spring 2012 *c.* 15m east of Trench 1 and *c.* 25m northeast of Trench 8 (Figs 9.3 and 9.4a). In the first season of excavations we identified intact Early Neolithic deposits with significant evidence for lithic production, most notably in the form of chert cores, beneath a dense disturbed deposit of stone and pottery. The rich chipped stone and worked bone assemblages indicated an area of intense activity. In spring 2013, therefore, we expanded this trench into a 6x6m area, with the

Figure 9.40. Trench 10, original 2 × 2m trench (centre) and 6m expansion with Wall 12 in northwest corner. Looking west, scale = 50cm.

original 2 × 2m trench at its centre, in order further to investigate Early Neolithic activities in this sector of the site (Fig. 9.40).

In summer 2013 we expanded Trench 10 further to the north and west in order to trace a well-preserved earthen wall, W12 C1420, that was exposed in the northwest corner towards the end of the spring 2013 season, and to explore the related activity areas and building structure. As this expansion revealed the walls of a large building B5, we consequently focused our excavations in this sector of the site. Subsequent extensions were made initially to encompass the full extent of B5, and in 2017 an area of adjacent buildings and external areas in a trench 20m N–S and 15m E–W at its maximum extent. The results from this sector of the site have proven so rewarding that the next phase of the project aims to investigate the neighbourhood around Building 5 and the underlying Building 8 (Fig. 9.42), which contain many burials.

Sequence of deposits, features and structures

Neolithic levels

BUILDING 8

Building 8 is the earliest structure thus far excavated at Bestansur (Figs 9.42 and 9.46). As B5 was constructed over B8 and currently remains largely *in situ* due to the high number of burials and time needed to excavate them, the complete plan and excavation of Building 8 awaits future investigation.

Where visible in plan and in the small areas excavated, it is possible to offer a preliminary description of Building 8. The thick walls of B8, up to 70cm wide, were constructed of layers of packed earth ('strip-chineh')/large mudbricks and boat-shaped mudbricks (Chapter 12), *c.* 8–10cm thick, set in layers of pale brown mortar. The wall surfaces were coated with multiple applications of diverse plasters, and occasionally whitewashes and, on the southern face of W56, traces of paint or pigment. The plan includes an open portico entrance, Sp54 1.6 × 4m, which faces southeast and is formed of two projecting walls, W46 to the west and W50 to the north. Within the west of this open portico, there is an offset plastered entrance leading into a rectangular room Sp56, 2.5 × 3.5m in area, beyond which a large rectangular room extends 4 × 6.6m Sp66.

In two small soundings we investigated the deposits relating to B8 on the eastern and western side of Wall 46, the eastern of the two walls projecting out to make the portico entrance to B8 Sp54 (Fig. 9.43). The first of these soundings, against the eastern face of W46 and the southern face of W48 in Sp54, was excavated *c.* 30cm down to the uppermost surface associated with these walls, on which were clear traces of humic plant remains from matting (Chapter 12).

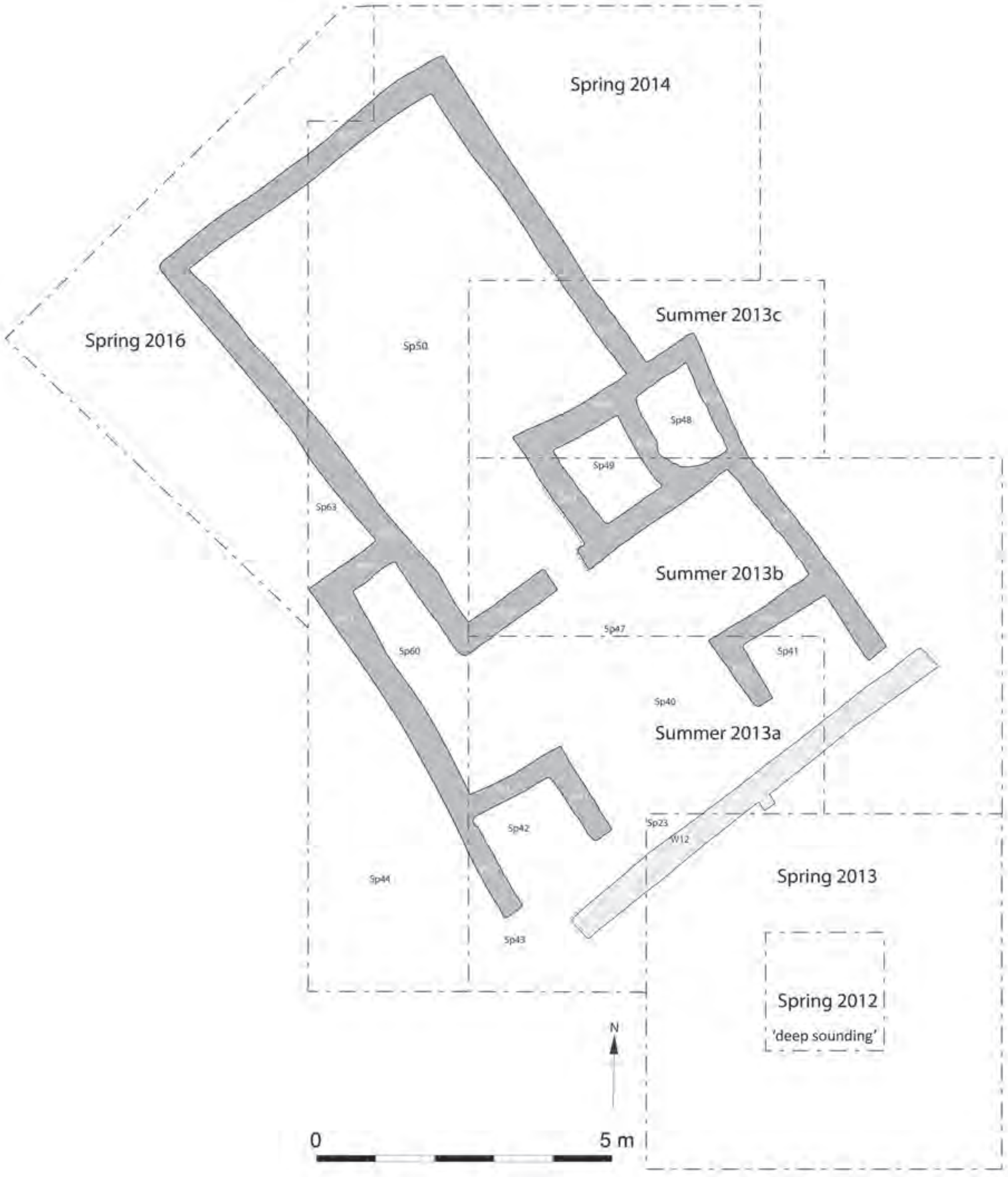


Figure 9.41. Phases of excavation expansion to the layout of Trench 10.

The deposit consisted of silty clay packing C1630 and revealed the northern face of W12, which continued down below the occupation surface.

The second sounding, 1.5 × 1.5m, was excavated in the external area Sp55 to the west of B8 W46 (Fig. 9.42). The deposit was *c.* 30cm of a brown silty clay loam C1667, with lenses of ash and shell fragments, consistent with other external area deposits excavated elsewhere across the site. The excavation did not reach the bottom of W46, and the construction level and dating of Building 8 is yet to be ascertained. The soundings have established that B8 was eventually cut down to a level where its walls stood to a minimum of *c.* 30cm and the rooms were packed to this level (558.60m asl), prior to construction of Building 5 (Figs. 9.42-3, 9.46).

Building 11

To the west of B8 and Sp55, also underlying the walls of B5, excavations revealed a series of walls associated with another structure of a similar phase, Building 11 (Fig. 9.42). Walls W69, W70 and W72 are partially

Figure 9.42. Multicontext plan of Trench 10 Neolithic architecture and external spaces.

visible in plan and are probably contemporary with B8. Walls 69 and 72 both have burnt plaster faces from *in situ* burning in a possible fire installation located between these two walls. Sub-floor excavations within Sp50 of B5 indicate the presence of a corridor or passageway running northwest to southeast between B8 and B11.

External Area, Space 27

Natural deposits have not been reached in the excavation of Trench 10. In the original 2 × 2m 'deep sounding', now in the southeast corner of the trench, Neolithic occupation deposits C1772 indicate earlier phases below the current excavation levels 3.04m below the ground surface at the deepest point in T10

(556.84m asl). The earliest deposits investigated thus far in a 1 × 2m half-section (Fig. 9.42) consisted of activity residues on sloping external surfaces, C1772. Ashy sediment, well-preserved large animal bones, clay shapes, stone beads and chipped stone discard indicate the deposition of working debris from burning, butchery and knapping in this area. Laid over these deposits was a thick pinkish white fired lime plaster surface, C1768 (556.96m asl; Fig. 9.44; Chapter 12). As with other deposits in this sounding, this surface sloped away from the entrance of the large buildings B8 and B5 to the northwest.

Onto plaster surface C1768, activity residues C1752 were deposited in the form of ash and large quantities of chipped stone debitage over which a thick layer of clay packing C1751 was laid. Clay packing C1751 modified the steep slope of the deposits, with deeper packing in the southeast shallowing to the north and forming a more gently sloping upper horizon. The continuity of activity in this external area Sp27 is evident, with further dense chipped stone working debris, C1749, followed by clay packing C1738=C1424 (557.37m asl), surfaces and ash lenses C1740 and C1423 and more clay packing C1413 (558.20m asl). These deposits represent the repeated discard of activity debris on external surfaces, periodically sealed and resurfaced with packing layers.

An unplastered earthen wall W12 was constructed on a southwest–northeast alignment (557.93m asl), to contain the mudbrick debris from demolition of B8 and to use this to create an enlarged flat area for the foundation of B5 which was larger than the underlying B8 (Fig. 9.42). Wall 12 was first identified in the corner of the 6 × 6m extension of T10 and was further exposed in the subsequent extensions to the north and east (Fig. 9.41). This retainer wall is *c.* 8m long and 48cm wide, constructed of red silty clay with carbonate inclusions. Wall 12 marks a break in the slope of the mound, with gently sloping deposits to the northwest and steeply sloping discard and packing deposits to the southeast.

To the southeast of W12, external deposit C1422 abutted the wall and sloped down towards the deep sounding, probably equivalent to C1413. External deposit C1422 comprised layers of occupation debris over an ashy surface (558.07m asl) and included several serrated chert blades with sickle sheen as well as fragments of tortoise shell.

Wall 12 appears to have been constructed between the close of B8 and the construction of B5, serving to close the entrance to B8 and provide a retainer for the mudbrick demolition debris of B8 and overlying packing C1421 used to create the level platform on which B5 was subsequently built. A small sounding, 2 × 1m, investigated the northern face of W12, the eastern face of W46 and the southern face of W48 of Building 8, through *c.* 30cm of a clean packing silt C1630, equivalent to C1421. Packing deposit C1630 was laid over a surface associated with the entrance of B8, Sp54 and abutted W12 (Fig. 9.45). Fugitive abutting and possibly adjoining walls at the northeastern end of W12 continue to be the subject of investigation.

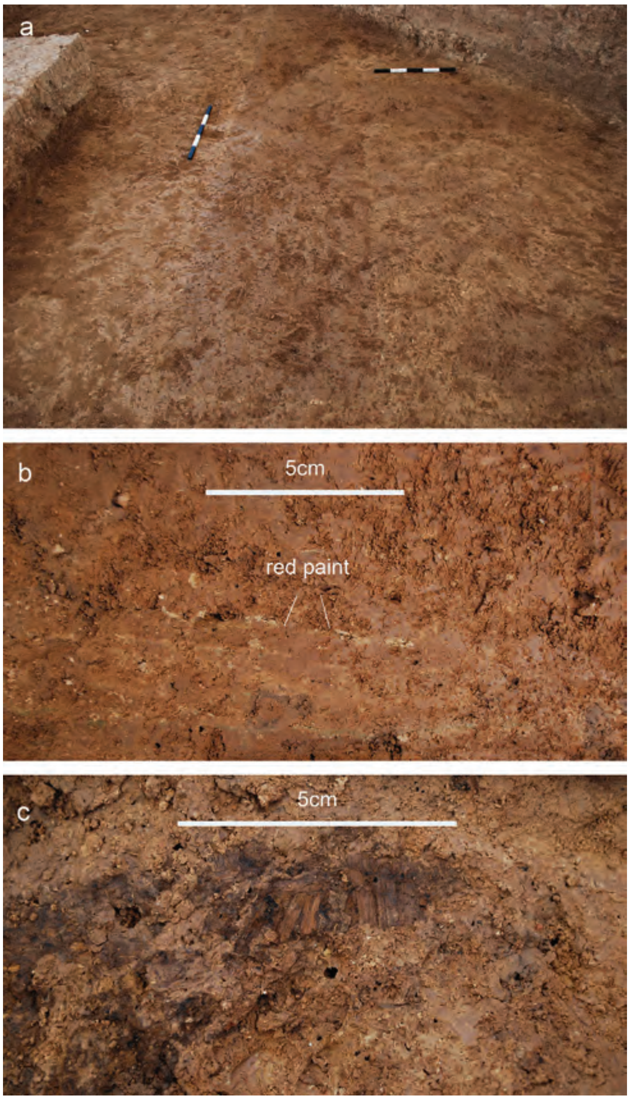


Figure 9.43. Building 8: a) walls W46-48, looking northwest, scales = 50cm; b) wall plaster on southern face of W56 in Sp56; c) matting on a surface in portico Sp54. Looking southeast, scale = 5cm. (See also Figs 12.22, 13.11).

Following the construction of W12, a *c.* 20cm sequence of sloping occupation debris and ashy deposits interspersed with resurfacing clay packing C1412 and C1414 in this external area were contemporary with activities in B5. The presence of green patches of clay in C1414 may represent roof material/collapse.

Building 5

Building 5 is large, at 7.6 × 12.5m, 81m^2, and complex with eight spaces and more than 65 human individuals

Figure 9.44. Fired lime plaster C1768 (right) overlying ashy external deposits C1772 (left) in the 2 × 2m sounding, viewed from the east. Scales = 50cm.

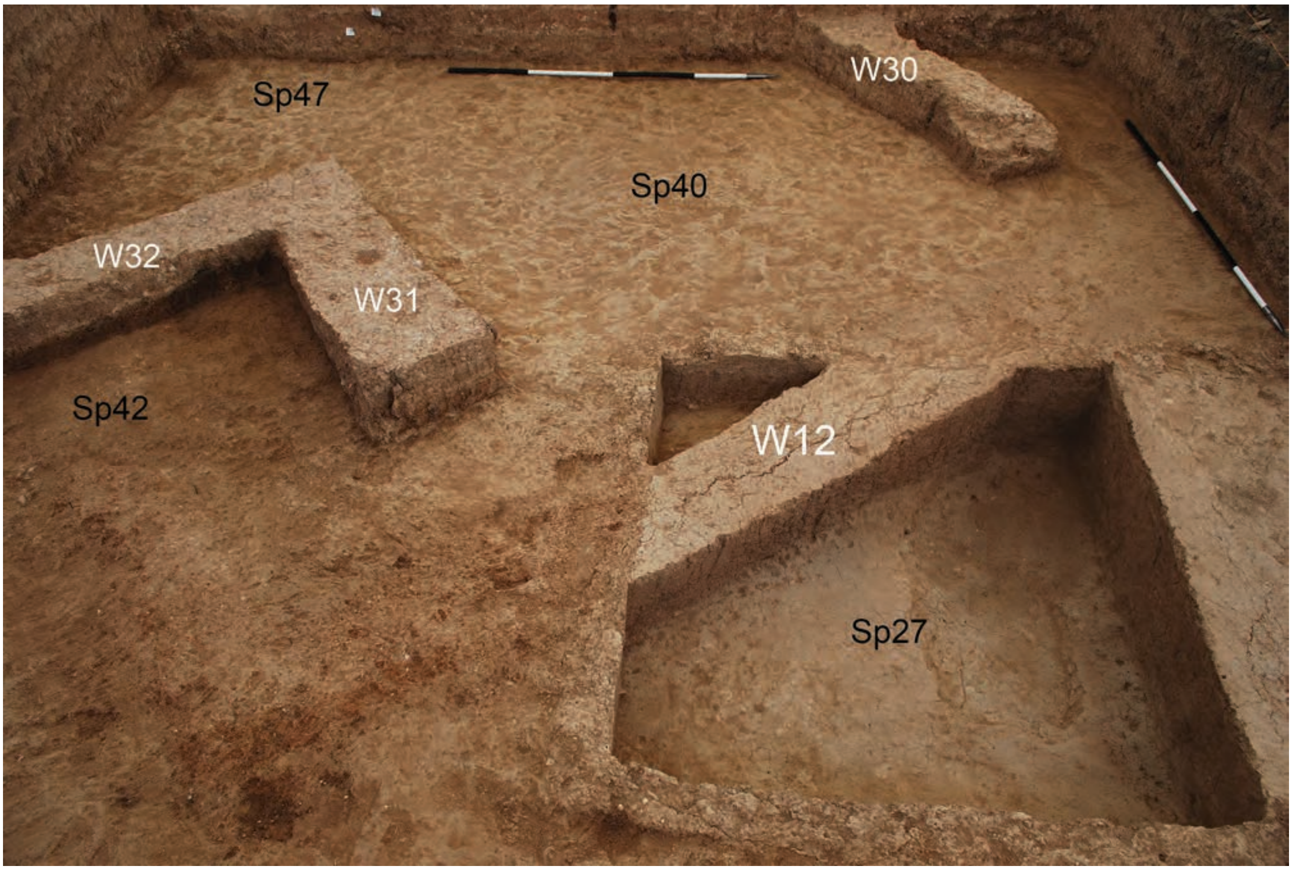


Figure 9.45. View of W12, looking north towards B5. Scales = 2m.

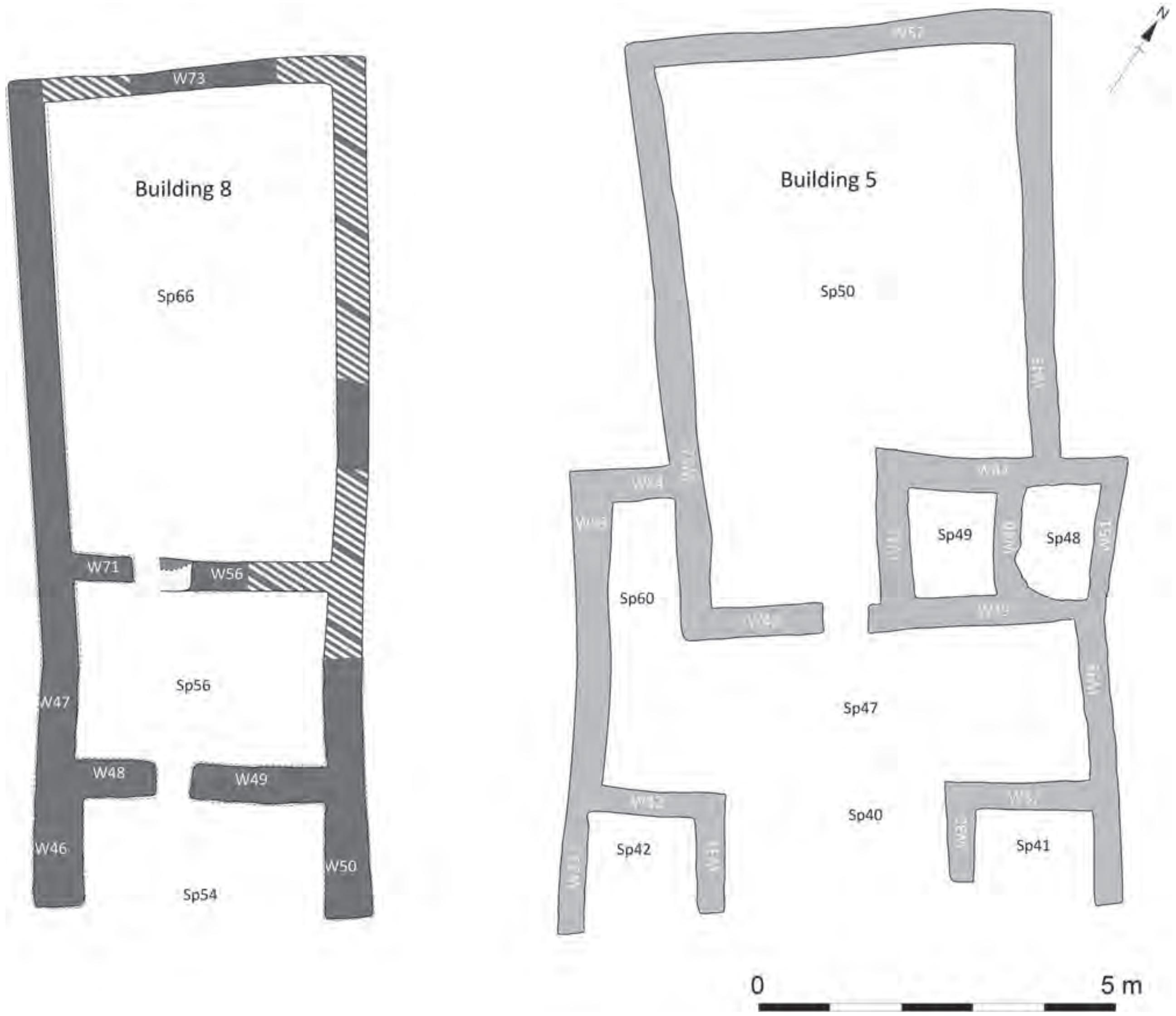


Figure 9.46. Plans of B5 and B8.

buried below its floors. All interior rooms and spaces of Building 5 were excavated to below floor level over several seasons in 2014, 2016–17 and 2019. Some sub-floor burials remain to be excavated as these are in the interface between the underlying Building 8 and Building 5.

The packing deposits in and around B8 and W12 appear to have been prepared as foundation deposits for an enlargement of the architectural plan of the building. The eastern walls of Building 5 were constructed immediately on top of the older walls and the packing, re-using some of the B8 wall stubs as wall bases for the overlying structure (Chapter 12), but enlarged beyond B8 to the west. This re-use is most evident in the eastern portico, where B5 W37 and W38 repeat the plan of B8 W49 and W50 (Figs 9.42 and 9.46). Building 5 W37 was offset from B8 W49, where the latter formed a raised surface along the southeast of Sp47, perhaps due to subsequent subsidence. The walls of B5 remain to a maximum height of *c.* 75cm in the northwest and *c.* 40cm in the southeast. Building 5 takes the form of a large multi-roomed, rectilinear structure that enlarged and elaborated on the plan of the preceding structure, with a wide entrance flanked by rooms and leading to a large entrance space that controlled access to a long room with a major focus on human burial.

Space 40

Building 5, like its predecessor Building 8, has a large open portico entrance Sp40, 1.6 × 3.2m, formed by two projecting walls: W30 to the east and W31 to the west. To either side of the portico entrance, there are two small spaces bound by walls on only three sides (Sp41, Sp42), that form an approximately symmetrical entrance, with a slight curved façade effect due to the shorter length of the walls framing the entrance, which places greater focus on the entrance.

The earliest surface across Sp40 was formed of the upper horizon of C1548, a layer of *c.* 10cm of clay

Figure 9.47. Stones in entrance, Sp40. Looking north, scale = 2m.

packing (558.47m asl), which extended to the south of B5 and covered the upper limit of W12 and B8. Deposited onto this surface, inter-bedded surfaces and occupation deposits C1541 and C1539 contained working debris including worked bone and chipped stone. In Sp40 and adjacent to the inner faces of W30 and W31 on the uppermost surface C1539 (558.78m asl), several large stones were deliberately placed in the entrance to B5 (Fig. 9.47). Included amongst a group of stones placed against Wall 31, a large boulder SF357 is especially notable for its surface covered in cut marks and drill holes, and which may have been used for craft activities (Chapter 22).

Space 41

To the northeast of portico Sp40 is a small external area Sp41, bounded by W30, W37 and W38. The surfaces in this space were contiguous with Sp40 and appear to have served equally as an external working space.

Space 42

To the southwest of portico Sp40, a further open-sided space, Sp42, is bound by W31, W32 and W33, repeating the layout of Sp41. The surface of this small space, C1550 and C1547, was covered with a thick deposit of small, angular stone fragments and ground stone debitage (Chapter 22), above which a further surface and occupation layer had accumulated, C1540 (558.63m asl).

Space 47

The open portico, Sp40, leads into a large rectangular room, Sp47, measuring 2.2 × 6.6m. This space is bounded by W32, W33, W37, W38, W39 and W42 but remains open to the south into Sp40. The interior wall faces have occasional traces of vivid red pigment. The floor of Sp47 had been repeatedly resurfaced with *c.* 20cm of interbedded layers of white plaster, packing and mud plaster C1620 and C1607 (558.74m asl), with traces of burnt material on the final floor C1599. To the north of Sp47, in line with the centre of the portico Sp40, there is a substantial constructed threshold, which dates to the earliest phase of the building. Placed across the threshold, a large smooth stone spans the entrance to Sp50 beyond (Fig. 9.48). *In situ* on the final surface of Sp47, C1599, rested a bell-shaped pestle SF369 with traces of red ochre, possibly from the processing of pigments, and a pierced stone disc SF372, next to the threshold between Sp47 and Sp50.

Space 60

A short alcove, 1 × 2m, Sp60 in the northwest corner of Sp47 was surfaced with a layer of packing material, C1785, similar to that in Sp47 (558.59m asl), onto

Figure 9.48. Threshold between Sp47 and Sp50. Looking northwest, scales = 50cm and 2m.

which *c.* 10cm of occupation debris C1742 had been deposited. As in Sp47 this occupation material was sealed with a layer of packing material C1736, *c.* 40cm in depth which likely served to close the building. Beyond W54 at the end of Sp60 in the north-west, the external walls are stepped in to form the narrowed length of the inverted T-shape of Building 5. It is possible that Sp60 may have provided access onto the roof, as this space structurally and spatially could accommodate a flight of stairs.

Space 48

Two small rooms were constructed to the north of Sp47: Sp48 and Sp49. The external walls of Space 48 form the north-easternmost extent of the wide section of Building 5, beyond which the plan of B5 was narrowed. Points of access into, or between, these small rooms remain unclear; the walls of these rooms stand to a uniform height of 55cm without evident breaks. It is possible that people may have used a different form of access, perhaps from above, to conduct activities in these rooms. They may have been used for storage and other activities that did not need access at floor level.

Space 48 consists entirely of an *in situ* oven measuring *c.* 1 × 1.7m, with burnt clay linings and a deep accumulation of ash (Fig. 9.49). The outer limits of the oven were formed by the internal faces of the walls of the room, constructed from the same materials as, and contemporary with, other walls in Building 5. The internal surfaces of the walls (W39, W40, W44, W51) were lined with a 5mm thick plaster C1677 that had been baked yellowish brown and rubified during use. The base of this phase of the oven was at 558.14m asl (C1676). The fill of the oven comprised alternating layers of ash and periodic lenses of oxidised burnt clay. The initial deposit C1675 was 3–5cm thick and extended across the entirety of the oven, onto which 4cm of dark grey ashy lenses, C1674, were deposited. The ashy lenses were sealed and the oven resurfaced with clay packing, C1610=C1673. Further episodic burning formed deep deposits of interbedded layers of red burnt deposits with lenses of grey ash, C1672 and C1671, and a final deep ash deposit C1669. The end of the use of the oven was marked by the placement of an upturned mortar SF449 in the centre of the oven and a brown marble macehead SF450 in the northwest corner (Chapters 21 and 22), and the ash sealed with a dark brown silty clay loam C1562=C1666=C1668 (558.92m asl).

Space 49

A small room Sp49 was constructed immediately to the southwest of Sp48, sharing walls W39, W40 and W44, and measuring *c.* 1.2 × 1.6m. On and above the

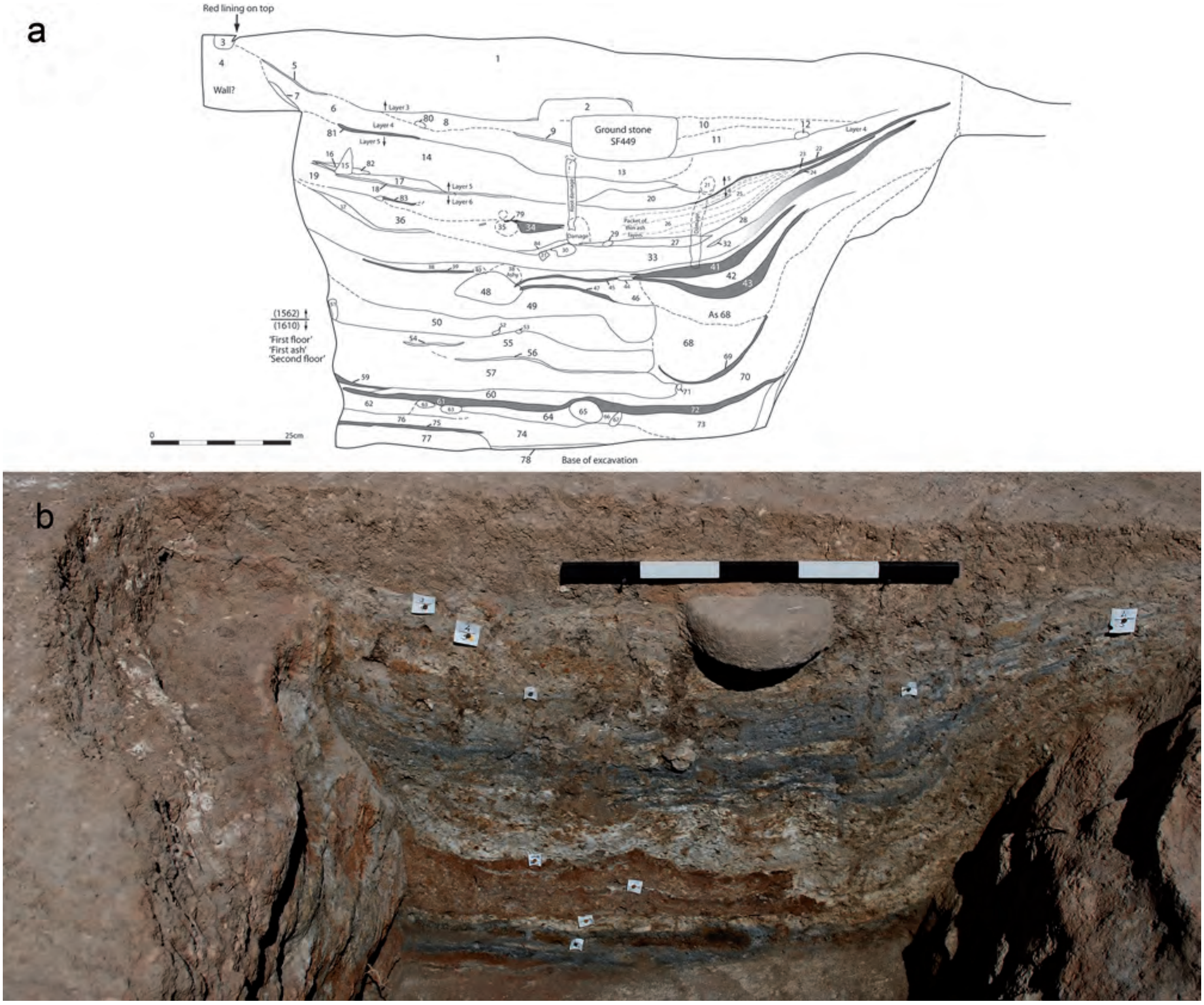


Figure 9.49. Section 100a of Sp48 and photo of ash layers with upturned mortar. Looking northwest, scale = 50cm.

Figure 9.50. Space 50 in B5, towards the threshold to Sp47. Looking southeast. Scales = 2m.

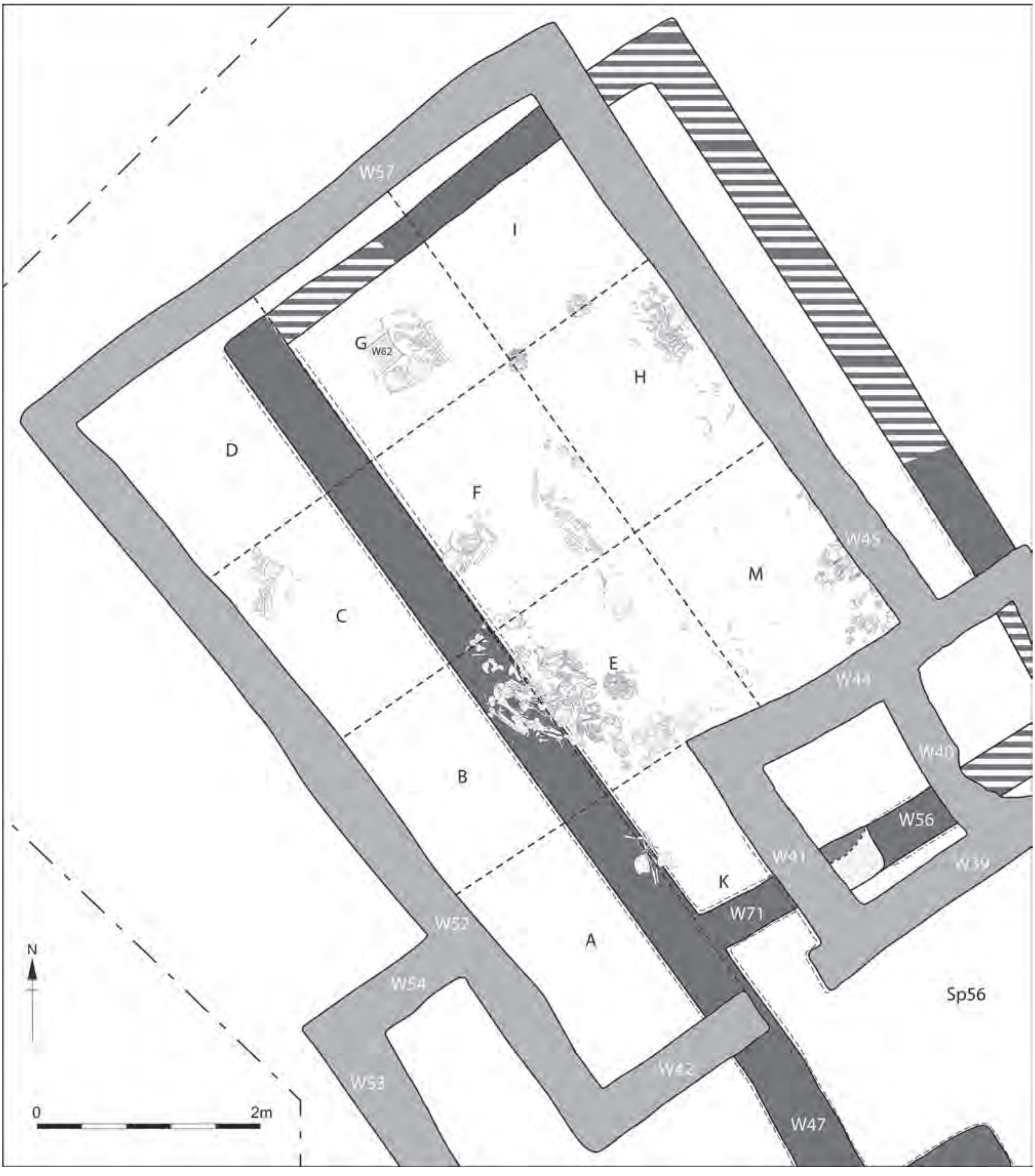


Figure 9.51. B5 Sp50 excavation and sampling grid and multi-context plan of human bone at the end of season 2017.

floor C1612, deposits C1608 and C1602 contained little anthropogenic material, including only five chert tools and a few fragments of hare, tortoise and bird bone. Wall collapse C1563 marks the final closure of Sp49 (558.79m asl).

Space 50

The threshold from Sp47 (Fig. 9.48), visible from the entrance of Building 5 and framed by the winged portico Sp40, was the sole point of access to the largest room of the building, Sp50. From Sp47, a narrow antechamber *c.* 2 × 2.3m opens into an open rectangular space *c.*4.7 wide by 5.3m long, the walls of which form the external walls of B5: W45, W52 and W57. The overall plan of Sp50 forms an inverse L-shape, measuring 7.6m in total from the large stone across the threshold to the furthest wall W57 (Fig. 9.50). The walls of B5 survive to a height of *c.* 40cm

Figure 9.52. Gravel skirting Sp50 B5. Looking southeast, scales = 50cm.

in the south and east (558.97m asl), and up to *c.* 75cm in the north and west (559.32m asl).

The floors of Space 50 were excavated and sampled for wet-sieving and flotation in eleven grid squares, *c.* 1.5 × 1.8m, to aid analysis of any spatial distinction in the activities within this large space (Fig. 9.51). Thin skims of floor and fill deposits had to be left against the wall faces in Sp50 as the walls sloped inwards, to prevent them from collapsing. These deposits and those provided by major trench edge sections across this large room as it was exposed have enabled the entire microstratigraphic history of this building and some burial cuts to be recorded by photogrammetry and drawing and sampled in detail (Chapter 12).

This large room appears to have served a specific purpose focused on the treatment and burial of the human dead. These acts associated with human remains span the life course of Sp50, from the foundation deposits to the upper fill and closure of the building. The human remains have thus far been partially excavated and it remains to be seen whether the underlying Building 8 held the same significance for the community of Bestansur. Three principal phases of deposition have been identified amongst the human remains: Phase 1 burials below the floors of Building 5, Phase 2 scattered and disarticulated remains on and between floor surfaces, and Phase 3 an inhumation and scattered remains associated with the fill of Building 5. Some of the human remains appear to have been deposited as discrete bundles within packing layers and fill or left as scattered remains on floor surfaces, while others appear to have been cut into packing as part of larger deposits. Objects associated with the burials were recorded *in situ* where visible, plus many tiny beads were recovered in flotation from contexts surrounding burial deposits.

The earliest human remains in association with the structure belong to the initial phase of foundation packing and levelling of the site over the standing walls of Building 8. This thick layer, C1625=C1781=C1803=C1809 (558.60m asl), appears to be contemporary with butchery activity to the south in Sp27, radiocarbon dated to *c.* 7735–7586 BC (Chapter 11). This silty clay levelling material was heavily disturbed by subsequent burial cuts and fills, which were difficult to identify in the field. Scattered throughout, stone and shell beads, loose teeth, and human bones indicate either placement of fragmented human remains within the packing material when laid or substantial turbation between the entrance and the centre of the space (Chapter 14), where infant burials are most concentrated (Chapter 19). The packing also incorporated a clay human figurine of Early Simple type (SF532; Chapter 21), a marble stone bowl body

Figure 9.53. Stone slabs in Sp50 B5. Looking south, scale = 50cm.

sherd (SF537; Chapter 21), and significant quantities of lithic tools (Chapter 20).

The walls of Sp50, contemporary with the rest of B5, were constructed onto the thick layer of packing C1625=C1781=C1803=C1809, in alignment with but offset from the walls of the preceding Building 8 (Fig. 9.42). Around the internal perimeter of Sp50, a *c.* 10cm wide skirting of limestone gravel C1626=C1782 made up of stones 0.5–3cm lined the space, up to 3cm deep (Fig. 9.52), also containing the disarticulated bones of at least one infant (558.71m asl). The deliberately laid stones abut the walls and may have served to provide drainage, to protect the walls from undermining by pests or as a means of bounding the sanctity of the burial space itself. The gravel in the south-east corner along W44 and the southernmost extent of W45 had been repeatedly cut through for burials in this area (Fig. 12.31).

A sequence of finely layered floors in Sp50, C1621=C1775 (558.93m asl), was constructed across the surface formed by the upper horizon of the packing and the gravel. The floor plasters were made from repeated layers of reddish brown, greenish brown and brown silty clay plasters, each <*c.* 0.5–1mm thick, but only totalled *c.* 1cm, except in the southeast corner at the base of the wall, where they are thicker (Chapter 12). The floor surface C1621=C1775 sloped down from west to east, possibly due to subsidence in the packing within the underlying Building 8. On the upper boundary of C1621=C1775 in the northwest corner of Sp50, evidence for organic fibres in the form of phytoliths and traces of pigment C1771 suggest woven reed or grass mats may have lined the floors and may account for the low density of micro-artefacts across the surfaces of this room, as other traces for matting were also detected across the floors (Chapters 12 and 14). In the antechamber to Sp50, along W42, eight large, narrow and smooth stone slabs were laid on surface C1621=C1775, parallel to the threshold, which could have provided a space for laying out and preparing bodies for burial (Fig. 9.53; Chapter 22). The latest activities in Sp50 are attested by a thin layer of ash on the floor in the northwest corner of Sp50 and the placement of a thin white stone with traces of soot/charred material on its surface against the wall face (Fig. 12.30).

Burial Phase 1a–c: It has been difficult to establish in some cases whether burials were placed within the packing that infilled Building 8, or are in cuts through the floors of Building 5, due to the thinness of the floors, at less than 0.5mm each, and less than *c.* 1cm in total, and the similarity of the burial fill to the surrounding packing, despite intensive cleaning and examination. A range of cuts and replasterings

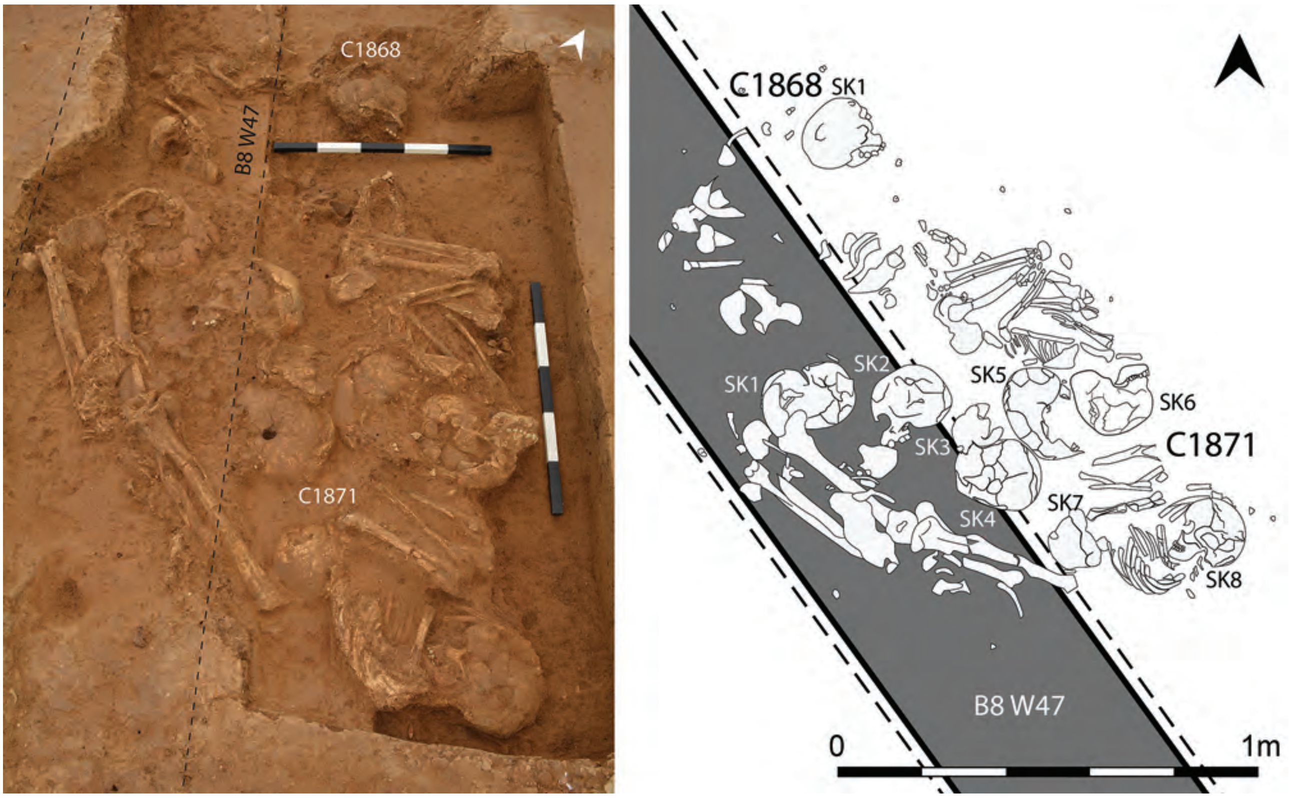


Figure 9.54. Dense deposit of human remains C1868 and C1871 in B5 Sp50, cutting B8 W47: a) looking northwest, scales =50cm; b) multi-context plan.

were identified in the microstratigraphic field sections across Sp50, and in the sequences left against the inward sloping wall faces to stop the walls from collapsing during excavation (as discussed and illustrated in Chapter 12).

In this account of the burial phases, therefore, we have sub-divided the earliest burials into three sub-phases to help to clarify their sequence of deposition. This phasing will be even clearer once the walls of Building 5 have been removed in future seasons. The sub-phases identified are: Phase 1a) burials that were placed within the fill/packing at the end of Building 8 as evidenced by their alignment with walls of Building 8, or that are overlain by the walls of Building 5; Phase 1b) burials for which no clear cut was found and it is uncertain whether they belong to Phase 1a or 1c, and; Phase 1c) burials that can be associated with cuts through floors and/or a distinctive layer of orangish brown packing *c.* 2–4cm thick immediately below the floors. The burials are numbered and grouped by context number, and individual skulls and bones recorded by photogrammetry, planning, and numbering (Chapter 19).

Most of the burials within Sp50 can be attributed to Phases 1a–c, either in the infill of B8 or in cuts through floors of B5. These burials were of both articulated and disarticulated adults and juveniles. The MNI for this phase is currently at least 65. These burials are predominantly located within the bounds of B8 and at least some may relate to phases of activity predating the construction of B5. Future excavation of B8 and the interface with B5 should help to clarify this point further. There is some evidence of placement of the dead according to their age, although some burials are of mixed age groups.

The juveniles were placed in the area closest to the threshold into Sp50 from Sp47, beyond the 2 x 2.5m antechamber in Sp50. A sequence of infant burials was interred up to 30cm below the floor surfaces. As some cuts through floors were identified in both the eastern and southern sections of deposits, many of these are probably associated with Phase 1c. The juvenile remains include 17 skulls and predominantly disarticulated and comingled bones from the rest of the body, C1811=C1812 (558.43m asl). The area adjacent to the antechamber continued to be used for more complete child and infant remains, which were repeatedly deposited with shell and stone beads (558.50m asl), in C1783, C1780 and C1731.

The uppermost burials within Phase 1 are small and well-defined in extent, undisturbed by subsequent cuts and inhumations, perhaps suggesting they can be attributed to Phase 1c. Burials C1780 and C1731 included infant and young child skulls which appear to have been placed to face towards the threshold with Sp47 and the entrance

Figure 9.55. Wrapped and flexed burial C1863 in B5 Sp50. Looking northwest, scale = 25cm.

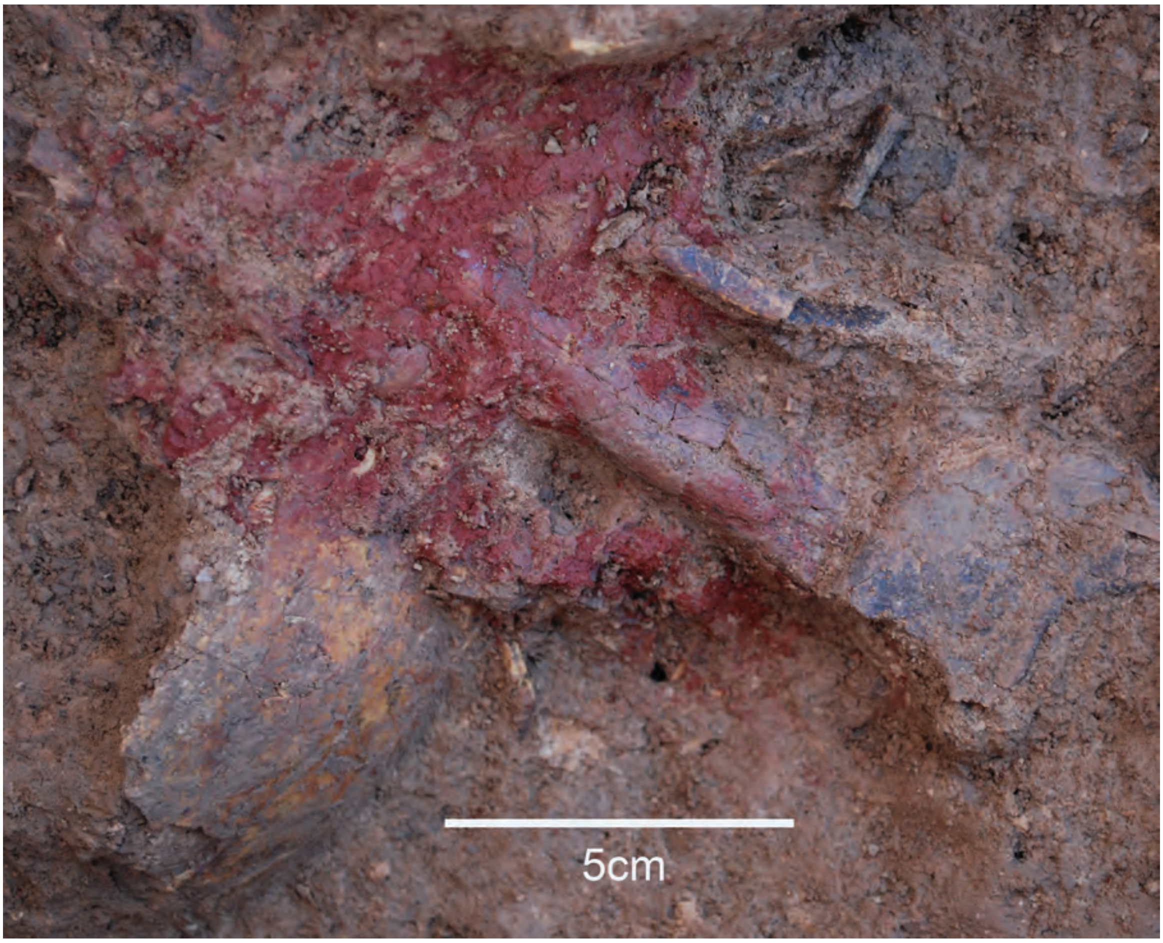


Figure 9.56. Red pigment on a skull in C1804=C1861.

to B5. C1731 comprised an extremely compact group of disarticulated bones from three young children including an infant, which may have been wrapped in a bag or basket. Two cowry shells with bitumen embedded into the dorsum, SF468 and SF470, were found close to the child skull in C1731, and may have been affixed to the burial container or possibly the skull, although no trace of fixative was visible in the eye sockets (Chapter 21). To the south, a double burial C1631 included two articulated juveniles ages 4–5 and 6–8 years old, buried in flexed positions with both skulls facing south towards the threshold from Space 47.

In line with the threshold and located at the centre of Sp50, the largest deposit of human remains excavated so far was cut partially into W47 of B8, and therefore can almost certainly be assigned to Phase 1c. Covering an area of *c.* 1 × 2m, this dense concentration of human remains included long bones with skulls C1784 and C1871 (558.38m asl), and skulls with two articulated juvenile skeletons C1868 (Fig. 9.54). Beneath the investigated levels, there are further long bones and other elements, which remain for future investigation. A skull and ribs were placed against an articulated, tightly flexed right leg and pelvis C1871, with further long bones, a cluster of vertebrae and an infant skull placed to the south. Immediately to the west eight skulls were deposited, C1868, two of which were associated with fully articulated juvenile skeletons.

Above these burials, the adult remains in C1784 had been deliberately disarticulated and deposited in a curving arrangement of ribs, upper limb bones, and pelvic bones, followed by a skull and an articulated leg, possibly all from the same probable female individual. A humerus and ulna were placed as if articulated but with the appropriate joints at the wrong ends. Into a small cut adjacent to C1784 along the line of B8 W47, a small infant C1866 had been placed.

To the northwest, placed against B8 W47, the body of one individual C1863 was tightly flexed and laid on its right side (Fig. 9.55). The bones were very compact and suggest this individual may have been bound, traces of which are represented by pigment and phytoliths in a darker sediment around the spine, ribs and pelvis. The flexed body C1863 was placed into a defined cut, C1885, with the skull of an adult beneath the pelvis, a juvenile directly beneath the skull, and a further adult skull to the northeast (558.38m asl). The cut for C1885 could be seen to intersect with a further cut containing three skulls, all of which therefore could be attributed to Phase 1c.

A group of adult burials, C1788=C1789=C1880, extend from the centre of Sp50 to the northern area and appear to form one deposit containing two adult skulls and disarticulated bones including long bones, ribs, vertebrae, and pelvic bones (558.40m asl). These burials have been cut into a wall, W82, relating to Building 8, and therefore relate to Phase 1c.

A spread of human remains was laid in packing along the line of the northeast wall W45 of B5 from the southeast corner with W45: C1804=C1861 spreading west towards C1811=C1812, and C1810 (558.41m asl). At least some of these human remains, including a skull, are overlain by W45 and therefore pre-date B5, and can be attributed to one of the earliest phases of burial, Phase 1a, as they are contained within the packing of B8. The burials along W45 appear to have been subject to a set of burial customs that differ from those accorded to the individuals placed at the centre of Sp50. No beads or other adornments were recovered with the skulls and long bones, but traces of red ochre staining on a skull in C1804=C1861 (Fig. 9.56) and a tibia in C1810, and a plaster-like substance on a humerus and other bones in C1810 indicate a distinct set of activities and perhaps wrappings associated with individuals interred in this sector of the room. The remains in C1810 possibly extend underneath W45, although the gravel C1626=C1782 skirting Sp50 has been disturbed in this area, suggesting the burial was cut through floors. Red ochre was also identified around an adult skull and mandible C1862 buried with disarticulated long bones, ribs and vertebrae, close to W52 along the western edge of Sp50. Wall plaster underneath the skull may have been present prior to the placement of the bones.

The varied practices represented by these Phase 1 articulated burials, disarticulated bone scatters and deliberately arranged clusters of bones demonstrate the curation of remains prior to and during eventual burial beneath the floors of Sp50. In some cases, such as C1731 and C1863, it is likely that disarticulated and articulated groups of bones were contained in wrappings prior to and during burial. Other deposits within Sp50 indicate partial decomposition prior to burial, for example in C1784, where the lower limb bones appear articulated, while other components such as vertebrae were completely disarticulated. The placement of discrete clusters of human remains with spatial variation according to age and burial practice, including the positioning of child skulls facing towards the threshold, demonstrates a set of socially negotiated rules enacted by the living. It is likely that the interment of later burials caused significant disturbance to earlier burials which may have been pushed aside to make room for the new depositions. False articulations of bones, as in C1784, might then result from attempts to tidy up human remains disturbed during later burial activities.

Burial Phase 2: Human remains from Phase 2 in Sp50 comprise scatters of small bones on the floor surfaces, C1621=C1775, and a separate single spread of larger bones. Disarticulated teeth and the bones of three infants lay on the upper horizon of surface C1623 adjacent to W44. On the sloping fine floor

Figure 9.57. Fire installation F15 in the southwest corner of Sp50. Looking southwest, scale = 25cm.

layers C1621=C1775 (558.93m asl), loose teeth with occasional vertebrae, ribs, and hand and foot bones were widely scattered. An adult cranial fragment lay *in situ* on the remains of a woven reed basket or matting, C1771.

Scattered on the final floor C1746 (558.97m asl) and in the room fill C1741 of Sp50, the disarticulated remains of a possible female adult extended over *c.* 4m^2. The spread of the bones and partial fragmentation to the limb bones suggest that this may have been a single individual, part way through decomposition. Overlying the large stones near the threshold to Sp47, disarticulated juvenile teeth and adult skull and long bone fragments were present in a *c.* 30cm deep packing deposit, C1604, containing wall collapse and plaster, demonstrating continued deposition of human remains in Sp50, or possibly even human remains laid out on the roof prior to collapse.

The latest phase of use of Building 5 is represented by C1746, a layer of occupation residues and some wall collapse on the floors of Sp50 and C1745, and the construction of a small fire installation in the southwest corner of the room (F15; Fig. 9.57). The fine floors of Sp50 are visible underlying this fire feature, confirming that it is late in the history of Sp50 and marks a significant change in the nature of use of this space associated with the end-life of the building.

Roof collapse is evident in the subsequent room fill C1877=C1883=C1884 and C1880 on top of pigmented matting (Chapter 12). Final and apparently deliberate wall collapse and closure, C1728=C1729=C1733 and C1741=C1857=C1867, mark the end of the use of Building 5. The closure of B5 did not mark the end of Neolithic activities in this area, however, as a dense cluster of *Helix salomonica* shells and chipped stone, C1832 *c.* 35 × 60cm, above the northwest corner of Sp50 indicates that this area of B5 remained in use as an external activity space. An accumulation of greyish brown silty loam above this event, C1565=C1718=C1719 (559.32m asl), suggests that use was infrequent and that little Neolithic activity took place in this area.

Burial Phase 3: The final burial event in the area of Sp50 is an articulated flexed adult burial C1708=C1714 (559.58m asl), *c.* 65cm above the uppermost floors C1746 in Sp50, which was disturbed by Iron Age pits and other later activity. The burial may relate to the collapse or closure of B5 or a reuse of a remembered space. A group of 19 heavily abraded *Nerita* beads, identical to those found scattered throughout the infant and child burials in Sp50, point to deliberately drawn parallels with the earlier inhumations during the life of B5. The continued use of *Nerita* beads in the Phase 3 burial is the only instance of beads securely associated with an adult burial. The Phase 3 human remains are situated in higher deposits which have

Figure 9.58. Remains of large constructed ovoid oven and ashy fill F16 in external area Space 44, southwest of B5: a) general view; b) excavation in quadrants. Looking south, scales = 50cm.

Figure 9.59. Building 9, Space 53 with boulder mortar (SF521) re-used as door post setting in entrance. Looking southeast, scales = 2m.

suffered severe disturbance from later, Iron Age, activity, animal burrows, and modern land-use activity. They may rather relate to a now eroded upper level of the site, which could have included a successor building to Buildings 8 and 5.

External area, Space 29

Contemporary with the closure of B5, a dense packing deposit of red silty clays C1409 was laid over the surfaces to the southeast of the building in Sp27, defined as Sp29 in its later phase. Activities in this area appear to have resumed, with evidence for working bone, clay and chipped stone present in subsequent lenses of Neolithic material C1405, C1332 and C1330 (559.06m asl). A further phase of activity shows a shift in the nature of the use of this area of the site,

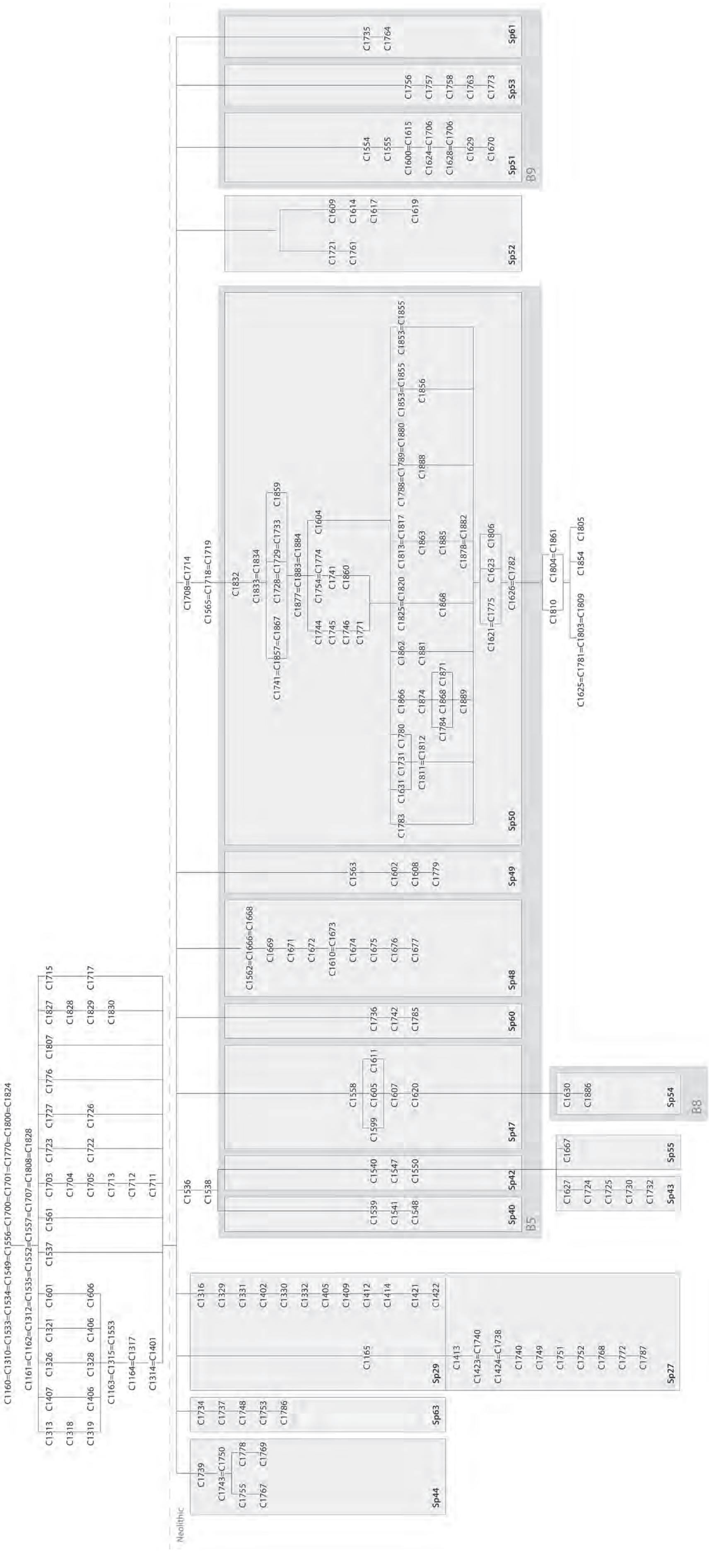


Figure 9.60. Matrix of the sequence of deposits in Trench 10.

represented by sloping lenses of ash and edible snail shell, *Helix salomonica*, and lithics *in situ* on surfaces C1331, C1329 and C1316 (559.11m asl), which are comparable to the deposits C1832 overlying B5.

External area, Space 44

To the northwest of Sp29 and less than a metre west of the southernmost corner of B5, significant ash deposits from a large fire installation F16 were scattered on thin sloping lenses of soil contemporary with activities in B5 (Fig. 9.58). The fire installation was constructed with a clay lining abutting two wall stubs to the south. Small quantities of carcass processing debris (Chapter 15) and several fragments of worked bone (Chapter 21) indicate external activities conducted around the fire installation. Seven objects of roughly shaped clay, possibly deliberately squashed and nullified, and numerous small clay fragments were lightly baked and discarded in the surrounding ashy deposits (Chapter 21).

Building 9

Building 9 was constructed to the northeast of Building 5 (Fig. 9.42). The western walls of Building 9 abut B5 W45 and W51. Building 9 is constructed on the same northwest to southeast alignment and on a similar layout to B5, although the spaces examined thus far indicate it was built on a smaller scale. The sequence of construction of these buildings is yet to be established, but they both post-date the closure and packing of the preceding Building 8. Two walls W63 and W65 frame a small 1.65m^2 portico Sp51, beyond which the walls W61 and W62 were stepped out to form an open 2.6 × 2.8m entrance space Sp53. At the northwest extent of Sp53, a wall W60 separated the entrance space from a larger 2.6 × 3.8m rectangular room Sp61. Although W59 is contiguous with W61 abutting B5 W45 to the southwest, W84 to the northeast has been stepped outwards to form a wider space, in the southeast corner of which is a large fire installation F17, to the east of which a further building B12 has been identified. Building 9 may extend further to the northwest and is subject to ongoing investigations. It is notable that B5 and B9 have their own external walls, without the use of party walls, and are constructed in different materials: B5 from reddish brown silty clay with carbonate inclusions and B9 from brown mudbrick with yellow mortar (Chapter 12). The distinction in material use and construction method suggests the builders had access to different source areas.

In and around Building 9, a series of silty clay surfaces was constructed, covered with occupation debris and resurfaced with clay packing. The lowermost surfaces investigated, downslope from B5, were a sloping dark grey silty clay floor C1670 in the portico Sp51, and a silty constructed floor C1773 in the entrance Sp53 (558.35m asl), on the surface of which lay traces of organic material, pigment and chipped stone tools. In Sp51 and Sp53, a *c.* 15cm thick layer of clay packing was laid over the surfaces and formed fresh working surfaces C1629=C1763. Three large fragments of ground stone, including a boulder mortar reused as a doorpost pivot (Fig. 9.59; SF521; Chapter 22) were found on the surface formed by the packing deposit in Sp53, over which a further layer of packing was laid C1758 (558.52m asl). The packing contained a group of eight cores of chert (Chapter 20) and a mixture of burnt red and yellow clays, possibly relating to the subsequent ash C1757 and packing C1756 deposited onto the surface. In the latter, craft objects including shaped clay tools SF480 and bone needles SF483, SF484 were mixed with sediment and ash and may represent a late stage in the use of B9. These refuse deposits and a stone surface C1624 in Sp51 are level with the phase of B5 wall construction (558.61m asl), and may suggest there was some terracing of houses down the slope of the mound as is common in villages in the region today. In the large room within B9 to the northwest, Sp61, wall and plaster collapse C1764 lie only 10cm above this level.

Buildings 10 and 12

The upper plans of walls relating to a further building B10 to the northwest of B5 have been identified in plan along the northern edge of the trench, but the associated deposits have not yet been excavated. The southernmost wall of B10, W58, abuts the rear wall of B5. The return wall, W80, indicates that B10 shares the alignment of buildings in this neighbourhood, and was laid out on a similar plot width. A series of narrow walls were constructed against the western wall, W52, of Building 5. The western wall W85 of a further building B12 was constructed abutting the northeast walls of B9 W62 and W84, following the external perimeter of this building. Future excavation will determine the extent and sequence of building construction in this neighbourhood.

Post-Neolithic levels

Subsequent activity at Bestansur has truncated the Neolithic levels in Trench 10. Stone walls C1807, C1827 and C1829 in the northwest corner of T10, above B5 Sp50, possibly relate to the later phase of activity on the eastern slopes of the mound identified in Trench 1 (Fig. 9.7). In the surrounding fields, bell-shaped pits, the truncated bases of five clay tannurs and a large *c.* 10m wide terrace surfaced with 20cm of stone and broken pottery, C1163=C1315=C1553, were cut into the underlying Neolithic deposits. This terrace covered the whole of the east side of Trench 10, at least 20m from the northern to the southern extent. Incorporated in its construction were a mixture of redeposited materials from the Neolithic to the Sasanian period. The overlying *c.* 40cm has been heavily churned by modern ploughing in crop fields surrounding the mound.

Contextual analyses and interpretation

Investigations in Trench 10 have revealed a neighbourhood of Early Neolithic buildings (Fig. 9.42), amongst which are represented two large well-built buildings constructed one on top of the other: Buildings 8 and 5. The repeated construction of these elaborate buildings with multiple floor and wall plasters suggest that the community at Bestansur constructed, reconstructed and expanded on a building of cultural significance. A substantial quantity of materials, labour and skill were committed to the construction and maintenance of B8 and the fired lime surface leading to its entrance, its deconstruction, and the preparation of an expanded platform area for the construction of its successor B5. In its construction, the symmetrical layout of B5 indicates a preconceived plan for the spaces that the structure would provide for the community. The evidence from B5 indicates that a series of spaces were used repeatedly for mortuary activity and it remains to be seen to what extent these activities reproduced social practices in the earlier phase. The dead were brought to this location for pre-burial activities, including the laying out of bodies on the floors and stone slabs in Sp50, and the probable disposal and burning of matting and wrappings in Sp48. The varied stages of decay and articulation, including the caching of skulls, indicate some post-mortuary processes took place outside B5 and perhaps some were conducted on the roof of B5. Burials tightly bound in wrappings, such as C1863, could have been carried to this building from further afield for final deposition.

The floors of Sp50 were kept clean of the debris of the living, with frequent replastering and use of reed matting. The low levels of micro-debris indicate that use of this space may have been restricted to activities and ceremonies relating to the preparation and final deposition of the dead. The people depositing their dead retained memories of areas and practices ascribed across the floors. Adult burials often with ochre and traces of wrappings and plaster were placed around the edges, child burials were sited closest to the threshold, some positioned to face towards the threshold and the realm of the living in Sp47. Traces of craft and trample in Sp47, which include activities such as the grinding of ochre with bell-shaped pestle SF369, perhaps originate from preparation of materials for burial. The traces of ash and burnt bone in micromorphological samples from Sp47 (Chapter 12) may originate from more domestic or food preparation and consumption activities. Until further buildings are excavated, it remains uncertain as to whether this building was solely for activities associated with mortuary practices and the ceremonies and receptions associated with them. The practice of the burial of dead below the floors of houses for the living has a long history in Southwest Asia, as at Dja'de and Çatalhöyük where up to 62 burials were placed during the life-history of one building, Building 1 (Chapter 19; Düring 2008; Coqueugniot 2016). The number of burials in Building 5 and packing of Building 8 exceeds this; at the end of spring 2019 a minimum number of 78 individuals have been recorded, 65 of which are reported in this volume.

Outside this liminal space between the living and the dead, there is substantial evidence for craft and consumption in an external area to the southeast, including bone and stone tool working debris, including the large incised stone at the entrance to B5 SF357, which may have been a surface for making leather goods (Chapter 22), and butchery debris. To the north and east, the walls of B5 were constructed independently, but butting up against surrounding buildings. The use of these adjacent spaces and neighbourhood to Building 5 is still to be explored, but evidence from B9 to the east indicates that this smaller building was built on a similar layout but was used for a different set of activities. Preliminary investigations suggest that more buildings which may be contemporary were constructed to the north, as far as Trench 6, and to the west, further up the slope of the natural rise and reaching as far as Trench 1. Each building was constructed with different wall materials and construction techniques and each may have had a fire installation. The independence of each of the buildings may suggest a community working collaboratively for shared mortuary practices, but possibly with a greater degree of independence and fragmentation for domestic activities, or the ascendancy of one group associated with B5 with particularly extensive social networks (Chapter 24).

The community of Bestansur appear to have abandoned the primary use of B5 after *c.* 7500 BC and the structure was destroyed soon after cessation of use as Sp50 is infilled with collapsed walls with the wall plaster intact and traces of probable roofing material directly on the floors. A retained memory of place led to continued occasional burials in the debris building up inside the walls of Sp50, but the definition between space for the living and the dead broke down and the standing walls of Sp50 provided shelter for a small fire installation F15 in the southwest corner. Eventually, the walls were levelled and the area above B5 became contiguous with the external areas to the southeast, with extensive layers of thick sloping packing laid as working surfaces covered with debris from external craft activities such as tool-working, including bone needles, and food preparation, including butchery and mollusc consumption.

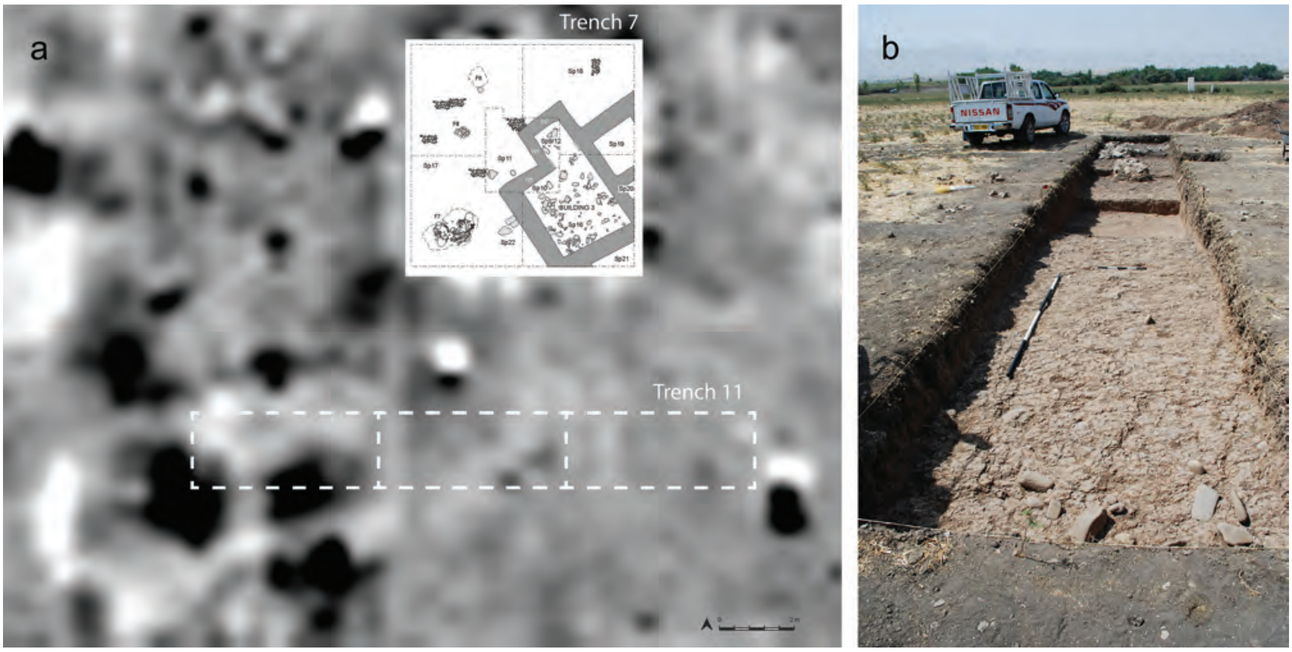


Figure 9.61. Trench 11: a) target area based on the results of geophysical survey; b) with Neolithic ground stone deposit C1245 in the eastern sector and stone walls in the western sector. Looking west, scale = 2m.

Trench 11

Selection of location and excavation strategy

Geophysical survey undertaken during the summer 2012 field season (Chapter 5; Fig. 9.61a) revealed the extent of later activity across the site and highlighted the importance of investigating and identifying the distinction between Neolithic and later signatures in the geophysical survey results. A 15 × 2m strip trench, Trench 11, was laid out in three 5m sectors to investigate features visible in the geophysical survey to the south of Trench 7. On the removal of 30cm of topsoil from an initial 2 × 5m area (the west sector), features identified on the survey results were revealed to be stone walls (Building 1). The trench was extended by 10m to the east, until it stretched 15m E–W and 2m N–S. The central and east Sectors targeted linear features extending to the south of Trench 7 and reached Neolithic surfaces in the east of the trench.

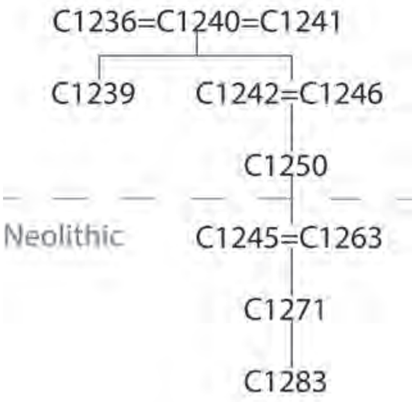


Figure 9.62. Matrix of the sequence of deposits in Trench 11.

Sequence of deposits, features and structures

Neolithic levels

The earliest deposits revealed were in the central sector of Trench 11. These comprised gritty white surfaces C1283 and C1271, which yielded very little anthropogenic material (559.80m asl). Overlying this surface, Neolithic occupation deposits C1245=C1263 (559.95m asl) contained ground stone, animal bone, chipped stone and molluscs, and small amounts of intrusive material from later activities (Fig. 9.61b). This deposit is level with, and possibly contemporary with, the external deposits in Trench 7.

Post-Neolithic levels

The Neolithic deposits are overlain with 45–55cm of mixed plough soil C1242=C1246 to the modern surface level in the eastern central sectors. In the western sector, clearly picked up by the geophysical survey (Fig. 9.61a), the remains of later stone walls have disturbed the Neolithic deposits. This stone structure contained a dense fill C1239 with fired clay and pottery. The walls, surviving only 30cm below the field surface, were poorly preserved, but the walls were constructed either directly upon or cut into intact Neolithic levels.

Contextual analyses and interpretation

Excavations in Trench 11 investigated the representation of later stone architecture in the geophysical survey results. Although it is not possible clearly to identify Neolithic features from the geophysical survey, it is evident that subtle differences in the fluxgate gradiometry results, representing markedly different use of materials, can be used to determine areas of substantial later activity and areas where the Neolithic levels may lie undisturbed. The features visible in the geophysical survey to the south of B3 in Trench 7 were proven to represent part of a much later structure. A single copper alloy trilobate arrowhead (SF83) in the mixed deposits suggests a Sasanian date for the destruction of this building. It is evident that the later deposits have cut into Neolithic features and that intervening horizons of activity are entirely eroded in this area of the site.

Trench 12 and 13

Selection of location and excavation strategy

During initial site survey in 2011, a poplar tree plantation obscured the north face of the mound. The trees were subsequently felled and burned independently by the farmer, revealing a steep section with eroding deposits (Fig. 9.3). A preliminary surface survey over this area in September 2012 observed and collected a light scatter of Neolithic chipped stone.

Initial investigations of the archaeological deposits began in April 2013, when a 13m-long section line (Fig. 9.63) was placed from east to west across the eroded slope of the mound to establish whether there were any Neolithic levels in the raised mound above the level of the surrounding fields in this area. Along the line of the section, up to 1.75m of deposits through the history of the mound were intensively cleaned and recorded, revealing a sequence of intact finely stratified Neolithic deposits at least 75cm deep, 1m below the top of the section. To the north of the section, a 4.5 × 1.1m wide upper terrace was cleared for investigation of the finely stratified deposits (Trench 12). In the field beyond, an initial 2 × 2m trench (Trench 13) uncovered the standing walls of a building, B7, and the excavation was expanded into a 6 × 3m trench to examine the deposits in and around this building and its connection with deposits in Trench 12 and the section face (Figs 9.64 and 9.65).

Sequence of deposits, features and structures

Neolithic levels

BUILDING 7

In Trench 13 we revealed the partial plan of Building 7 (Figs 9.64, 9.66) spanning the 4.5m east–west extent

Figure 9.63. Trench 12 section cleaning, looking southwest.

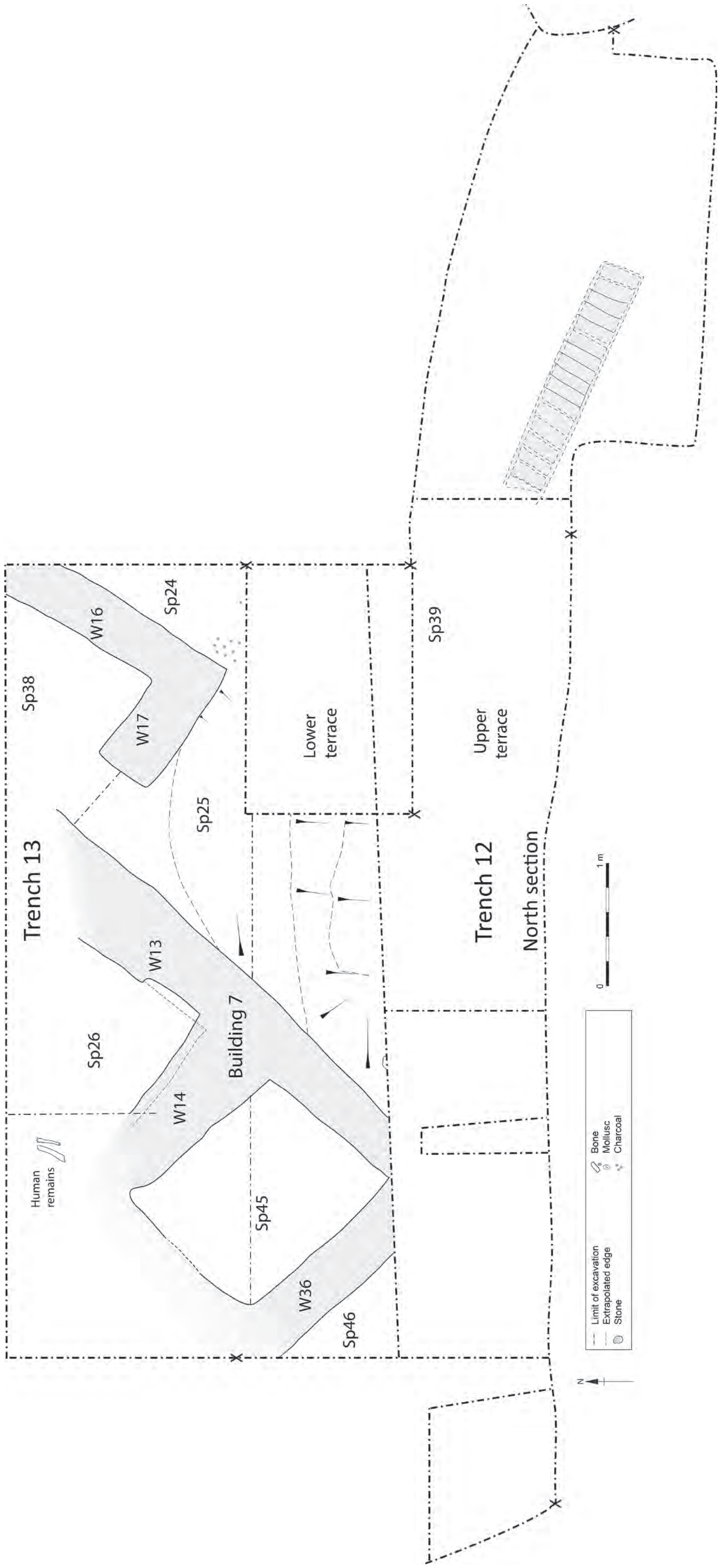


Figure 9.64. Multi-context plan of Trenches 12 and 13.

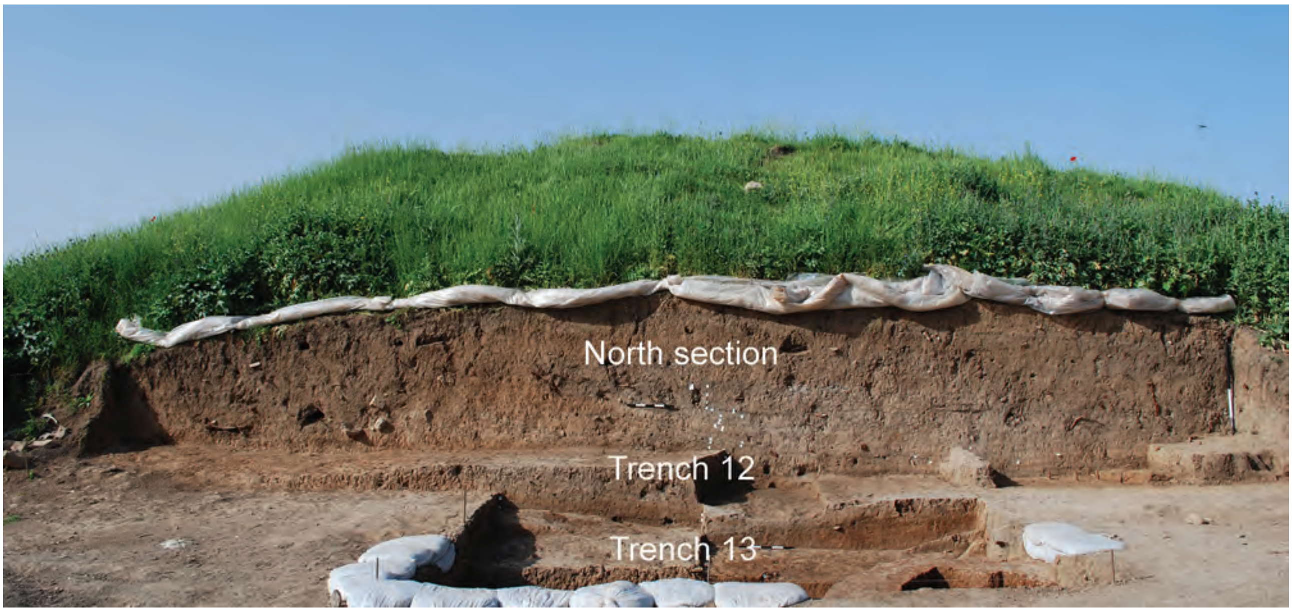


Figure 9.65. Relationships between north section and Trenches 12 and 13. Looking south, scales = 50cm.

Figure 9.66. Trench 13 walls looking west, scale = 50cm.

of the trench and extending beyond the limits of the current excavations in all directions. The rectilinear walls of B7 are the earliest features investigated to the north of the mound, oriented on the same northwest–southeast alignment observed in all sectors of the site. The unplastered earthen walls were constructed from a pale reddish brown silty clay loam with carbonate inclusions, *c*. 50–60cm wide, and were exposed to a maximum height of 45cm (560.53m asl), surviving up to 30cm below the sloping modern field surface.

Space 38

A narrow entrance is formed by the terminus of W17 and W13 and provides access from an external area Sp25 to the west into an internal room Sp38, 1.3 × 1.4m, the northern extent of which extends beyond the area of excavation. Inside walls W13, W16 and W17, Sp38 was filled with up to 40cm of reddish brown silty clay packing that formed the foundation of the building (559.65m asl). No well-defined floors were identified. Two fine obsidian blades without evidence of retouch had been placed against the southern face of W17 and two further examples were found in the packing C1569. An earlier building and phase of occupation, including green mudbricks set in mortar, were revealed at the base of C1569.

Space 26

Wall 13 was constructed as the external boundary wall to at least two spaces, Sp26 and Sp45 separated by W14, and extends southwest beyond the limits of Sp38. An area of 1.2 × 1.2m in Sp26 has been partially exposed; the northern limits are unclear due to erosion but Sp26 likely extends beyond the current area of excavation. The earliest investigated activities in Sp26 formed *c.* 20cm of discontinuous occupation lenses and wall collapse in a brown silty clay loam C1570 (560.15m asl) representing a late phase in the use of B7. A dark brown silty clay loam containing occupation residues, C1492 *c.* 3cm thick, with charred flecks, traces of red pigment, *Helix salomonica* shell and sparse stones, formed on the surfaces above the occupation lenses C1570. The fill of Sp26 included *c.* 15cm of yellowish brown silty clay loam with construction aggregates C1489 (560.33m asl). The fill of Sp26 is similar to the packing and levelling C1579 in Sp45. Fragmentary human bone possibly from a flexed burial had been cut into the fill of Sp26 from a later phase, now truncated by ploughing and overlain by *c.* 35cm of topsoil C1373.

Space 45

To the southwest of Sp26, W13 and W14 formed the boundaries of Sp45 with a return identified to the southwest, W36, and a northern bounding wall enclosing this small internal space. Space 45 is a small interior room, 1.2 × 1.3m, with no evident means of access at the level preserved. The south half of Sp45 was heavily truncated by a later irrigation ditch, which cut the walls down by almost 20cm in comparison to the north of the room. Lying on a silty clay surface, *in situ* scattered chipped stone, bone and *Helix salomonica* shell were covered by *c.* 10cm of lenses of occupation deposits C1580 with burnt aggregates (560.05m asl). The final closure of Sp45 was similar to, and possibly contemporary with, that in Sp25. A deposit of reddish brown silty clay loam packing and construction aggregates C1579, *c.* 20cm thick, filled Sp45 to the height of the standing walls (560.25m asl), immediately below the modern plough soil C1572.

Space 46

The corner of Sp46 was revealed to the southwest of Sp45 beyond W36. A sequence of deposits C1584 cut by an irrigation ditch was revealed in section (560.36m asl). A succession of well-prepared mud plaster floors with lenses of charred deposits, *c.* 1–2cm thick, sealed with *c.* 8cm of greyish green ash ran beyond the area of excavation to the south and west.

External area, Space 24

An external area to the south and east of B7 was excavated as two separate units, Sp24 and Sp25. External area Sp24 >0.9 × 1.4m was investigated to the east of W16 and extended beyond the limits of the excavated area. Craft activities that took place in Sp24 are represented by the working of stone and bone tools, with high levels of micro-debris, and animal bone demonstrating mixed pathways to deposition, including slaughter, digestion, burning and intrusive micro-mammals.

The earliest occupation surface excavated across Sp24 comprised *c.* 5cm of grey lenses with charred fire-spots in a light greyish brown silty clay C1521 (559.81m asl). Banded occupation deposits in Sp24 contained discrete lenses of yellow organic matter, charred plant remains, burnt aggregates and fragmented *Helix salomonica* shell. Deposited onto surface C1521 were a fragment of a limestone bowl SF444, fragments of worked antler SF488, SF490 and SF491 and crab claw SF492, a bone needle SF318 and chipped stone debris including tools with burin facets. Over these working deposits, a 20cm thick layer of silty clay packing C1520 was laid, onto which formed an ashy silty loam trampled surface C1491.

In situ burning was conducted on surface C1491 and formed a lens of black ashy charred loam C1479 surrounded by a thin accumulation of ashy discard and trample, C1474 (560.01m asl). A deliberate packing and levelling of this area covered the deposits in a layer of *c.* 10cm thick yellowish brown and greyish brown silty clay loam C1392, immediately below the modern plough soil C1322.

External area, Space 25

To the west of Sp24, in the area immediately to the south of the threshold into B7, further craft activities and deposition of bird and fish bone took place in external area Sp25. The earliest investigated deposit consists of cobbled stones C1665, 10–20cm in size, set in a compact silty clay (559.83m asl), which counteracted the slump of the underlying sediment *c.* 50cm from the B7 threshold (Fig. 9.66). The cobbling C1665 incorporated a discarded pecked mortar SF368 which had been placed upside down (Chapter 22). The paved area was overlain by *c.* 10cm

Figure 9.67. Ashy deposits C1581=C1494 in Sp25 T13. Looking south, scale = 50cm. (See also Fig. 12.26).

of multiple interbedded layers of greyish and slightly greenish ashy silt loam C1582 and C1581=C1494 (Fig. 9.67), with charred lenses C1485, burnt aggregates and sparse discontinuous lenses of yellow organic material from omnivore and human coprolites (Chapters 12, 13 and 16). A layer of packing C1578 (560.12m asl) sealed the deposits, and the sequence of high temperature burning C1577 and ashy discard C1576=C1486 was repeated, onto which an almond-shaped clay object SF332 (Fig. 21.6) and a lozenge-shaped translucent orange carnelian bead SF328 (Fig. 21.20) were deposited, before sealing with a further layer of silty clay loam packing C1575=C1490=C1480. Space 25 continued to be used for discard of further ashy deposits, C1517, repeatedly sealed with clay packing material C1515=C1513=C1484.

External area, Space 39

South of B7 and above the packing and levelling of the earthen building, subsequent Neolithic evidence surviving in the slope of the mound was unaffected by modern ploughing. At the interface between Trench 12 and Trench 13, we excavated an upper sequence of finely stratified surfaces and occupation deposits preserved in a *c.* 1.2m wide 'terrace' that had been cut by the irrigation ditch to the south in an area, designated Sp39 (Fig. 9.66). The deposits were excavated along the section line of Trench 12, the investigation of which was carried out in three separate operations over different seasons: the eastern between 0m and 7m, the central section between 7m and 9.5m, and the most western section between 9.5m and 11.5m. Equivalencies have been drawn between these finely stratified contexts where possible to establish the stratigraphic relationships. No walls were identified along the upper terrace and it is likely that the well-prepared surfaces, periodic accumulations of ash and orange organic material were the discarded waste from external activities in this repeatedly used external area.

Above the final deposits in Sp25, C1515= C1513= C1484, a finely stratified ashy occupation deposit C1475 was covered with a *c.* 7cm sequence of lenses of occupation surfaces and brown silty clay loam packing C1387, onto which further ash, C1386=C1529=C1530, was deposited with a long bone point SF292, ground stone and animal bone, indicating food preparation activities. A further deposit of ash, C1384=C1528=C1531=C1532, contained bird bone, crab claw, stone beads SF251 and a fragment of an alabaster flanged bracelet SF336 (Chapter 21). A *c.* 10cm thick layer of brown silty clay loam packing with ephemeral surfaces, C1378=C1526, sealed the ash. The subsequent occupation included further layers of packing with ashy lenses on external surfaces, C1377=C1525 and C1375=C1524=C1523, with flecks of red ochre.

Figure 9.68. Fishing net weights SF317 on external ashy surface C1519. Looking southwest, scale = 10cm.

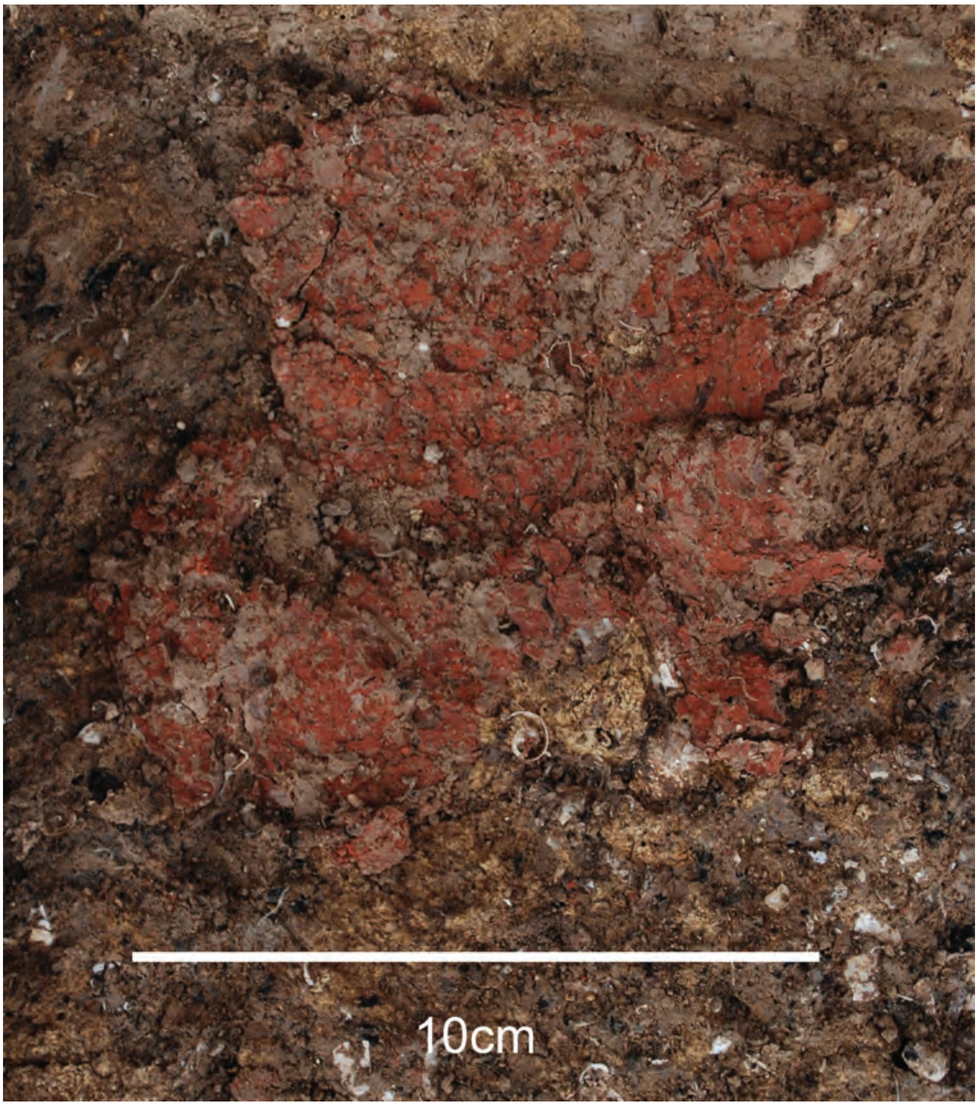


Figure 9.69. Red pigment, yellowish organic matter, ash and shell, Trench 12 C1395–97. Scale = 10cm.

A rich range of artefacts and bioarchaeological materials were deposited in these layers, including abundant bone, chipped stone and molluscs. Deposited onto external surface C1523, a dozen fragments of pierced flat stones SF321 bore strike marks indicative of deliberate destruction (Chapters 21 and 22). The stones may have been used to weight fishing nets and a relative abundance of fish bones has been recovered from the surrounding deposits (Chapter 15). The net sinkers and occupation deposits C1375=C1524=C1523 were sealed with packing material C1522=C1488=C1483 and a layer of ashy midden-like material C1519=C1388=C1487 containing a lens of human and pig coprolites C1397 (Chapter 16), abundant bone, and *Helix salomonica* shell, onto the surface of which a further set of more than 30 fragments of net sinkers SF317 (Fig. 9.68) were clustered and covered with more silty clay loam packing, C1514=C1467=C1482. The repetition of the deposit of deliberately broken net sinkers and the high proportion of fish bones in this area demonstrates specific cultural activities and ecological and dietary choices that are less represented in other sectors of the site.

Above the packing C1514=C1467=C1482, ongoing activities in this area deposited a series of interbedded silty clay layers and accumulated deposits C1382, *c.* 4cm thick, which included a fragment of pigmented red plaster C1395 and orangish brown organic material C1396, which GC-MS analyses have shown are omnivore coprolites from humans and wild boar (Fig. 9.69; Chapter 16). In the western extent of Trench 12, on the upper horizon of clay packing C1514=C1467=C1482, a *c.* 1mm layer of very pale brown silty clay plaster C1477 was laid as a clean surface sloping down from north to south. A patch of ash C1476 was discarded onto surface C1477 and 5cm of discontinuous layers from *in situ* burning C1478 accumulated, over which a dense greyish brown silty clay loam packing was laid, C1471. An extensive, sterile red silty clay packing layer, *c.* 2cm thick, C1466=C1379, sealed these accumulated occupation deposits and provided a foundation and surface for further activities in the area. A localised area of grey silty clay packing, C1376 in the west of the trench, may have been a heat affected surface on which subsequent *in situ* burning had occurred, represented by charred black layers C1372=C1374 *c.* 9mm thick and the deposition of a patch of probable coprolite or dung, C1371.

In the southwest, the upper horizon of packing C1466=C1379 was plastered with thin pale brown/whitish silty clay plaster C1390, 2mm thick. A lens of black burnt material C1394 had accumulated on plaster surface C1390. The pattern of use of this area, for burning, scattering ash, and resurfacing with clean packing and levelling material continued to repeat through the eroded section of T12, extending a full 1m above the surface of the field to the north and 2m above the earliest deposits examined in Trench 13.

Eastern extension, Trench 12

In the east of the Trench 12 section, a large late cut was identified containing material from mixed periods. The cut was excavated and cleaned in a 4 × 1 × 1.8m trench in order to investigate whether any architecture associated with the finely stratified surfaces and deposits in Sp39 was present to the southeast, and to assess whether this area was external or internal. The post-Neolithic cut continued more than 1m into the mound, which rises steeply at this point, and the fill C1512, C1518 and C1571 was excavated entirely down to its base. Intact compact deposits were present and a mudbrick discontinuous wall, *c.* 40cm wide and more than 2m in length, was identified in plan on approximately the southeast–northwest alignment of all Neolithic truncated buildings across the site. The full extent of this wall has not been exposed and it lies stratigraphically earlier than the lowest levels reached along the Trench 12 section line.

Post-Neolithic levels

In the upper 1.25m of the Trench 12 section there appears to be a hiatus in activity at Bestansur, as eroded colluvium extends across the full extent of the Trench 12 section. The deposits in Trench 13 have been truncated by a drainage ditch and modern ploughing.

Contextual analyses and interpretation

Trenches 12 and 13 revealed Neolithic occupation deposits spanning 1.75m in depth, with further deposits as yet unexplored below the lowermost excavated levels (Fig. 9.70). Thus far three major phases of Neolithic occupation have been identified to the north of the mound. The earliest phase has not been excavated but is represented by green silty clay mudbrick and mortar architecture, partially exposed in the north of Trench 13, below Space 38 and C1569.

The second phase comprises red silty clay earthen architecture of Building 7, with walls 45-50cm high which were placed on the same alignment as buildings across all sectors of the site, and contemporary external areas with activity on surfaces and midden-like deposits, repeatedly resurfaced with silty clay packing. The earthen architecture defines at least four separate spaces. The occupation deposits in all areas are sloping and may represent the latest phases of much earlier use of this area. In Sp24, there was a slightly sloping roughly stone-paved surface on which a comparatively deep sequence of finely stratified ashy deposits with charred remains had accumulated (Chapter 12). In Sp25 there was a sequence of remarkably well-preserved articulated plant remains and omnivore coprolites, some of which are human. This whole area including Building 7

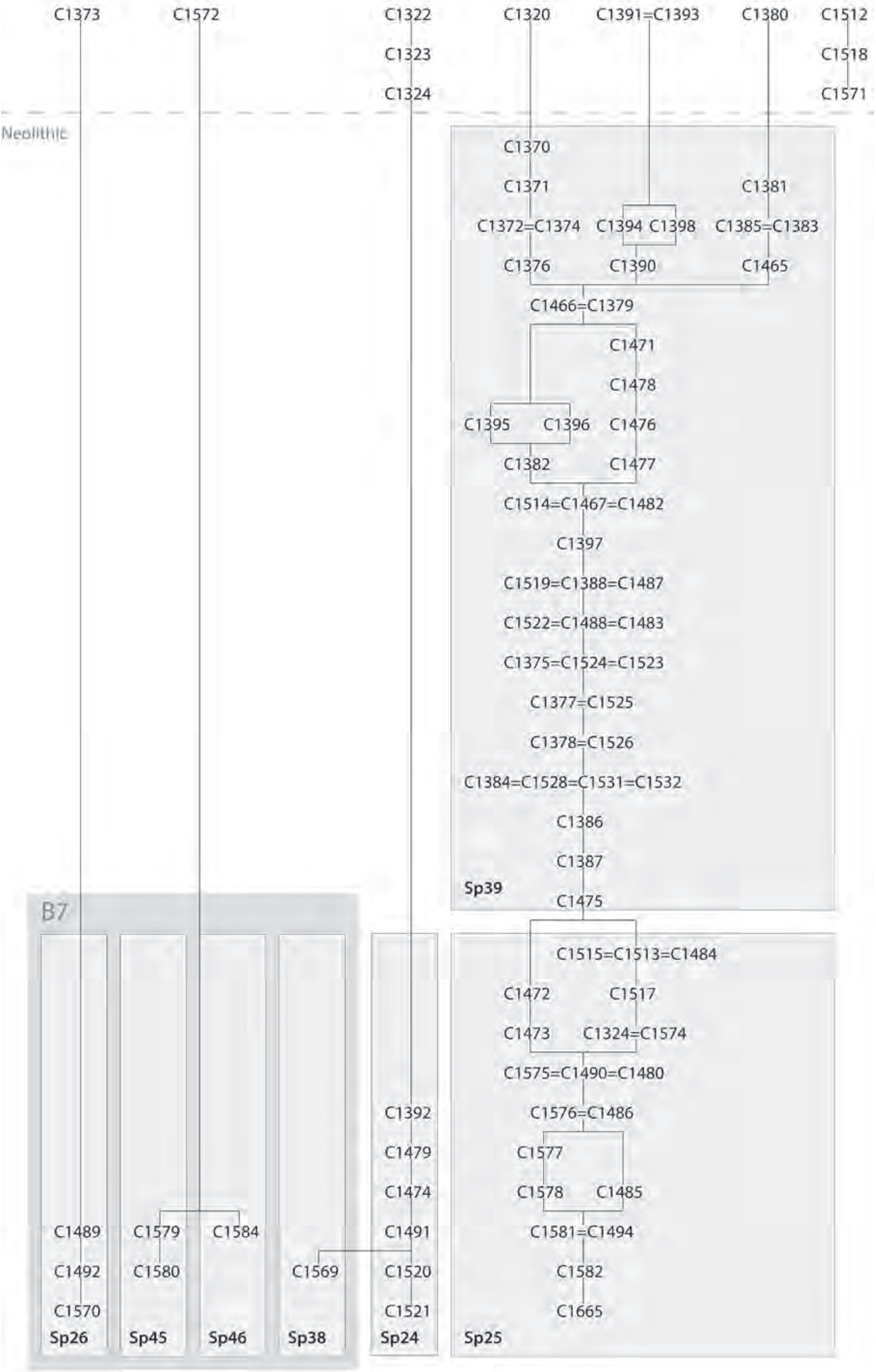


Figure 9.70. Matrix of the sequence of deposits in Trenches 12 and 13.

was sealed/levelled by thick layers of packing, more than 30cm thick. The preservation of surfaces and charred deposits in Sp24 and Sp25 below this packing suggests that this infilling started shortly after the accumulation of ashy deposits C1479 and C1494. The sparse traces of ash between the layers of infilling may suggest there were several phases to this levelling. One explanation for the slope of the infilling/packing and later deposits may be compaction and decay of underlying organic rich lenses C1485, C1494 and as yet unexcavated deposits.

Following the infill and closure of B7, the final phase of activities is represented in Trench 12 by a 1.25m deep sequence of sloping plaster surfaces and a diverse range of occupation residues including: ash rake-out and the discard of possible food residues such as *Helix salomonica*, human and wild boar/pig coprolites (Chapter 16); the discard of broken probable fishing net weights and personal adornments (Chapters 21 and 22); and the use and discard of chipped stone and animal bone (Chapters 15 and 20). A ^{14}C determination was obtained from a pig carpal in Trench 13 C1386 (Beta-408868) indicating these deposits date between 7185 and 7050 BC (Chapter 11), post-dating the activities in Trench 10 by up to 600 years.

This phase of occupation in Trench 12 and the section face represents a marked change in the use of this area. This occupation is represented by a long sequence of finely stratified layers of deliberately laid packing, each *c.* 2–10cm thick, and overlying lenses of occupation and discarded residues. Some layers of packing are very localised and provided a well-defined activity surface *c.* 1m in diameter. Other layers of packing are more extensive and extend across a distance of at least 5–6m. Some surfaces were plastered with thin whitish/pale brown plaster *c.* 2mm thick. Traces of activities on these surfaces include: fire-spots marked by *in situ* charring; accumulations of ash and charred remains; chipped stone tools; ground-stone fragments and unworked stone; sheep horn and separately a sheep pelvis; coprolites/dung; intact and fragmented molluscs; beads and red-pigmented plaster fragments; and discard of fishing weights.

It is currently uncertain whether the entire Sp39 represents an external or internal area. Some of the well-prepared and finely plastered surfaces in the western investigations suggest interior spaces similar to those at Çatalhöyük (W. Matthews 2005). Some of the Trench 12 surfaces were plastered with thin white plasters, *c.* 1–2mm thick, but unlike Çatalhöyük these white plasters were not repeatedly applied to the same surface with no intervening accumulations of occupation nor packing. At Bestansur, the composition of the intervening accumulations of ash, shells and organic remains resembles deposits discarded repeatedly in middens. That they often only represent a single or few lenses rather than deep multiple sequences, and are well-preserved, suggest that these thin accumulations resemble occupation deposits left *in situ* or discarded just prior to re-surfacing. The presence of house mouse bones in these deposits suggests that this area is associated with year-round occupation. There are also significant differences in types of faunal remains discarded here, when compared to other areas of the mound, including greater abundance of fish suggesting a more domestic character.

10. EXCAVATIONS AND CONTEXTUAL ANALYSES: SHIMSHARA

Wendy Matthews, Roger Matthews, Kamal Raeuf Aziz and Amy Richardson

Location and environment of Shimshara

We selected the prehistoric occupation levels at Shimshara for excavation as the site provides an important comparison to Bestansur for investigation of local and regional variation in Early Neolithic ecological and socio-cultural strategies and networks. Shimshara is located *c.* 110km north-northeast of Bestansur at *c.* 500m asl, 36˚12′02.71″ N, 44˚56′18.10″ E, on a raised conglomerate outcrop on the right bank of the Lesser Zab river at the northeast edge of the Rania Plain strategically close to a major pass, the Sungasur Gorge, where the river cuts through a ridge of mountains *c.* 1000m high (Fig. 10.1). The gorge provides access northeast to a small plain and the mountainous border region of Iraq with Iran. Other natural routes include the Lesser Zab river which leads south then west to the Mesopotamian plain in the Kirkuk region, and provides access south to a network of basins leading to the Shahrizor Plain and the Diyala River. Routes to the northern Mesopotamia plain and Turkey are accessible via the Erbil region to the west.

The Rania Plain is the second most fertile plain in Sulaimaniyah province, after the Shahrizor Plain, and is surrounded by limestone mountains and hills, some with cliffs. It is currently used extensively for agriculture (Fig. 10.2) and grazing of large mixed flocks of goat and sheep. The region of the Dokan Dam Lake is currently a Key Biodiversity Area, surveyed by Nature Iraq in 2007–10 (Bachmann *et al.* 2013). There is a high number of plant species in this region, characterised as Mountain Forest Vegetation and Mountain Riverine Forest, with oak forest, steppe and riverine ecosystems (Bachmann *et al.* 2013). The inhabitants of Shimshara would have had access to a range of ecozones and biomes within 4–5km, one hour's walking distance, as attested in the plant and animal remains, notably pig, which thrives in riverine forest. Lake core evidence from Lake Zeribar, 900m asl, 130km southeast from Shimshara, suggests that there was a slight increase in oak and shrub (Chenopodiaceae) pollen at higher elevations of 1400m asl during the Neolithic occupation at Shimshara (van Zeist and Bottema 1977; Stevens *et al.* 2001). Oak pollen, however, remains low at <10% of the total pollen spectra in contrast to recent levels of 40%, whilst Chenopodiaceae represent 20–30%. Quantities of grass pollen remain high, at 40–30%, but continue to fall from a peak at *c.* 8500 BC, probably due to the impact of human cultivation and animal grazing. To investigate the local palaeoclimate and environment at Shimshara, at the lower elevation of *c.* 500m asl, sediment cores from the sulphur mineral ponds 1.3km north of the site at Lake Ganau *c.* 510m asl, are currently being analysed by Maria Rabbani at the University of Reading in collaboration with Manfred Rösch and Simone Mühl, University of Hiedelberg, and Elena Marinova-Wolff, State Office for Cultural Heritage, Baden-Württemberg (Chapters 3 and 24; Mühl *et al.* 2018)

Early excavations at Shimshara

Shimshara was first excavated in 1957 by a Danish team led by Harald Ingholt (Mortensen 1970) prior to flooding of the site by waters from the Dokan Dam which was constructed in 1959. The site is *c.* 330m long, with a high northern mound, originally *c.* 110 × 80m and 12m above a low adjoining southern mound. In the high northern mound, Ingholt excavated 16 levels

Figure 10.1. Eastern edge of Shimshara looking north-east to where the Lesser Zab river enters the Rania Plain through the Sungasur Gorge.

Figure 10.2. Fertile agricultural fields and grazing flocks in the middle distance.

of occupation to a depth of 8m below the top of the mound, numbered from the top down, recorded as *c.* 519–511m asl (Mortensen 1970: 2, pl. I, fig. 8). Levels 16–9 were attributed to the Hassuna period which spans *c.* 6500–6000 BC. These levels were exposed in a *c.* 15 × 2m trench in the south of the high mound in squares L10–O10. These early levels were 3.4m thick in total, recorded as spanning *c.* 511–514.4m asl. The basal two to three levels, however, are likely to pre-date the Hassuna period as no pottery was recovered from Levels 16–15, and only one pottery sherd from Level 14.

Within the 15 × 2m trench Ingholt (Mortensen 1970: figs 10–20) uncovered walls of rectilinear mudbrick architecture often with stone foundations in Levels 16–14. Traces of pebble floors were uncovered in a number of these levels, as well as clay lined basin/ovens in Levels 10 and 9, in the latter close to a child burial. Levels 16 and 13 had been destroyed by intensive fire. The Danish team did not reach natural in any trenches in the high mound or the lower mound. The upper Levels 8–1 are Hurrian, early second millennium BC, and Islamic in date. The lower mound is predominantly early second millennium BC or Middle Bronze Age in date. Contemporary cuneiform texts refer to Shimshara as the 'Kingdom of the Gate-Keepers', indicating the strategic importance of the site and its proximity to the Sungasur Gorge (Eidem and Laessøe 2001).

Assessment of the impact of Dokan Dam flood waters and topographic survey

Our investigations aimed to assess the impact on the ancient settlement mound of half a century of submergence and erosion by dammed waters. Due to recent drought the site has been periodically accessible since 2011–12, when the waters from the Dokan Dam on the Lesser Zab recede in late summer. An initial assessment of Shimshara was conducted in September 2012 in order to investigate the nature, depth and preservation of extant deposits in planning for a short season of excavation in summer 2013. It has not been possible, however, since then to return as the lower flanks of the mound in particular have been submerged by lake waters, due to increased precipitation in the region.

It is estimated that *c.* 160,000m^3 of the upper and lower mounds, including 3–4m in height from the upper mound, have been lost due to dam water erosion between 1959–2012, a period of 53 years (Eidem 2012; 2015). The entire eastern flank of the *c.* 330m mound is currently being undercut by seasonal dam waters and currents from the Lesser Zab River. Although the conglomerate outcrop is comparatively resistant to erosion the overlying unconsolidated slightly sandy silty clays on which the site is located are highly susceptible to erosion by the flowing waters of the lake.

On the lower mound at Shimshara there has been extensive damage and loss of archaeological strata due to the high level and erosive channel flow and wave-action of the lake. This damage and the exposed palatial buildings of the second millennium BC were investigated by a team from the Netherlands Institute for the Near East, directed by Jesper Eidem (2012; 2015). Initial analysis of the upper northern mound suggests that a significant proportion of the southeast corner of the mound has been eroded by dam waters, exploiting a weakness close to the edge of Ingholt's 15 × 2m north–south trench in L10–O10. In winter 2012 dam waters rose dramatically due to high precipitation and the high-water level lapped up to the very base of the earliest Neolithic levels leaving a high-tide mark and waters since winter 2013 have covered the base of the mound.

Dating of the deposits at Shimshara

At least some of the deposits recorded in our investigations pre-date those excavated by the Danes, as they lie directly on natural which they did not reach. As with Ingholt's Levels 16–15, the absence of pottery suggests they are Neolithic and pre-date Hassuna, which starts at *c.* 6500 BC. A pre-Hassuna date is supported by a radiocarbon date from the earliest deposits above natural. One of a cluster of charred nutshells from the earliest deposits in the west–east section was dated 7450–7080 BC at 2 sigma (95% probability), which at 1 sigma (68% probability) is 7330–7180 BC (Beta-342482; Chapter 11). The style of lithics, including abundant obsidian, and marble bracelet fragments support this date.

Investigative approaches at Shimshara

Following initial assessment in summer 2012, we conducted fieldwork and excavation of the early prehistoric levels in the upper mound at Shimshara in summer 2013. We cleaned, analysed and recorded two large sections that had been created by water erosion, one west-east *c.* 8.5m long, another north–south *c.* 40m long. We cleaned, photographed and drew the 8.5m West–East section and 17m of the longer North–South section to assess the nature and depth of extant occupation (Fig. 10.3). The assessment and section cleaning established that there are at least 2.5m of extant Neolithic deposits at Shimshara, above natural. No pottery was encountered, either in the colluvium at the base of the mound or *in situ* within the sections recorded. Bone, lithics and small finds were collected for analysis. The sections were then sampled for a range of analyses including:

- micromorphological analysis of architectural materials and accumulated deposits to study resource management and built environment design and use (Chapter 12) and collection of archival archaeobotanical blocks

- spot geochemical and phytolith analyses (Chapters 13 and 16)
- integrated wet-sieving and flotation for analysis of charred plant remains, zooarchaeology and micro-archaeology (Chapters 14, 15 and 18)
- spot collection, mapping and labelling of key bones in the section face for zooarchaeological analysis (Chapter 15), and wood for identification.

In August 2013, two trenches were excavated in accessible areas adjacent to the main profile to investigate the range of Neolithic activities and ecological and socio-cultural strategies at Shimshara. Trench 1, located west of the North–South section profile, was positioned in order to investigate traces of Neolithic occupation in a comparatively flat area of the mound, adjacent to where burnt surfaces were visible in the section-profile. Trench 2, north of the West–East section profile, targeted a well-preserved sequence of stratified surfaces and occupation deposits, including a white plaster layer that in thin-section consisted of re-worked aggregates of multiple layers of wall plaster, almost identical to the elaborate wall plasters from Çatalhöyük, Turkey (W. Matthews 2013; Chapter 12). Excavation of Trenches 1 and 2 required major stabilisation and terracing of the mound surface to enable safe access and working, due to the steep slope of the mound. The spoil from excavated deposits was deposited at the base of both sections to protect the base of the mound from further erosion and to provide further stepped terraces for access and safety whilst working. Excavated deposits were sampled for wet-sieving and flotation, conducted at Bestansur field laboratories, and the excavated deposits were dry-sieved on-site.

Analysis of field sections

The conglomerate outcrop on which Shimshara is sited was covered by *c.* 5–8m of pale slightly reddish brown slightly sandy silty clay. These natural deposits at the base of both sections were stepped or cut down from west to east probably deliberately in the Neolithic to create a flat construction and occupation surface. This step/cut is *c.* 1.5m deep and was identified close to the edge of the North–South section line (Fig. 10.4). Overlying deposits tend generally to slope down to the east towards the Lesser Zab River, evident in the West–East section.

West–East section

In the 8.5m long West–East section, there are *c.* 2–2.5m of extant deposits above natural. These deposits extend *c.* 25m north behind the section face. They are particularly vulnerable to erosion by rising dam waters as they protrude out into the flood stream flow. The earliest deposits in the west of this section comprise lenses of ash and grey mixed deposits with clusters of charred nutshell fragments, one of which was radiocarbon dated (see above; Chapter 11). These early deposits were sampled for integrated flotation and wet-screening, SA761, and micromorphology SA757. They were overlain by a thin band of orange brown deposits, *c.* 10cm

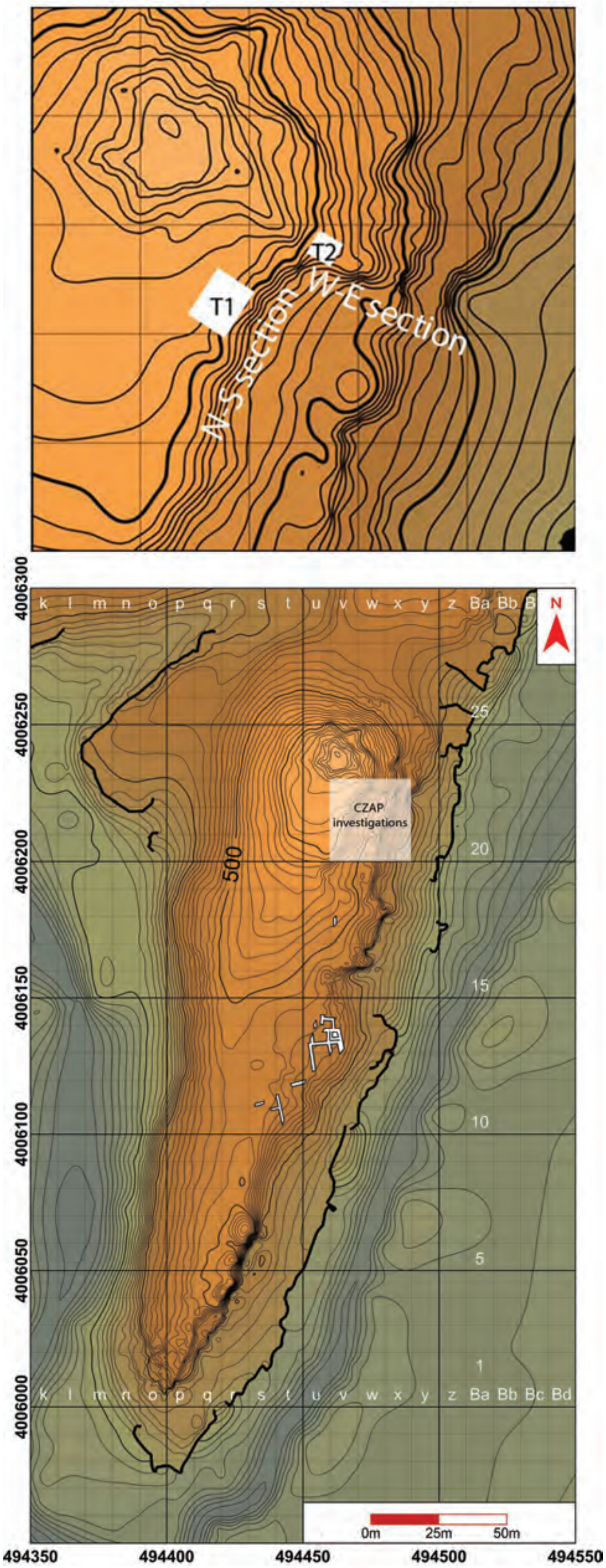


Figure 10.3. Contour map of Shimshara and location of the CZAP investigations (courtesy of Jesper Eidem).

Figure 10.4. Cleaned sections West–East (right) and North–South (Left). Looking northwest, scales = 2m and 50cm.

thick, mixed grey deposits, then a second band of orange brown deposits. The band of subsequent grey deposits with stones was sampled for comparative integrated flotation and wet-screening, SA760. These deposits were covered by a third band of orange brown packing/levelling that extended across the entire West–East section, *c.* 14–25cm thick, then mixed grey deposits with stones.

Overlying this deposit, in the west of the section was a series of at least five prepared surfaces, *c.* 7–10cm thick, with overlying lenses of orange brown, ash, charred plant remains and a white plaster *c.* 1cm thick (Fig. 10.5). The uppermost sequence was sampled through micromorphology sample SA753. The sequence was covered by a mixed layer with stones, below the modern surface of the mound. Deposits in the east of this section comprise a sequence of thick grey banded deposits with layers of stones, perhaps comprising or on a rough floor/surface. At *c.* 0.8m above natural, there is then an extensive band of orange brown packing/levelling, *c.* 25cm thick, which corresponds with the third band of orange brown deposits in the western half of the section. Overlying this banding is a layer of pale greyish brown deposits that were levelled to form an extensive surface more than 2m in length in section. On this surface, there was a layer of charred plant remains and phytoliths, visible in the field, bone fragments and a bone pendant (SF117). The surface and sequence were sampled for higher-resolution analysis in micromorphology block SA763. They were overlain by mixed grey deposits with scattered stones, and another extensive orange brown band of packing/levelling, then mixed deposits with stones below the modern surface of the mound.

North–South section

In the 17m long North–South section, there are *c.* 1.5–2m of extant deposits above natural (Fig. 10.6). Deposit thickness increases from the North–South section face northwest towards the centre of the mound. A band of natural deposits at least 70–100cm thick was revealed at the base of this section, comprising pale slightly reddish brown slightly sandy silty clay with white carbonate inclusions, overlain by pale brown deposits, sampled as micromorphology block SA756. The earliest anthropogenic deposits comprise bands of grey silty clay, *c.* 30cm thick, accumulated on the lower slopes of the underlying natural mound at 1–10m north from the southern datum point. These deposits included exceptionally well-preserved mineralised plant remains that suggest the deposits may have formed in a comparatively wet environment and been rapidly buried by fine-grained sediments to prevent rapid oxidation and microbial activity (Fig. 10.7).

Figure 10.5. Well-preserved sequence of surfaces and lenses of ash, charred plant remains and white plaster aggregates (top) in the west of the West–East section. Looking west, scale = 50cm. (Chapter 12; Fig. 12.33.)

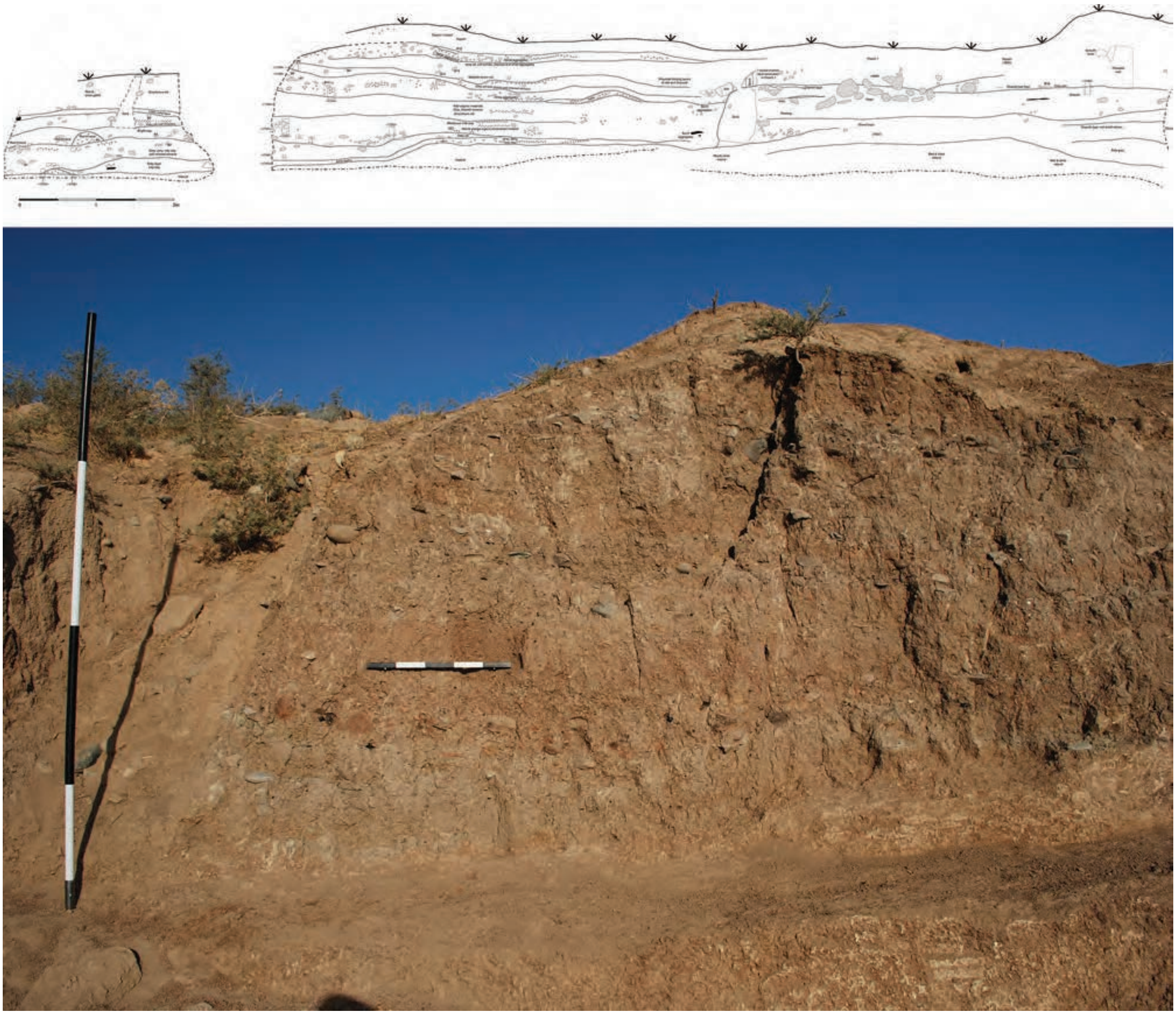


Figure 10.6. North–South section showing banded grey deposits with scattered stones. Looking west, scales = 2m and 50cm.

Figure 10.7. Mineralised plant remains in the North–South section.

Overlying deposits comprise successive bands of discard in an open area/midden, in a sequence more than 1.25m thick. Analysis of the 3-D topography of deposits in small gully sections, perpendicular to the main section profile, revealed that although these banded deposits followed the horizontal/slightly sloping north–south contours of the mound, they sloped quite steeply up to the west, suggesting that they had been discarded from higher levels towards the centre of the mound to the west. This interpretation was confirmed by excavation of this slope in Trench 1. These banded deposits included burnt aggregates and occasional large fragments of charred wood, sampled for dendrochronology and wood identification. At the northern end of the long-section, analysis of the deposits below and between Trenches 1 and 2 revealed a well-preserved floor with charred plant remains, phytoliths and bone *c*. 10cm below levels of excavation in the northeast of Trench 1 associated with a possible wall at 15.5m north from the southern datum point, and a probable wall associated with the pebble and stone floor sequences at the southern edge of Trench 2, C1651.

Excavations in Trench 1

In Trench 1, 5 × 4m in area, we uncovered flat horizontal deposits in the west of the trench towards the centre of the mound, and a break of slope in the east that sloped down to connect with deposits observed and recorded in the main section (Fig. 10.8). The lowermost excavated deposits comprise discarded burnt midden-like/open area deposits, C1661, that were the same as and joined up with the banded grey deposits in the main North–South section. These deposits were overlain by a) thick

Figure 10.8. Lowermost deposit C1661 and cobbled surface C1645 in the west with fire installation in the north of Trench 1. Looking south, scale = 2m.

packing/fill C1653, then b) a surface with areas of *in situ* burning and discarded rake-out, excavated as C1649. The occupation deposits included discarded animal bone, one of which was a large scapula. The overlying packing/fill was also thick but was eroded in the east and excavated as mixed deposit C1634 below topsoil C1632. It is possible that the large stones in C1653 may have been eroded from a nearby wall. In the western half of the trench the latest excavated deposits comprise a stone cobbled surface C1645, adjacent to a clay-lined fire-installation. This occupation layer may have been burnt as it is overlain by an extensive grey layer with ash, excavated as C1643, below topsoil C1634, C1632.

Excavations in Trench 2

Trench 2 was 2.4m north–south and more than 3m west–east. The lowermost levels excavated in summer 2013 comprised a series of small pebble and stone surfaces mixed with occupation residues (Fig. 10.9) adjacent to a mudbrick wall. These surfaces were excavated as C1652 (fewer stones), C1654, C1655, C1656, C1659 and C1662 (with whitish ash). A number of broken marble bracelet fragments (SF426 C1652, SF434 C1662; Fig. 10.10) and an incised stone bowl fragment (SF431 C1659) were present in these occupation deposits. These deposits were covered by a thick layer of burnt sediments and aggregates, C1639. The next phase of occupation was represented by a layer of dark grey *in situ* burning and a cluster of animal bone, C1647, overlain by higher temperature more oxidised ash C1644. Overlying deposits were also burnt, but more heterogeneous, perhaps from burnt levelling, C1638.

Discussion

Our new excavations and field-section analyses have identified the foundational occupation levels at the site, which were not reached by the Danish excavation in 1959. They reveal that Neolithic occupation at Shimshara spans in total *c*. 1300 years, from *c*. 7300 to *c*. 6000 BC. Within Iraq, occupation at Shimshara was thus later than and contemporaneous with that at Bestansur at *c*. 7660–7000 BC, and slightly earlier than and concurrent with occupation at Jarmo and Hassuna. In Iran, Shimshara is contemporary with Tepe Guran, Ali Kosh, Sarab, Chogha Bonut and Hajji Firuz (Aurenche *et al.* 2001; Zeder 2005; 2009; Chapter 11).

The occupation sequences and deposits at Shimshara are well preserved. The earliest deposits comprise grey silty clay with well-preserved mineralised plant

Figure 10.9. Excavation of deposits in Trench 2. Looking west, scale = 50cm.

Figure 10.10. Marble bracelet fragment SF434 C1662 in Trench 2.

remains and sparse traces of human activity. These are overlain by a series of finely stratified midden and open area deposits, dated to *c*. 7330–7180 BC at 1 sigma (68% probability). One unexcavated layer in the West–East section comprises a layer of aggregates of multiple layers of white-wash from the walls of a building. These fine white-washes are coated in some instances in soot and are similar to those encountered on the walls of elaborate contemporary buildings from Çatalhöyük, Turkey (W. Matthews 2005: figs 19.8–9; Chapter 12).

In the excavated areas we established that occupation and activities in the west of Trench 1 were conducted on a flat working area that extended towards the centre of the mound. Deposits from these activities were discarded to the east down a break in slope, including burnt stones, aggregates and bone from food preparation and cooking. In the area of Trench 2, the earliest excavated deposits represent diverse activities on a series of small pebble and stone surfaces bounded to the south by a mudbrick wall. The occupation deposits on these surfaces include a range of residual artefact fragments including lithics, carved marble bracelet fragments and an incised stone bowl fragment (Chapters 20–22).

In summary, therefore, the finely stratified midden deposits and well-preserved mudbrick wall and surfaces attest significant sedentary occupation at the site. A rich range of plant and animal remains were recovered, including the charred remains of cultivated and gathered resources, such as lentil and pistachio, as well as well-preserved reed and grass phytoliths, animal dung fuel, and abundant fauna, including pig, sheep, birds and fish (Chapters 12–18). The diverse range of materials and artefacts at Shimshara provide evidence of access to a wide range of resources and slightly different networks and technological traditions than at Bestansur (Chapters 20–22 and 24).

Given high dam water levels, and the loss of >160,000m^3 from the mound since 1959, Shimshara constitutes an important site that remains at major risk and where we plan to continue excavations in future years should the flood waters allow it.

11. RADIOCARBON DATING OF BESTANSUR AND SHIMSHARA

Pascal Flohr, Roger Matthews, Wendy Matthews, Amy Richardson and Dominik Fleitmann

In this chapter we present eleven ^{14}C dates from Bestansur and one from Shimshara, and discuss them in relation to the previously published Sheikh-e Abad and Jani dates (Matthews *et al*. 2013c) and the wider context. The Bestansur and Shimshara samples were all analysed by Beta Analytic laboratories. The samples, their contexts and the results are provided in Table 11.1. All ^{14}C dates were calibrated in OxCal version 4.3 using the IntCal13 curve (Bronk Ramsey 2009; Reimer 2013). All dates referred to throughout this chapter, and the entire volume, are calibrated BC dates unless otherwise stated.

The aim of the dating programme was to examine the development of sedentism and early agriculture in the EFC by placing the sites in their chronological context, and by comparing them to local and regional developments and climatic and environmental change in the Zagros and Southwest Asia. A major aim of the CZAP project is to assess the chronology of continuity and change in the Zagros Neolithic (Chapter 1).

Assessment

In order to interpret the sites in their chronological and environmental framework, we first assess the reliability of the ^{14}C dates. We use several criteria that are discussed in detail in Flohr *et al*. (2015) and Marshall (2012). First, we evaluate the laboratory assessment as it indicates, among other things, whether the samples contained sufficient carbon for analysis. Secondly, the dating precision is assessed. Large standard deviations may indicate a problematic sample, while they may also make site occupation appear erroneously long. Thirdly, the reliability of the dated material is examined. Bulk samples are problematic, as the inclusion of sediment or roots will cause contamination and yield dates that are too old or too young, respectively (Gillespie 1984; van der Plicht 2001). Shell is also known to result in problematic dates, due to hard water effects and the uptake of older carbon (Bowman 1990). Other problematic material can be burnt bone, bone apatite, and bone carbonate. Finally, we consider the deviation of $\delta^{13}C$ values as this can indicate contamination (van der Plicht 2005).

If the ^{14}C determination itself appears reliable, it is furthermore important to assess whether the sample dates the context in which it was found. Small samples, like seeds, may have been transported through sediment layers, while charcoal samples may represent 'old wood' (van der Plicht 2001). It is therefore important to establish whether the samples have a clear relation to their context and whether they were likely deposited *in situ* which for bone, for example, may be indicated by articulation (Bayliss 2015).

Based on the above quality-check criteria, the seven ^{14}C dates from Sheikh-e Abad and Jani appear reliable. There were no problems reported by the laboratory, the dates have low standard deviations (≤ 60 ^{14}C years), they were conducted on a range of different materials that can be confirmed to be reliable (charred seeds, charcoal and bone collagen), and the $\delta^{13}C$ values are as expected for each type of material (Table 11.1). It is more difficult to assess whether the samples precisely date their contexts but this appears likely, as the dates fully agree with the stratigraphic order, between and within trenches (Matthews *et al*. 2013c). While two of the dates are on charcoal, and could potentially represent old wood, the fact that they are in chronological and stratigraphic agreement with short-lived samples, which are both on seeds and bone, makes this less likely.

Table 11.1. Radiocarbon samples and dates from CZAP sites in Iraq and Iran. Calibration was conducted in OxCal 4.3 (Bronk Ramsey 2009) and uses IntCal13 curve (Reimer et al. 2013). Start dates are the oldest date in the probability range; end dates are the youngest dates in the probability range; small gaps in the range are not indicated in the table.

Sample	*Context*	*Material*	*Details*	*Lab no*	*^{14}C (uncal) ±1σ*	*δ^{13}C (‰)*	*Cal BC 1σ*	*Cal BC 2σ*	*Assessment*
Sheikh-e Abad									
S75	T1, 512	Charred seed	*Astragalus*	Beta-258647	10130±60	N/A	10,007–9671	10,078–9456	Reliable, short-lived
S2	T1, 515	Charcoal	Unidentified	Beta-267508	9970±50	–23.8	9650–9321	9746–9299	Reliable, potential old wood effect
S68	T1, 511	Charred seed	Poaceae	Beta-267509	9730±60	–22.7	9278–9159	9303–8852	Reliable, short-lived
S65	T2, 617	Charred seed	*Vicia ervilia*	Beta-258646	8840±60	–23.2	8191–7822	8219–7750	Reliable, short-lived
S800a	T3, 800	Bone collagen	Sheep/goat	Beta-258648	8600±40	–18.9	7647–7578	7721–7567	Reliable, short-lived
Jani									
S72b	Section 23	Charred seed	Cyperaceae	Beta-258649	8860±60	–23.4	8208–7884	8230–7759	Reliable, short-lived
S11	Section 11	Charcoal	Unidentified	Beta-267510	8820±50	N/A	8169–7761	8206–7737	Reliable, potential old wood effect
Bestansur									
SA123	T5, C1078. Shell midden	Mollusc shell	*Helix salomonica*	Beta-326883	9570±40	–9.7	9125–8828	9152–8788	Unreliable, old carbon effect
SA740	T7, C1254	Charred seeds	*Lens* sp.	Beta-342482	2770±30	–23.4	973–848	997–839	Probably intrusive
SA803	T7, C1262	Charred seeds	*Lens* sp.	Beta-343963	2740±30	–22.9	906–841	971–816	Probably intrusive
	T10, C1412A. Open area	Bone collagen	Goat tibia	Beta-368934	8610±50	–19	7672–7580	7741–7552	Reliable, likely deposited in situ
RD7	T10, C1772. Butchery deposit	Bone collagen	Sheep scapula	Beta-406556	8620±30	–18.5	7647–7587	7713–7581	Reliable, probably deposited in situ
SA1223	T12, C1388. Midden area	Charred plant material	2 lentils	Beta-351365	6380±40	–21.5	5464–5315	5471–5304	Too young for associated material: unreliable
406557 supp	T13, C1386. Butchery deposit	Bone collagen	Pig carpal	Beta-408868	8130±30	–20	7141–7063	7185–7050	Reliable, articulating carpals suggest deposited in site
SA261	T10, C1781. Packing below floors	Tooth collagen	Human	Beta-533614	8640±40	–19.6	7677–7592	7736–7586	Reliable
	T10, Ext. deposits close to B5	Bone collagen	Human femur	Beta-533619	8460±30	–19	7567–7520	7579–7495	Reliable
SA851	T10, C1972. Fill of cut into B8 W57	Tooth collagen	Human	Beta-533625	8440±30	–20.3	7546–7496	7574–7482	Reliable
SA821	T10, C1868. SK6 in skull cluster	Tooth collagen	Human	Beta-533626	8330±40	–20	7471–7356	7519–7301, 7216–7204	Reliable
Shimshara									
SA757	Section	Charred nutshell	*Pistacia* sp.	Beta-342484	8230±40	–24	7322–7180	7447–7082	Reliable

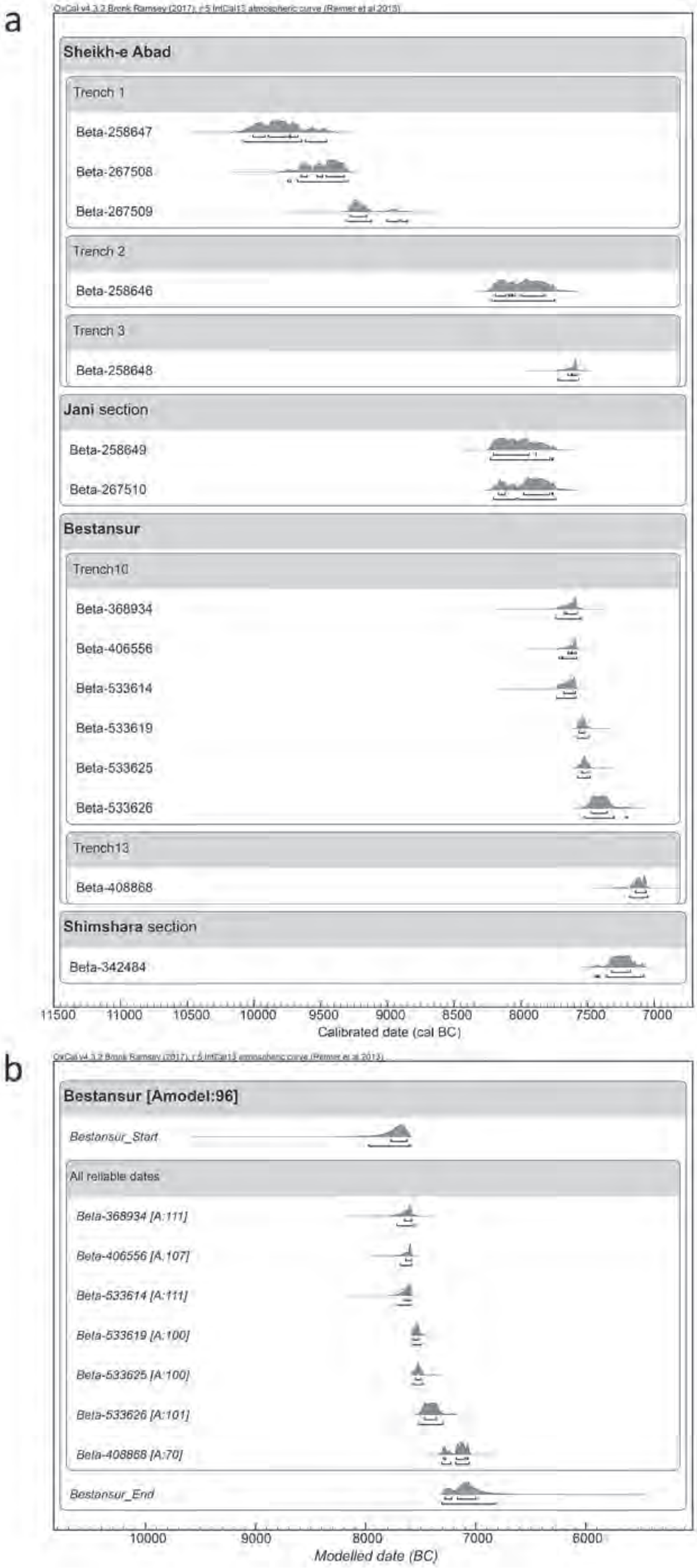


Figure 11.1. a: Calibrated reliable ^{14}C dates (cal BC) from Sheikh-e Abad, Jani, Bestansur and Shimshara, arranged by trench and, where known (for Sheikh-e Abad and Jani), stratigraphic order with the oldest sample first; b: Modelled reliable ^{14}C dates from Bestansur.

The 11 ^{14}C dates from Bestansur are more challenging to assess. All dated contexts were Neolithic based on the associated material, but the calibrated ^{14}C dates range from *c.* 9000 to 900 BC. Because of, initially, limited amounts of charred seeds, charcoal and bone collagen preserved in the materials sampled from this site, concessions had to be made in choosing ^{14}C samples. Consequently, one of the samples, Beta-326883, was a mollusc shell. Land snail shell has often been shown to be too old for its context, by as much as up to 3000 years, due to the snail uptaking old, ^{14}C-depleted carbon, probably calcium carbonate derived from limestone (Rubin 1963; Goodfriend 1983; 1987; Quarta 2007). While there are cases in which no offset is present or it can be corrected for (Pigati 2010; Carvalho 2015), in the case of Beta-326883 the date is clearly too old compared to the other ^{14}C dates and the archaeological material. While the date indicates that the occupation was probably Neolithic, it is not more precise than that and has to be treated as unreliable.

The two youngest Bestansur dates are probably reliable as ^{14}C determinations, with low standard deviations, reliable material and expected δ^{13}C values. They are clearly too young for the associated Neolithic material, however, at *c.* 1000–800 BC, and are therefore intrusive from Iron Age levels at the site. As seeds, they could easily have moved through sediment layers (van der Plicht 2001; Finlayson 2011). Moreover, the seeds were found in well-defined circular and ovoid patches of 6–13cm, about the size of a rodent hole. After submission of these two samples for ^{14}C dating, more of such caches were found and it was established that they were associated with well-preserved rodent remains (Chapters 12 and 18). Charring may have occurred post-deposition by burning of field stubble, nowadays a common practice in the region, or the lentils may have been gathered in a charred state. We therefore have to discard these dates as reliably representing Neolithic contexts. The Iron Age dates are clearly associated with the Iron Age settlement at Bestansur.

Beta-351365 represents charred plant material but was a mixture of charred remains from the same deposit. The context comprises short-lived midden-like deposits between laid surfaces and is potentially a reliable context. The Chalcolithic date of the sample, however, does not match the Neolithic material in these contexts. As no Chalcolithic-type material has been found during the survey or excavations at Bestansur (Chapter 9; Altaweel *et al*. 2012). It is more likely therefore that it represents a mixture of Neolithic and intrusive Iron Age material, especially since different charred remains from this context were combined for this sample to provide enough datable material. Bioturbation was observed to be a problem in the upper 0.5m of Trench 12, from where the sample was derived (Chapter 9).

While these dates, and others discussed in Chapter 18, show a degree of intrusion of small charred materials into Early Neolithic levels, we do not believe they significantly impact the contextual and chronological security of the excavated Neolithic levels at Bestansur. Apart from some elements of the charred plant assemblages, all recovered materials from our Neolithic levels are clearly of Early Neolithic date as confirmed by: 1) all radiocarbon dates on animal and human bones (Table 11.1); 2) consistent and coherent lithic assemblages exclusively of eighth millennium BC date (Chapter 20), and; 3) the complete absence of even very small ceramic sherds from any excavated context interpreted by us to be Early Neolithic in date.

This evaluation of the security of the dates, therefore leaves seven samples from Bestansur which have a Neolithic date and which are reliable as ^{14}C dates. Beta-533614, -533619, -533625 and -533626 are human tooth and bone collagen from Trench 10 from reliable contexts. For the remaining three Neolithic dates, the *in situ* and articulated nature of the dated bones strongly argues that they too come reliable contexts. Beta-406557 was one of several articulating pig carpals, which suggests it was freshly deposited. Beta-368934 was from a goat tibia that also appeared to have been deposited *in situ*. Beta-406556 was assayed from a sheep scapula in an extensive butchery deposit and is therefore also likely to be reliable. We therefore accept these seven dates as reliably dating Neolithic Bestansur, pending an increased number of dates in future studies. This acceptance is strongly supported by chronological comparisons to well-dated material from other sites based on stylistic studies reported on in this volume. The material culture, chipped stone and small finds in particular, support assignation of a date of mid–late eighth millennium BC date to the main excavated levels at Bestansur and a later eighth millennium BC date to excavated levels at Shimshara.

A single sample from a charred nutshell in basal deposits of Shimshara was ^{14}C dated. This date appears to be reliable but, as a nutshell, it cannot be completely ruled out as intrusive. Nonetheless, its visible association with ash and grey mixed lenses makes a functional relation to the context likely. We tentatively accept this sample as reliable, but additional samples are needed for confirmation.

Previously, four samples were dated from the now largely eroded Pottery Neolithic levels at Shimshara (Mortensen 1970). Unfortunately, these dates are not reliable as they had a very low carbon content (0.16–0.32%). Because the material dated was temper in potsherds, there is an increased chance that the dates are contaminated by organic matter in the clay or post-depositional uptake of carbon in the porous sherds. Contamination is possibly also reflected in the large standard deviations (≥150 ^{14}C years) and the very old date for K-981 (10030 ±160 ^{14}C years).

Chronology of the CZAP sites

The calibrated reliable ^{14}C-dates from the four CZAP sites are shown in Figure 11.1. Sheikh-e Abad is the earliest of these sites. It was first occupied in the early tenth millennium BC at the very beginning of the Holocene, perhaps even commencing in the Younger Dryas (see also below), and its later dates fall within the early–mid-eighth millennium BC (Matthews *et al*. 2013c). A Bayesian model of the Sheikh-e Abad dates is shown in Figure 11.2, although it should be stressed that the number of dates is too low to take the results with certainty, and the start and end boundaries in the model should be seen as approximate indications only. It is likely, however, that the available dates bracket the occupation span as the earliest date, Beta-258647, comes from the basal level, while the latest date, Beta-258648, comes from the top of the mound. It is so far not certain whether occupation is continuous between the earliest and latest dates but if it is the site has at least a 2000-year span, dating from the early tenth millennium BC to the first half of the eighth millennium BC.

The available Jani dates are of late ninth or early eighth millennium BC and show that the site is likely to have been contemporaneous with the later (Trench 2) occupation at Sheikh-e Abad. The two Jani dates come from deposits within the cleaned and sampled section of the exposed mound (W. Matthews *et al*. 2013h; 2019b). Below both dated samples there are *c*. 2m of intact Neolithic deposits, while above them there are *c*. 4m of Neolithic and Early Chalcolithic deposits. As such, it is possible to compare developments at these two sites in highland Zagros in Iran for this period.

The oldest three Bestansur dates, which are statistically the same as each other, are almost exactly contemporaneous with the youngest Sheikh-e Abad date. A 'difference' analysis in OxCal suggests that the sites might have been occupied at the same time, with the start date of Bestansur very likely before the end date of Sheikh-e Abad (by 32–2323 years, 95%). The end boundary of Sheikh-e Abad is, however, based on a single date only. The 'difference' between the oldest reliable Bestansur date, Beta-533614, and this youngest Sheikh-e Abad date, Beta-258648, is 151 years (overlap) to –87 years (no overlap), on average 34 years. It is therefore currently not completely possible to say for certain whether Bestansur was only occupied immediately after Sheikh-e Abad was abandoned, or whether there is an overlap in

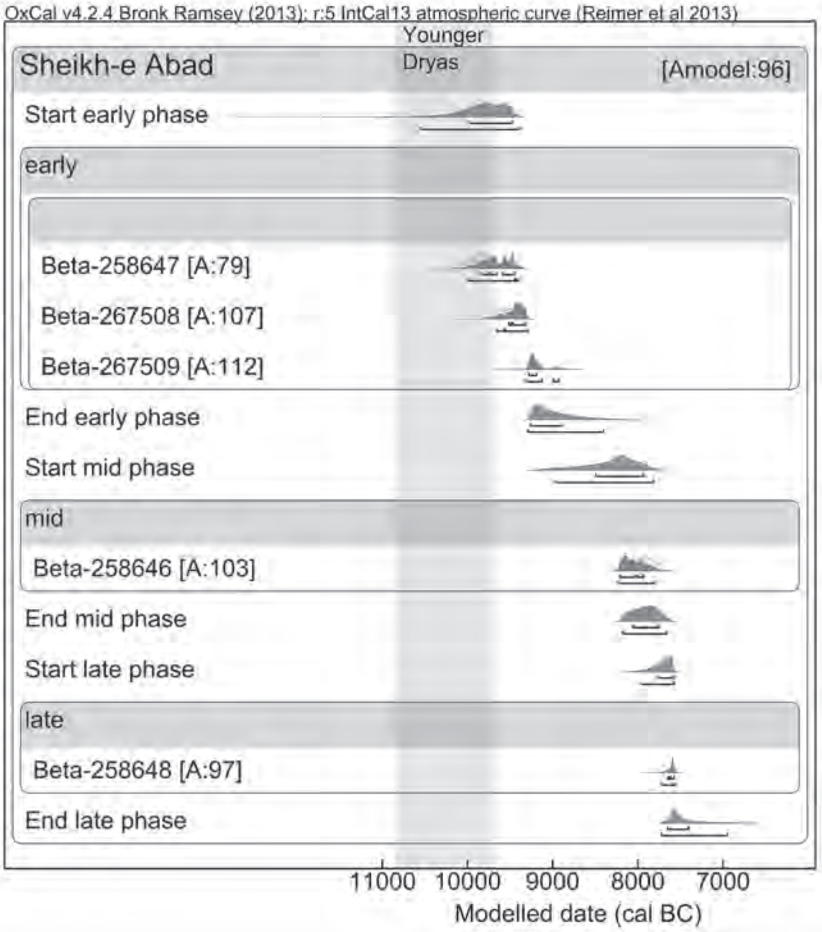


Figure 11.2. Modelled ^{14}C dates from Sheikh-e Abad. The end of the Younger Dryas is indicated (dating after Vinther 2006).

occupation. As the basal layers of Bestansur are still below the ^{14}C-dated layers (Chapters 6 and 9), the latter is the likelier option.

It is difficult to estimate the duration of occupation at Bestansur with the currently available ^{14}C dates. In addition there are still unexcavated levels beneath the current trenches, and the total depth of Neolithic deposits under the Iron Age mound may be from longer-lived occupation than that sampled at the edges of the mound. Nonetheless, the ^{14}C dates clearly indicate that Bestansur was occupied during the mid and latter half of the eighth millennium BC. The current date range is from *c.* 7640 to 7170 BC with an approximate error of 40–70 years to either side. It is therefore most (95%) likely that the currently excavated contexts at Bestansur were in use some time between c. 7700 and 7100 BC. This date range agrees with multiple components of the excavated archaeological materials at Bestansur, including the rectilinear architecture, chipped stone materials such as Çayönü tools, and small finds such as alabaster bracelets (Chapters 12, 20, 21). As the earliest and latest dates come from different, stratigraphically unconnected trenches, it is not yet certain whether the site was continuously occupied throughout this range, and earlier deposits remain undated (Chapter 6; Fig. 6.6).

The Shimshara date of 7320–7180 BC (1σ; 2σ 7445–7080 BC) overlaps with the later part of the Bestansur Neolithic dating. This date comes from the lowest deposits in the cleaned section (Chapter 10), about 3m below level 16, the lowest, aceramic level excavated in the 1950s (Mortensen 1970). It therefore probably indicates when the site was first occupied, as it directly overlies natural and is from the centre of the mound.

In the 1950s the later prehistoric layers on the mound at Shimshara, levels 13–9, were excavated and dated to the Hassuna period. While the ^{14}C dates are unfortunately unreliable because of their low carbon content and large standard deviations, three of them agree with the general assignment of this pottery style to the late seventh millennium BC. It was remarked at the time that these Pottery Neolithic levels 13-9 overlay Aceramic Neolithic levels (Levels 16–14 and unexcavated deposits below) (Mortensen 1970), which are now shown to go back to at least *c.* 7100 BC. As at Bestansur, this dating is confirmed by the chipped stone assemblage and marble bracelets found in proximate contexts (Chapters 9, 20, 21). Severe erosion of the upper layers of the high mound at Shimshara since its inundation in the late 1950s (www.nino-leiden.nl/projects/rania-plain-tell-shemshara) has probably removed any prospect of more accurately dating the upper prehistoric layers, as these have been washed away.

Investigating these four sites within one project is highly informative, as it allows for an assessment of chronological development and variation between the ecological and socio-cultural zones in the highland and lowland Zagros. The four sites together span the entire Early Neolithic. Because the sites also partially overlap in time (e.g. Sheikh-e Abad Trench 2 and Jani; Sheikh-e Abad Trench 3 and Bestansur Trench 10; Bestansur Trench 13 and early Shimshara), a spatial and cultural comparison is possible at least for these time spans.

The CZAP sites in their regional contexts

Figure 11.3 shows the dates from the CZAP sites in their regional context, compared to other sites in the EFC from which reliable dates are available (further details in the appendix, available at www.czap.org). The sites are also compared to the PPNA–PPNB periodisation commonly used in the Levant and southeast Anatolia, with the dating of these periods following Benz (www.exoriente.org/associated_projects/ppnd). It is important to note that the black boxes and lines in Fig. 11.3 are based on ^{14}C evidence only and that actual site occupation may have been shorter or longer than indicated in the figure.

The comparison of the CZAP sites with other sites in the EFC is complicated because of the low number of reliable ^{14}C dates from this region. Many sites here were dated in the 1960s and 1970s, and these dates are frequently unreliable because of large standard deviations or because they are based on bulk samples (e.g. dates of Abdul Hosein, Seh Gabi, Tepe Siahbid, Chogha Sefid, Tepe Sabz, Jarmo, Shimshara, M'lefaat and Nemrik; see appendix 11.1 at www.czap.org). Nonetheless, some conclusions can be drawn and, for this discussion at least, Neolithic occupation can be divided into four approximate periods.

First, at the start of the Holocene, and perhaps within the end of the Younger Dryas, the early occupation at Sheikh-e Abad is contemporary with that at Chogha Golan and Tang-e Bolaghi. Slightly later, but probably contemporary with at least the later part of this early phase at Sheikh-e Abad, is occupation at the Central Zagros site of Asiab (Bangsgaard *et al.* 2019). Evidence of occupation at Asiab comes in the form of ashy layers, pits, and a large semi-subterranean structure (Bangsgaard *et al.* 2019). At lower elevations, Qermez Dere, and potentially M'lefaat and Nemrik, are probably contemporary with Sheikh-e Abad, while further afield there are PPNA sites with early dates, for example WF16 in Jordan (Mithen 2007; Wicks 2018) and Körtik Tepe in southeast Anatolia (Benz 2012; Coşkun 2012).

A second period of dated occupation in the Zagros can be correlated with contemporary occupation in the Levantine Middle PPNB, based on the later period of occupation at Sheikh-e Abad, occupation at Jani, and Chogha Golan, East Chia Sabz, and Ganj Dareh.

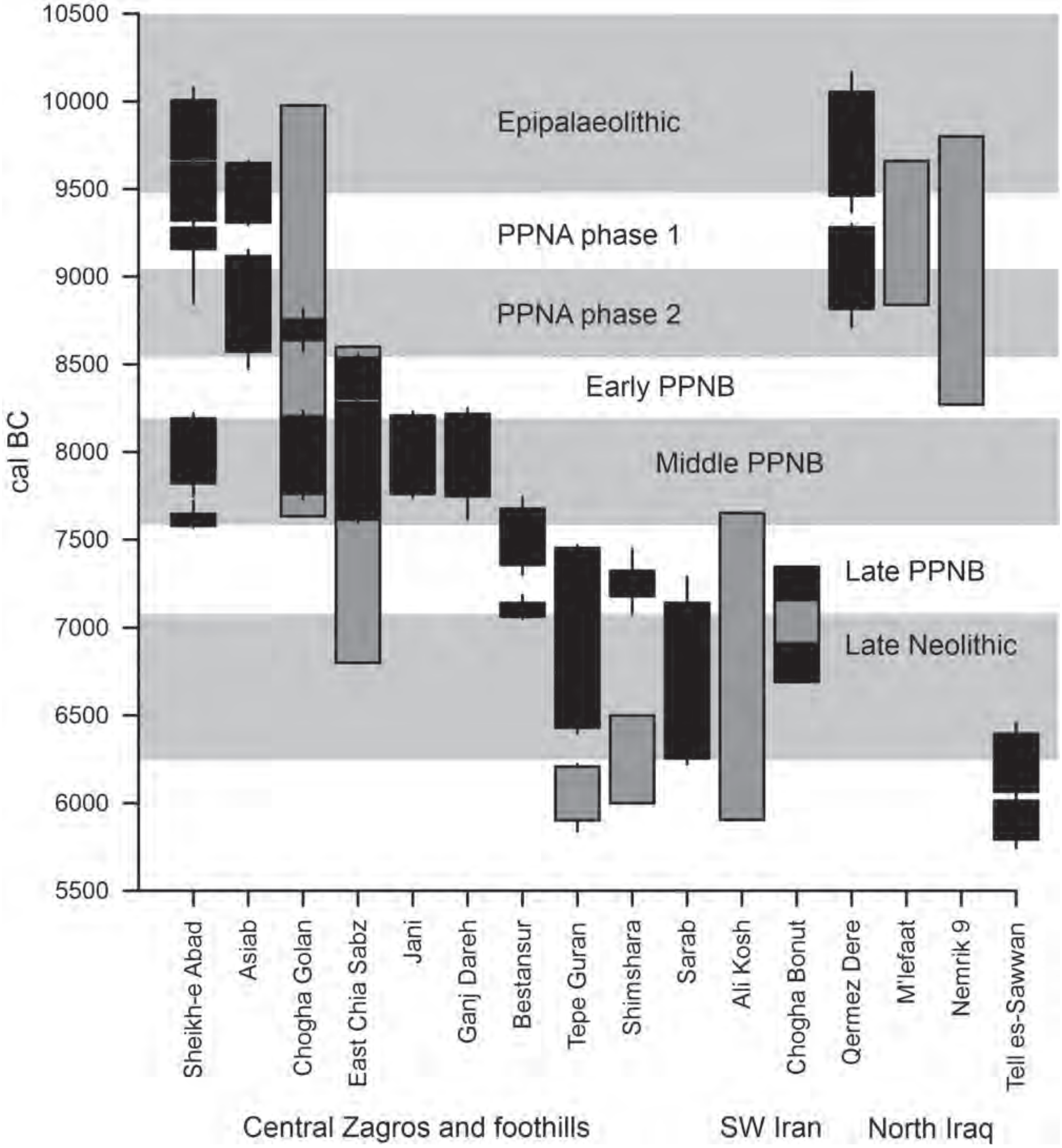


Figure 11.3. Overview of ^{14}C dated Neolithic site occupation in the EFC. The black boxes give the 1σ ranges of the available reliable ^{14}C dates, while the lines indicate the 2σ range. Contemporaneity with WFC periodisation illustrated by shaded bands.

It is likely that occupation at Bestansur started in this period. At most of the Zagros sites, substantial architectural structures were constructed in this period. It is interesting that a cessation of occupation at sites appears to have taken place around 7600/7500 BC, with no ^{14}C evidence for occupation at Sheikh-e Abad, Chogha Golan, Jani, and Ganj Dareh after this date, although later flexed Neolithic burials were dug into Building 1 at Sheikh-e Abad, suggesting at least some occupation post 7600 BC. Around the same time in the southern Levant settlements to the west of the Jordan river were abandoned, while those in the east grew and new sites were occupied there (Kuijt 2002). Nonetheless, no such shift appears in other regions, and the potential 'cessation of occupation' in the EFC may only be the result of limited research and the erosion of upper deposits. For example, while no ^{14}C dates are yet present post *c.* 7500 BC at East Chia Sabz, it is clear from the stratigraphy and material culture that the site continued until at least 7000 BC (Darabi

2013). In addition, Bestansur was probably inhabited from before 7600 until after 7200 BC.

A third period of dated occupation is contemporary with the Late PPNB period in the Levant and comprises sites such as, arguably, Tepe Guran; however, Mortensen (2014) dates the site to 6700–5500 BC. It is likely that Bestansur was still inhabited, while occupation at Shimshara and Sarab appears to have started around this time. Contemporary occupation in southwest Iran includes levels at Ali Kosh.

The last period considered here is contemporary with the Late Neolithic across the Middle East. Tepe Guran, Sarab and Ali Kosh were occupied and Levels 13–9 at Shimshara probably also correspond with this phase, as do Hassuna and later Samarra sites, such as Tell es-Sawwan. Already during but especially after this period, the number of sites in the central western Zagros appears to be very low, perhaps in some cases because they may be buried below later levels on larger mound sites common in the region..

Beyond the EFC, the CZAP sites add to the trans-regional view of polycentric and reticulate socio-cultural development through the Early Neolithic of Southwest Asia (Asouti 2017). In looking west and northwards from the CZAP study region, the earliest occupation at Sheikh-e Abad coincides with significant evidence for human activity at sites such as Mureybet, Jerf el Ahmar and Dja'de in Syria, Körtik Tepe, Hallan Çemi, Göbekli Tepe, Hasankeyf Höyük and Çayönü in southeast Anatolia, and Pınarbaşı and Boncuklu in central Anatolia. The eighth millennium BC occupation at all four CZAP sites can be viewed as part of a major episode of socio-cultural transformation across all of Southwest Asia, as attested at multiple sites including Abu Hureyra 2A–2B and Halula in Syria and Nevalı Çori, Göbekli Tepe, Çayönü, Cafer Höyük, Boytepe and other sites in southeast Anatolia, as well as with Aceramic Neolithic sites of central Anatolia such as Kaletepe and Aşıklı Höyük (dates and discussion for most of these sites are available at Benz's online 'PPND' website).

Climatic and environmental context

Figure 11.4 shows that the four CZAP sites are largely dated to within the Early Holocene period (*c.* 9700–5000 BC), which was generally warmer and wetter compared to the preceding periods, although there were periods of aridity. Greenland ice core proxies show an increase in temperature (Johnsen 2001; Rasmussen 2006; Vinther 2006), and records from the eastern Mediterranean region are in agreement in suggesting such warmer and wetter conditions (Bar-Matthews 1997; Robinson 2006; Sharifi *et al.* 2015), although seasonality appears to have been pronounced (Asouti 2017). The situation in the EFC, however, remains under discussion (Chapter 3). Only a few long-term records are available from the Zagros area, namely the Zeribar and Mirabad lake core records. In these records, the end of the cold and dry Younger Dryas period is marked by a decrease in *Atriplex*-type and *Artemisia* pollen, an increase in grasses (Poaceae) and *Pistacia* trees, but an increase in oak trees does not start until after 6000 BC (Wasylikowa 2006; Schmidt 2011; Stevens 2001). These attributes suggest an end to the very cold and arid conditions of the Younger Dryas, confirmed by the Lake Neor record (Sharifi *et al.* 2015). However, the delayed increase of oak is argued to indicate that conditions were still drier than in the Late Holocene (Stevens 2001), although it likely reflects a more effective response of grassland to the new conditions in the EFC (Asouti 2017). Alternatively, there may have been human and habitat factors in the delayed tree spread (Roberts 2002; Djamali *et al.* 2010; W. Matthews 2013; Asouti and Kabukcu 2014). Nonetheless, relatively low Early Holocene lake levels have also been inferred from Lake Mirabad ostracods (Griffiths 2001) and Sr/Ca ratios (Stevens 2006) and from Lake Zeribar diatoms (Snyder 2001), and aridity is confirmed by the presence of *Chenopodium rubrum* seeds there (Wasylikowa 2005). In any case, plant stable isotopes indicate that at least occasionally plants were water stressed (Riehl *et al.* 2014).

It is currently not possible to determine whether the earliest levels of Sheikh-e Abad date back to the Younger Dryas, nor whether occupation started only at the beginning of the Early Holocene. The end of the Younger Dryas is currently dated to *c.* 9700 cal BC (Vinther 2006). The earliest Sheikh-e Abad date, on a short-lived specimen from the basal layers of the site, dates to 10,078–9456 BC (2σ). Therefore, this seed could as well date to the Younger Dryas as to the earliest Holocene period (Fig. 11.2). The interpretation is difficult because there is only a single date, and made more complicated because of the radiocarbon calibration plateau around the transition of the Younger Dryas to the Holocene (Benz 2012). It is also likely that dates from the older end of the plateau are under-represented (Benz 2012).

There is no doubt that at least the later occupation at Sheikh-e Abad as well as the occupation of Jani, Bestansur and Shimshara occurred within a longer-term period of climate stability or amelioration in the Early Holocene. Nonetheless, cold and arid events occurred during this period. The most pronounced of these is the so-called 8.2 ka event, with cold and arid conditions indicated throughout the northern hemisphere around 6250–6000 BC (Alley 1997). This event occurred later than any of the currently investigated occupation of CZAP sites, although the later levels at Shimshara may have been contemporaneous. Of more interest to the time period investigated here is the 9.2 ka event, from *c.* 7300 to 7100 BC, which was comparable to the 8.2 ka event,

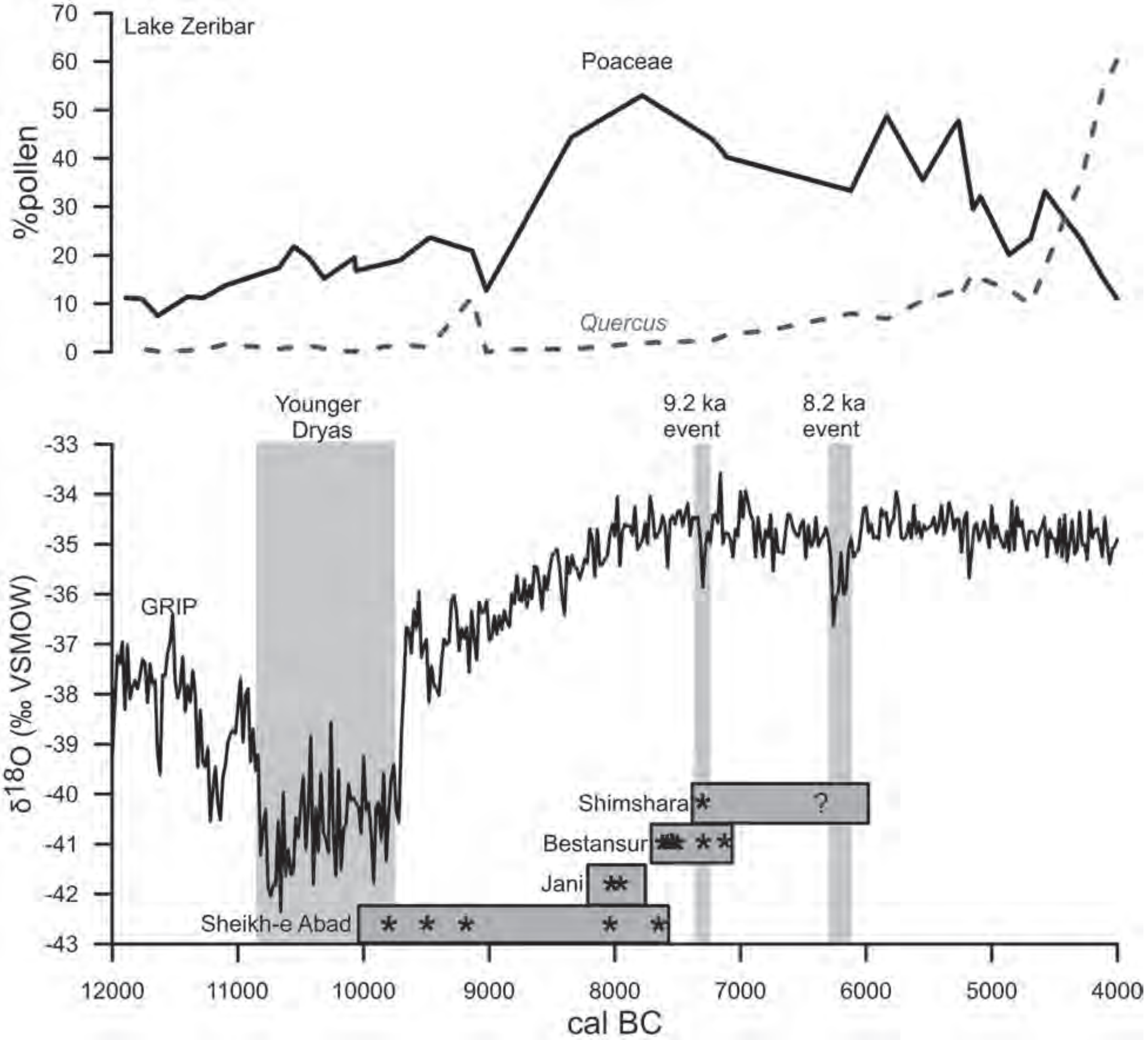


*Figure 11.4. Occupation at Sheikh-e Abad, Jani, Bestansur and Shimshara, and climate and environmental proxies. Ice core (GISP) $\delta^{18}O$ (Rasmussen 2006; Vinther 2006); Zeribar pollen from van Zeist and Bottema 1977, courtesy of M. Djamali. * = ^{14}C dates from CZAP sites.*

albeit less severe (Fleitmann 2008). Occupation at both Sheikh-e Abad and Jani appears to have ended before this event, but if occupation between Trenches 10 and 12 at Bestansur was continuous, this site spans the 9.2 ka climatic episode. Shimshara was also likely occupied during the 9.2 ka event, although it is currently not certain if it started before, during, or afterwards. From the perspective of climate and environment change, therefore, these CZAP sites are potentially very interesting as they could give insights into how Neolithic societies reacted and adapted to such adverse climatic events. While it was recently shown (Flohr *et al*. 2015) that there is no evidence for a widespread impact on societies of the 9.2 ka or 8.2 ka events, communities may have been able locally to adapt to changing climatic conditions, for which further precise site-specific studies are needed (Chapter 3).

12. SUSTAINABILITY OF EARLY SEDENTARY AGRICULTURAL COMMUNITIES: NEW INSIGHTS FROM HIGH-RESOLUTION MICROSTRATIGRAPHIC AND MICROMORPHOLOGICAL ANALYSES

Wendy Matthews

Introduction

Research rationale and context

It is increasingly evident that there were multiple centres in the origins of agriculture and sedentism and that Early Neolithic developments across Southwest Asia were more regionally varied and protracted than previously argued (Willcox 2005; Fuller *et al.* 2012a; 2014). Early settled communities also appear to have been more resilient than expected and able to adapt to climate change (Flohr *et al.* 2017). Explanations for this variability and resilience draw on evidence for the diversity and sustainability of local resources, plant and animal management strategies, as well as socio-cultural practices that supported the development of both local as well as cross-regional communities and networks (Arranz-Otaegui *et al.* 2016a; Asouti 2017). It is increasingly recognised that sustainability in the past as well as today is shaped not only by environment but also by economy and society and that these are inextricably inter-related (Marston 2011; Lopez 2012; United Nations General Assembly 2015). It is important, therefore, that debates on early sedentism and agriculture examine more closely local and regional variation in the development and sustainability of early sedentary agricultural communities and apply integrated interdisciplinary approaches.

Crucially in investigating these issues, this research examines a range of methodological challenges that are fundamental to understanding the archaeological record more widely and the development and sustainability of early sedentism and agriculture in particular by examining new micro-contextual evidence at high-resolution through integrated micromorphological, phytolith and biomolecular analyses by gas chromatography/mass spectrometry (GC-MS). The first set of methodological challenges addressed are the difficulties in identifying the nature, use and health of built environments due to the sparsity and taphonomy of macroscopic artefacts and materials left on floors which, to date, has restricted discussion of early sedentary community organisation and sustainability (Braidwood *et al.* 1983: 10). The second set of challenges is in characterising resource management and diet as many routine archaeobotanical and zooarchaeological studies face challenges in identifying the diversity of plant resources utilised (Arranz-Otaegui *et al.* 2016a; 2016b), early stages in animal management (Zeder 2005), and the nature and breadth of human diet (Flannery 1969; Stiner *et al.* 2012). The strengths of the approach in this research lie in the potential for microscopic examination of intact sequences of deposits in thin-section to enable high-resolution analysis of a very diverse range of bioarchaeological and micro-artefactual remains and their micro-contextual associations that are crucial to understanding their ecological and social significance, but are otherwise lost or irreversibly bulked together during routine excavation and sampling procedures (W. Matthews 1995).

This study of some of the world's earliest sedentary agricultural communities examines the challenges that these communities faced in the light of current global challenges and the topics of the UN Sustainable Development Goals today, as the potential and relevance of this approach has become more paramount during the course of the project (Isendahl and Stump 2019). The objective is to provide a new lens for examination of past lifeways and development by focusing on real-world problems and applying cross-disciplinary approaches in order to develop sharper insight into the environmental, economic and social challenges faced and the nature and sustainability of the strategies developed, as outlined in the methodology section below. Knowledge of innovation and design solutions from more than 10,000 years ago may enable us to inform strategies today, providing examples of 'otherwiseness' (Mizoguchi 2015) and stimuli to new formulae and approaches.

This research significantly expands the geographic focus of debates on early sedentism and agriculture by examining the under-explored region of the Zagros in the Eastern Fertile Crescent which Braidwood *et al.* (1983) and more recent studies have established was a core-region in the origins and spread of domesticated plants and animals and people (Matthews *et al.* 2013a; Riehl *et al.* 2013; Darabi 2016; Darabi *et al.* 2018). It was initially argued that the Zagros was colder, drier and less habitable than other regions for early sedentary communities in the Early Holocene, based on an apparent sparsity of archaeological sites (Hole 1996), trees (Van Zeist and Bottema 1977) and spring rains (Stevens *et al.* 2001). New archaeological surveys, excavations and dating, however, have identified a range of sites spanning 10,000–6000 BC that provide important new opportunities for investigating local and regional variation in early sedentism and agriculture, and new climate and environment research has revealed that the region was more habitable and biodiverse than previously argued, and that tree cover was more extensive as insect-pollinated trees, for example, are under-represented in the Lake Zeribar pollen core (Chapter 3; W. Matthews 2013). The new case-studies at Bestansur and Shimshara examine local and regional strategies in the development of sedentism and agriculture on a transect from the lower Zagros in which they are situated to the highland Zagros when compared to new research in western Iran (Matthews *et al.* 2013a; Riehl *et al.* 2013; Darabi *et al.* 2018).

Structure of this chapter

This chapter begins by highlighting key research issues in the study of firstly, early sedentism and its impact on social organisation, ritual and health. It explores the potential for new approaches to these spheres of life through analyses of built environment design, sustainability, use and disease pathways. The second major focus is on resource management and sustainability and the prospects for new micro-contextual approaches. To pursue these research aims, we develop and apply new integrated microstratigraphic, micromorphological, micro-analytical and archaeobotanical approaches, which are specified in the methodology section. The new insights that these integrated approaches have provided are examined in the following results sections. We examine in turn: 1) post-depositional alterations and their impact on preservation of organic, inorganic and micro-artefactual materials and deposits as these affect all subsequent analyses and interpretations; 2) contextual variation in the diverse range of construction materials, bioarchaeological and micro-artefactual remains and deposit-types to investigate the taphonomy, use and discard of these materials with particular focus on the wide range of plant remains and parts as well as coprolitic material within these early sedentary communities; and 3) sector by sector analysis of the built environment and types of activities conducted across the community at Bestansur.

In the discussion, which comprises the second half of this chapter, we use these new high-resolution contextual data-sets to investigate early built environment design, sustainability, socialisation, ritual and health and increasing resource management. In the first major section on early sedentism, we focus in particular on: architectural innovation and hygrothermal properties; built environment planning and creation of communities; ritual and burial within settlements; living conditions and disease reservoirs, vectors and pathways and refuse and waste-management. In the second major section on resource management, diet and sustainability, we examine the contribution of new integrated micro-contextual approaches to the study of the biodiversity and sustainability of resource use in construction, fuel and energy use, food security and diet, animal management and products, and risk management. We conclude with a review of key issues and future directions.

Sedentism, society and ritual: Built environment design, use, sustainability and health

Early sedentism, social organisation and ritual

In studying early sedentism, rather than investigate 'sedentism versus mobility' it is more interesting and fruitful to consider how and in what ways communities create and occupy settlements and landscapes (Valla 2018). The transition to sedentism was not a unilinear evolution, as already contended for the Neolithic in the Zagros (Pullar 1977) and observed in ethnoarchaeological studies in the 1960s in the high Zagros (Watson 1979); many societies even today include a range of mobile and sedentary strategies. A key question is how early communities were created, organised and sustained in increasingly large and densely populated settlements, and what the role of ritual was in this development (Hodder 2018; 2019). The configuration of architectural buildings, features and materials are themselves material representations of continuity or change in social roles and relations, both spatially across communities and chronologically across life cycles and generations as they both define and are marked by the activities and environment that they host (Leatherbarrow and Mostafavi 2002; Bloch 2010; W. Matthews 2018). During the Neolithic, communities across many regions of Southwest Asia constructed communal buildings and spaces capable of hosting public-scale inter-relations, as well as increasingly well-defined and separate houses that are argued to mark increasing privatisation of resources and the emergence of the household as a fundamental social unit (Byrd 2000; Bogaard *et al.* 2009). At the same time, there is increasing evidence for networks and sharing as a strategy for risk management and social sustainability (Marston 2011; Chapters 21 and 24).

Analyses and interpretations of settlements and buildings, however, may be hampered by the sparsity of finds on floors and the coarse temporal resolution provided by routine excavation and bulk sampling. Despite extensive excavations and innovative wet-screening and flotation at Jarmo, 65km from Bestansur, Braidwood (1983: 10) lamented "we have no really good evidence that might specify the use to which the various rooms in the house were put". Few artefacts were left on floors, as at many archaeological sites (W. Matthews *et al.* 1997a; W. Matthews 2018). In addition, because many finely stratified floors and occupation deposits are often <1–10mm thick, excavation and routine bulk sampling often mix diverse strata and components. As a consequence of these methodological constraints, many studies are obliged to examine the incremental constructs of building phases and levels (e.g. Kohn and Dawdy 2016: 132–133), which represent aggregations of practices over several years or generations and thereby restrict analysis of how communities create and occupy space (Foxhall 2000: 496; Robb 2010).

One key aim in this chapter, therefore, is to apply forensic-scale micro-contextual analyses to inform on the development of settled life and creation of communities by providing new high-resolution micro-historical data on how early sedentary settlements were created and occupied, and the role of ritual practices at temporal resolutions that are closer to lived timescales of the everyday, seasonal, annual and life cycles. It is at this scale that we can evaluate processes and agents of continuity and change (Courty and Coqueugniot 2013).

Built environment sustainability and health

There is currently little discussion of the sustainability and health of early sedentary built environments, which is surprising as it is widely recognised that the development of early sedentism and agriculture represents a major demographic and epidemiological transition (Barrett *et al.* 1998; Larsen 2006; Harper and Armelagos 2013: 146; Scott 2017; Larsen *et al.* 2019), with evidence for incipient changes in the Epipalaeolithic (Stutz and Bocquentin 2017). The development of increasingly sedentary lifeways and agriculture is argued to have had potentially positive impacts on sustainability and health, by increasing food security and human fertility, and thereby laying the foundations for increased population (Bocquet-Appel 2011a). At the same time, populations were increasingly exposed to diseases from domesticated animals and commensals, and from living together in more densely populated settlements (Larsen 2006; Harper and Armelagos 2013: 146; Larsen *et al.* 2015; Fournié 2017). Like resources, there is increasing evidence for local and regional variation in the prevalence of morbidity, physiological stress and mortality, as well as in the effectiveness of disease prevention and mitigation strategies (Larsen *et al.* 2015) because health is not only biologically, but also socially, economically and culturally constructed (Lopez 2012). Built environment design, use and living practices can increase or restrict disease reservoirs, carriers and pathways, whether or not these are informed by direct knowledge of disease source or means of remediation (Lopez 2012).

A key aim in this research, therefore, is to provide new insights into early sedentary built environment sustainability and health, by integrated microstratigraphic and micromorphological analyses of firstly, construction materials and techniques as they can have major environmental and health impacts (Lopez 2012; Maskell *et al.* 2018), and secondly by forensic-scale analysis of the diverse bioarchaeological, inorganic and micro-artefactual traces of activities and their precise depositional contexts in order to provide insights into built environment habitability, waste-management, and health and disease reservoirs, vectors and pathways (Lopez 2012).

Resource management and sustainability: A micro-contextual approach

The origins of agriculture arguably provided increased food security and settlement sustainability through greater management and propagation of plant and animal resources and provided the foundation for a major demographic transition (Bocquet-Appel 2015). Greater reliance on a more restricted range of species and more densely populated crop stands and herds, however, can also increase risk and exposure to disease and other threats such as drought, extreme weather, fire and raiding. Of the estimated 400,000 plant species, 300,000 are edible. We currently, however, only cultivate *c.* 150 species and 50% of plant protein and calories come from three species: wheat, rice and maize (Reed and Ryan 2019). The search today is for increased biodiversity to widen the pool of food resources and reduce risk. Whilst there is some evidence to suggest a dramatic shift from use of wild to domesticated species at a range of sites in Southwest Asia, including Ganj Dareh in the highland Zagros, from Levels E to D, *c.* 8200–8000 BC (van Zeist 1984), there is increasing evidence that this shift was not unilinear and was protracted through time (Zeder 2011; Fuller *et al.* 2012a). There is growing evidence for considerable inter-breeding of wild and domesticated plants and animals over several thousand years, local selective development and adoption of domesticated species, and use of wild resources, which are still understudied (Arranz-Otaegui 2016b; Arranz-Otaegui *et al.* 2018a; Whitlam *et al.* 2018). Key questions, therefore, are how biodiverse were the resources available to and used by the communities in the lower Zagros, which species were domesticated and which wild, and how were they managed?

The aim in this research is to study new interdisciplinary data on plant and animal resource use and management by integrated high-resolution contextual analysis of a wider range of traces and indicators than routinely studied, through micromorphological analysis of diverse archaeobotanical and zooarchaeological remains in thin-section, including non-charred plant remains and human and animal coprolites.

Resource diversity, management and utilisation

Plant resources, cultivation and use

With regard to plant resources, Arranz-Otaegui and colleagues (2016a: 14005) have argued that "we must reconsider the importance ... attributed to cereals … and should emphasize the key role that other plant taxa ... played during this time". There has been an over-emphasis on the significance of seed-bearing plants and resources such as cereals and pulses and woody fuel resources, as flotation methods preferentially recover seeds and woody materials rather than leaves, stems and roots which are frequently collected from wild plants (Colledge and Conolly 2014). The focus of research on charred plant remains, moreover, restricts study of plants to those that have been subject to burning and have survived, often only below low temperatures <350–500°C (Boardman and Jones 1990; W. Matthews 2010; 2016). Previous micromorphological research has shown, firstly, that a much wider range of plant materials and parts are present in archaeological deposits than those routinely recovered by flotation and secondly, that micro-contextual analyses can provide high-precision information on the contextual association of plant remains and thereby greater insights into their use and significance (W. Matthews 2010; 2016).

The aim here is to investigate through integrated micromorphological and phytolith analyses the diversity of plant materials, parts and resources utilised for food, fuel, fodder, construction and artefacts, for example, to sustain communities in the Zagros, and to compare them with those recovered by water-flotation and from other sites and regions of Southwest Asia as there is increasing evidence of considerable local and regional variation in environment and ecology in the Neolithic. This study of diverse plant remains is of particular importance at Bestansur as few charred plant remains have been recovered by flotation from the site (Chapter 18). One key objective and focus of the analyses below therefore is on why there are few charred plant remains, and what we can learn from study of other plant materials and parts.

Animal management and resources

The earliest stages in animal management are problematic regarding detection in zooarchaeological assemblages. First, changes in bone morphology indicative of domestication, such as reduction in size and changes in horn core morphology may be delayed by 500–1000 years, due to time-lags in genetic change and inter-breeding with wild populations. Secondly, studies of kill-off profiles are dependent on identification of indicators of sex and age, which are influenced by a range of factors including environment (Zeder 2005).

This research aims to provide new insights into early management of animals by integrated micromorphological and GC-MS analyses to test for the presence of animal dung on archaeological sites as dung is an independent marker of human proximity to animals and animal management and penning, as well as a major 'secondary product' notably as manure to enhance plant productivity and as an energy resource when burnt as fuel (W. Matthews 2005a; 2010; Bull *et al.* 2005; Portillo *et al.* 2009; 2020; Shahack-Gross 2011; Shillito *et al.* 2011; Spengler 2018). In addition, studies of dung and plant and microfossil content provide indicators of wider environment and vegetation (Ghosh *et al.* 2008) as well as animal diet and management practices at timescales of one to two days (Shahack-Gross 2011), and will provide important insights into local environment and vegetation cover in the Zagros where few paleoenvironmental records exist to date.

Human diet: Integrated analyses of human coprolites

A major ongoing debate is whether there was a broad-spectrum revolution in the diversity of food consumed by humans, and how this may have stimulated and sustained the transition to early sedentism and agriculture through diversification and intensification to enhance year-round food security and buffer risk (Flannery 1969; Marston 2011; Zeder 2012a; Stiner *et al.* 2014). Crucially, however, it remains unclear whether small and medium seeded grasses and other wild plant foods in charred archaeobotanical assemblages were actually consumed by humans or whether they originate from animal dung burnt as fuel (Miller 1996; Charles 1998; Valamoti 2013). As a consequence, it is uncertain how long, attenuated and diverse the transition to agriculture may have been (Fuller *et al.* 2012a).

In order to provide new precise high-resolution insight into the biodiversity of human diet, this research applies integrated micromorphological, GC-MS and phytolith analyses, firstly to establish the presence and ubiquity of human coprolites which are otherwise difficult to detect and sample separately from surrounding deposits due to their small size and thinness of many lenses or traces, which may be <1–2mm (Shillito *et al.* 2013a; 2013b), and secondly to study the contents of human coprolites as a wide range of plant, fish and bone remains indicative of diet may be preserved within them.

Integrated analyses

It is hoped that study of the micro-contextual associations between these diverse resources within their depositional contexts within the settlement at Bestansur will also aid investigation of the inter-relationships between different data sets that are often otherwise studied separately within their respective specialist fields and difficult to integrate (Miller 2013; Fraser *et al.* 2013; W. Matthews 2013). Thus we aim to contribute new insights into continuity and change in environment, early plant and animal management and sedentism, particularly as it is increasingly recognised that environment, materials, tasks and communities are often complexly entangled and interdependent (Hodder 2012).

Methodology

Interdisciplinary approaches to the built environment, resource management and sustainability

An interdisciplinary approach and analytical methodology have been applied as examination of built environment management, sustainability and health requires understanding of the environmental, economic and social context of material use and discard (Lopez 2012), and diverse organic and inorganic materials were used and discarded in the built environment. To this end, this research is informed by approaches and theory in: technological choices to study the affordances of materials (Sillar and Tite 2000; Knappett 2005); anthropology to study the role of features, spaces and buildings in shaping social relations (Bloch 2010); current built environment studies to examine early built environment design, sustainability and health (Lopez 2012); and ecology to study resource management and sustainability (Marston 2011; Jackson *et al.* 2018; Isendahl and Stump 2019).

A range of complementary analytical techniques have been applied and piloted to identify specific organic and inorganic components and materials *within* their microstratigraphic context in the field and in large resin-impregnated micromorphological thin-sections, as well as in high-precision spot samples that are closely correlated to the microstratigraphic units in thin-sections, which are presented in detail in the following chapter, Chapter 13. Analyses of dung from ethnoarchaeological and other on-site samples are discussed by Elliott (*et al.* 2015; Chapter 16). A high-resolution approach is needed as many depositional layers are less than 5mm thick, and some surface materials and accumulations are less than 1mm to 12µm thick.

Microstratigraphic analysis and sampling in the field

In this study, microstratigraphic sequences were examined in Trenches 1, 4, 5, 8, 9, 10 and 12/13. Sections through sequences were analysed and sampled at the edge of excavations and pits, in half sections through features such as fire-installations, or in plinths in key areas, *c.* 20 × 30cm in plan and 20–50cm high. Sequences were covered with plastic prior to analysis to prevent drying. The strata were cleaned with an artist's palette knife and photographic blower in order to highlight the sharpness of boundaries and reveal individual macroscopic lenses and components. Microstratigraphic sequences were then photographed, drawn at 1:5, 1:10 or 1:20 depending on the size and complexity of the stratigraphic relations analysed. Deposits were described using the CZAP recording system which is based on standard soil science procedures adapted for archaeology (Hodgson 1974; Courty *et al.* 1989; W. Matthews 1995; Chapter 2). Block samples for micromorphological analyses were cut from section faces, *c.* 15 × 7 × 8cm in size, and wrapped tightly in tissue and tape.

Additional block samples were collected for archaeobotanical, coprolite and other analyses and wrapped in aluminium foil or tissue and tape for *in situ* analysis in the field and specialist laboratories using stereo-binocular and SEM microscopy, as well as dissecting and sub-sampling for high-precision spot analyses.

Micromorphology: high-resolution contextual analysis and interpretation

Forty thin-sections from Bestansur and nine from Shimshara were manufactured, analysed and recorded for this study from a wide range of context and deposit types. An additional 38 thin-sections from Bestansur were collected and analysed by Elliott with a specific focus on identification of animal dung and animal management (Chapter 16).

Micromorphology blocks were air-dried, oven dried at 60°C, impregnated with an epoxy-resin and cut, ground and polished into large thin-sections, 14.7 × 6.7cm, 25–30µm thick using a Brot system oil-cooled diamond grinder-polisher. The thin-sections were analysed at ×25–400 using a Leica DMLP polarising microscope in plane-polarised light (PPL), cross-polarised light (XPL), oblique incident light (OIL), incident light fluorescence (ILF) (Leica Filter system AS, Filter system N2.1S: wavelength excitation 515–560nm, transmitting >590nm), and a quarter wave plate for identification of spherulites (Canti 1999). For all 49 thin-sections, individual microstratigraphic units and boundaries were defined and correlated with excavation units (see Fig. 12.10). Key components and features were recorded on print-outs of each thin-section, and summary descriptions of each unit and microstratigraphic sequence were input into the post-excavation record for each space (Chapter 2). Microstratigraphic unit numbers were assigned to all deposits that could be discerned as distinctive or separated by a boundary from preceding and succeeding deposits, and are referred to after the thin-section sample number (SA) as SA1286.9 and where there are more as SA 1286.9, 11, 13, for example. Excavation trench numbers are referred to with the prefix 'T' (e.g. 'T9'), space numbers with the prefix 'Sp' and feature numbers with the prefix 'F'. The figures are ordered where possible according to the order in which they are referred to in the text. As we consider in turn component types, deposit-types and then contextual interpretations, however, there is some cross-referencing to earlier or later figures to illustrate key data at each of the stage of the analyses and discussion.

Seventy microstratigraphic units were selected for quantification. Units were analysed and recorded using an internationally standardised methodology (Bullock *et al.* 1985; Courty *et al.* 1989; W. Matthews 1995; Stoops 2003) and additional reference atlases for micromorphology (Stoops *et al*. 2009; Nicosia and Stoops 2017) and plant anatomy and phytoliths (Metcalfe 1960; Schweingruber 1990; Rosen 1992; Piperno 2006; Phyt-core). Components, including plant remains, were quantified as a percentage by area of each microstratigraphic unit in thin-section, using visual abundance charts (Bullock *et al.* 1985: fig. 24; *cf.* Courty *et al.* 1989: fig. 5.4). Interpretations of the origin, deposition and post-depositional alteration of components and deposits are based on well-established principles of sedimentation and archaeological site-formation processes (Butzer 1982; Schiffer 2007; Goldberg and Macphail 2006) and ethnoarchaeological comparanda from the region (Kramer 1979; Watson 1979) and more widely (e.g. Mallol *et al.* 2007), with reference to specific case-studies where appropriate. In discussing indicators of uses of space, concepts of key anthropogenic activity markers (Rondelli 2014; Lancelloti *et al*. 2017) are considered and contextual analysis of associations used as a key with which to examine their significance with reference to space type, biography and associations of surface materials as indicators of intended use and accumulated deposits as histories of place (Leatherbarrow and Mostafavi 2002: 23; Robb 2010: 506–507; W. Matthews 2018).

Integrated in situ *analyses of construction materials, archaeobotanical remains and coprolites*

A range of techniques was piloted and applied to high-precision analysis of materials *in situ* in the resin-impregnated thin-sections in collaboration with other researchers. The strength of this *in situ* approach is that it enables precise analysis of materials and components in single lenses as spot and bulk sampling irreversibly disaggregate and destroy evidence of micro-contextual associations and depositional context and may lead to inadvertent mixing with surrounding sediments. The methodology and results are discussed in detail in Chapter 13 and cross-referred in the integrated contextual and thematic discussions in this chapter.

Environmental scanning electron microscopy with energy dispersive X-ray (ESEM-EDX) and infra-red microscopy (µ-IR) were conducted to analyse the composition and technology of construction materials and pigments (Godleman *et al.* 2016). Confocal Laser scanning microscopy (CLSM) and 3-D autofluorescence imaging was applied to evaluate its potential for microbiome studies of diet and gut health and disease, by *in situ* analysis of selected plant remains and microbiological traces in coprolites and deposits in micromorphological thin-sections. Portable XRF (pXRF) analysis of construction materials and activity areas in resin-impregnated slices was applied to investigate the technology and composition of construction materials and geo-chemical traces of activities.

Integrated high-precision spot sample analyses of construction materials, archaeobotanical remains and coprolites

A range of analyses was also conducted on high-precision spot samples closely correlated to the microstratigraphic units in thin-sections, to identify and quantify specific components and materials that require extraction from their depositional matrix (Chapter 13). In the laboratory at the University of Reading high precision spot samples were collected from the back of each block prior to impregnation from each macroscopically discernible layer, with typically 6–15 samples collected per block, of *c.* 10–50g of deposit, and their locations recorded and mapped by high-resolution photography.

In the field laboratory, spot smear slides were analysed to identify the presence and type of phytoliths and calcareous dung spherulites present in deposits to inform on plant and coprolite preservation and use and excavation and sampling strategies and interpretations during field investigations by Wendy Matthews and Marta Portillo (W. Matthews 2000; 2005; Shillito *et al.* 2013a).

High-precision spot phytolith samples were then analysed and quantified in specialist laboratories at the University of Reading. Biomolecular analyses by gas chromatography – mass spectrometry (GC-MS) were conducted to establish whether yellowish organic matter identified by field and micromorphological analyses was coprolitic, as proven in previous research in the Zagros and other regions of Southwest Asia, and to determine origin (Bull *et al.* 2005; Shillito *et al.* 2013a; 2013b). pH, particle size, clay mineralogy by X-ray diffraction (XRD), and Fourier transform infra-red (FTIR) (Godleman *et al.* 2016) were also conducted to characterise the sediments and preservation conditions in natural deposits below the mound and construction materials and occupation deposits on the mound, in a pilot study prior to the coring programme (Chapters 6 and 13).

Deposit-type classification

Deposit-types have been identified and classified to enable intra- and inter-site comparison of natural sediments, construction materials and accumulated occupation deposits across Bestansur and Shimshara and other early settled communities. The classification of the major Deposit-type categories 1–22 is the same as that applied at the third millennium BC urban settlement of Abu Salabikh in southern Iraq (W. Matthews 1995) to enable analysis of continuity and change in the evolution of architectural technologies and built environments spanning *c.* 5000 years. The sub-types, however, are specific to each site, given local variation in source materials.

Deposit-types have been assigned on the basis of integrated field and thin-section observations and grouped according to depositional context and attributes, and CZAP field context classifications. For construction materials, deposit-types have primarily been discerned and assigned according to their specific architectural member, material colour, particle size, inclusions and microstructure as these inform on source materials and manufacturing techniques. For accumulated occupation deposits, we have distinguished deposit-types primarily on the basis of the abundance, type and preservation of plant and humic or coprolite remains which are major constituents of anthropogenic deposits. Other micro-artefactual and bioarchaeological inclusions are also considered where they provide key indicators on specific activity types. Occupation deposits have also been analysed and classified according to: particle size; the related distribution of the coarse and fine materials; orientation and distribution of constituents which are indicative of depositional processes such as discard practices, trampling, weathering, and sweeping, as discussed in detail in W. Matthews 1995 and supported by a wide range of ethnoarchaeological, experimental and site formation research (Schiffer 1996; W. Matthews *et al*. 2000). Other alterations such as bioturbation and cracking are discussed separately, as these tend to be more indicative of post-depositional alterations unrelated to the deposit-types, as deposits were often rapidly buried as at many intensively occupied settlement sites (Butzer 1982). 'Sediment' is used in the CZAP project to characterise deposits that include more mineral rich deposits.

Space-type classification

Space-types have been classified according to the CZAP field context classifications (Chapter 2) and with regard to their syntactic position and the principal activities represented by the size, features, surfaces and macro and micro-artefactual residues within them.

Results

In examining the results, we consider first the microstratigraphic and micromorphological evidence for preservation conditions and post-depositional alterations as these parameters and agencies affect all subsequent analyses and interpretations. The characteristics of the diverse components in deposits at Bestansur are then reviewed with particular focus on the plant remains as these are a major component of deposits and important resource. The concluding results sections examine Deposit-types and their contextual variation as a basis for study of the ecological and social sustainability and health of early sedentary communities and built environments in the lower Zagros in the following Discussion and conclusions sections.

Preservation conditions and post-depositional alterations

A major objective in the microstratigraphic analyses in the field and high-resolution micromorphological analyses in thin-section is to assess preservation conditions and the impact of post-depositional agents and processes on materials and deposits.

The burial environment at Bestansur is generally oxidising (aerobic) and moist below the surface, due to the proximity of the large spring and impermeable shale and marl beds (Saeed Ali 2008: fig. 4.8). In the field we observed a range of other post-depositional agencies and alterations. Foremost of these was bioturbation represented by: plant roots, live earthworms and other soil fauna including ants and millipedes; relic channels and burrows from these and small mammals; burrowing snails recovered in flotation samples (Chapter 18); and cracks and fissures when the deposits dried out. It is these post-depositional processes that have resulted in the introduction of some later material into underlying Neolithic layers, notably charred seeds, affecting interpretation of the charred plant remains assemblages and radiocarbon dating determinations, discussed below and in Chapters 11, 18 and 24, as encountered at other sites in the region, including Jarmo (Braidwood *et al.* 1983). The topsoil in many areas of the site and in the overlying fields was *c.* 30–50cm thick formed by colluvial wash from the mound slopes and ploughing.

Below the topsoil, however, many microstratigraphic deposits and boundaries were clearly visible during excavation, through careful cleaning, site management and conservation strategies to control soil moisture and provide shade (Chapter 8), and observational experience at the site.

A range of analyses were conducted in the first season to assess preservation conditions (Chapter 13). Samples included natural deposits underlying the site, wall and floor materials, and ashy occupation deposits. pH values across all of these deposit types are neutral to slightly alkaline at pH 7.37–7.57 and pH 8.15–8.58, enabling preservation of calcareous materials such as bone, shell, plant ashes, silica phytoliths up to *c.* pH 8.2 (Weiner 2010: 175), but restricting pollen survival (Avery and Bascomb 1974).

Many deposits are classified as silty clay–silty clay loam by particle size determination (Hodgson 1976). These compact fine-grained deposits make excavation and recovery of fragile materials such as clay objects and bone difficult (Chapters 3, 9 and 21), but have also created localised more anoxic conditions, particularly where there was rapid ancient burial, resulting in local preservation of organic materials including humic plant remains, as discussed below.

X-ray diffraction (XRD) analyses of the clay mineralogy revealed that 42–59% of the clay fraction comprises expandable clays (Chapter 13). These clays are highly susceptible to shrink-swell during the alternating dry and wet-conditions that characterise the shift from hot dry summers to cold wet winters, and the stormy spring and autumn seasons in this region (Chapter 3). Expandable clays may lose and gain up to a third of their volume during these cycles, potentially impacting the morphology and preservation of materials that they contain and resulting in cracks and mixing of materials that may fall into them (Chapter 18). XRD analysis of the mass percentages of the mineral phases indicated that calcite was predominant across all samples, at *c.* 50–60%, followed by quartz at 25–35%, and kaolinite, albite, dolomite, haematite and potassium feldspar at <2% (Chapter 13).

In natural and anthropogenic deposits >0.5m below the modern surface, it is evident in thin-section that bioturbation affected at least *c.* 20–30% of many deposits and boundaries, attested by channel, chamber and mamillated voids, mixed infillings and soil faunal pellets (Fig. 12.1b). On drying, cracks form, often vertically, and comprise *c.* 5% of deposits <0.2–1mm thick in thin-section, and *c.* 5–10mm thick in the field, as at Jarmo (Braidwood *et al.* 1983: figs 76, 78, 88). Micro-artefactual and bioarchaeological remains have been identified in bioturbation channels or old cracks and excluded from quantifications of materials within microstratigraphic units (Fig. 12.1b).

Clay coatings of channels and chambers are characteristic of land disturbance/clearance (French 2003). They have been observed in some deposits across the site including in natural deposits in T4 and in some of the deepest deposits exposed at the edge of a pit F11 in T9 (Fig. 12.1c) >1.5m below surface.

Carbonate calcretions or coatings had formed on some Neolithic artefacts. In thin-section, carbonate coatings and infillings were observed in natural deposits in T4 (SA447) and occupation deposits such as T10 Sp53 SA2297.2 below an ash layer. Vivianite, a neo-formed phosphate mineral, was occasionally observed in organic-rich deposits (Fig. 12.34b–c; McGown and Prangnell 2008; Weiner 2010). Neo-formed framboids are present in a range of deposits including omnivore coprolites, at least some of which on human bone have been identified as manganese by pXRF analyses (Fig. 12.16a; Chapter 19). With regard to neo-formed minerals, no salts were observed during excavation nor in thin-section, in marked contrast to deposits in south Iraq (Matthews 1995).

Amorphous organic staining from decay of organic materials is also present in a range of deposits and is associated with plant and bone fragments discussed below. Microbiological traces were observed and are currently being investigated to determine whether some are ancient and can contribute to microbiome studies.

The remaining >50–70% of deposits and boundaries in thin-section were generally moderately-well-preserved. It is these undisturbed areas of deposits

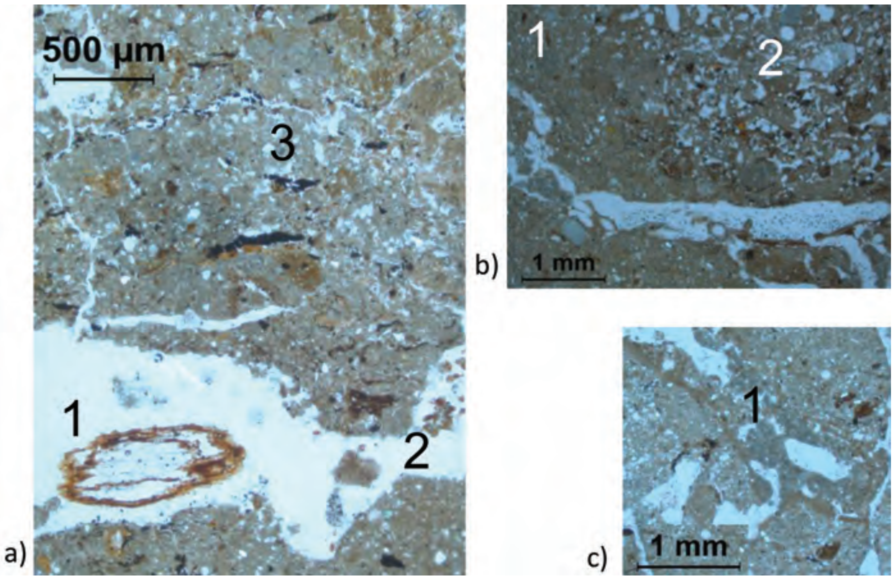


Figure 12.1. Post-depositional alterations at Bestansur include: a) bioturbation by modern roots leaving channels, chambers and traces of modern roots [1] and intact surrounding deposits [3], [2] soil faunal pellets, and [3] occupation deposits with fragmented linear charred plant remains in situ *(T9 F11 SA1290.4 PPL); b) well-defined bioturbation [1] chamber edge with evidence of some compression and [2] infill with unoriented comminuted charred plant remains and microartefacts excluded from analytical quantifications (T13 Sp24 SA1289.2–3 PPL); c) clay and carbonate infillings in a channel [1] (T9 F11 SA1289.4 PPL).*

in thin-section that are the focus of all analyses of deposit attributes and quantification of components. Examples of exceptional preservation include the wall plasters and washes <0.1–0.5mm thick in B8 Sp56 W56 (Fig. 12.22 below); floor plasters and occupation lenses <0.5–1mm thick in T10 B5 Sp50 (Fig. 12.30); impressions and traces of matting as articulated phytolith and humic remains also in T10 Buildings 8 and 5 (Figs 12.22 and 12.24); and articulated lenses of coprolites, phytoliths and occasional desiccated plant remains in *in situ* fuel in T10 Sp48 F18 and organic rich external area deposits in T12/13 (Figs 12.12–12.16); and sharp not abraded bone fragments (Chapter 15).

Anthropogenic post-depositional alterations include: *in situ* burning resulting in rubification and charring of surfaces and materials (Figs 12.10 and 12.26); trampling leading to comminution of deposits (Fig. 12.11f) and kick-zone accumulations in the corners/recesses (Fig. 12.30); sweeping resulting in rounded aggregates (Fig. 12.30); and truncation and removal of deposits.

Material resources and properties: High-resolution identification and micro-contextual analysis

The following sections examine the preservation and characteristics of the diverse components in deposits at Bestansur, before discussing deposit types and their spatial variation in subsequent sections. The contextual significance of all of these materials and microartefacts is discussed throughout this chapter.

Rock fragments and minerals

The predominant rock type present is carbonate from local Cretaceous limestone (Saeed Ali 2008; Karim 2011; Chapter 3), present in natural deposits, at 8%, <5mm in size (SA447) and construction materials including packing and mud-bricks. Sub-rounded river gravels principally of these carbonate rocks were used as surfaces and lining walls in T10 B5 Sp50 (Fig. 12.23 below). More exotic obsidian, chert and marble are present as micro-artefactual remains and debitage, discussed below.

Natural sediments and aggregates

Natural deposits below the base of the mound were excavated and sampled in T4 (Fig. 12.2a–c; Chapters 3, 6, 9 and 13). These comprise pale brown silty clay loam with carbonate inclusions and sparse charred flecks. The scarcity of water-laid deposits and crust fragments in open areas at Bestansur, as at other sites such as Çatalhöyük, is perhaps surprising as they can form rapidly during and after rain or snow melt and flooding (Goldberg and Macphail 2016). As Butzer (1982) observed, however, natural agencies within settlements tend to be less readily detectable in periods of positive or sustained demographic growth due to the impact of human activity. Water-laid crust fragments have been identified in thin-section in a range of external areas including a midden-like layer in T9 open area Sp15 (C1158, SA286.3); T10 Sp27 SA1283.5–6 and adjacent to the exterior wall face of Building 5 in Sp52 C1609 SA1635, as well as early in the history in the entrance room to B5

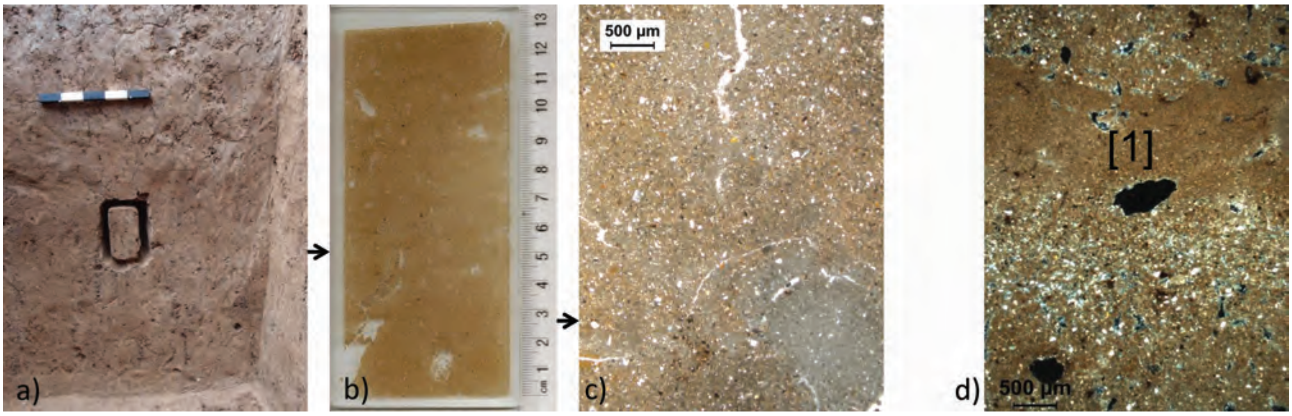


Figure 12.2. Natural deposits at Bestansur: a)-c) at base of Trench 4 (C1087-8 SA447.1, PPL); d) well-sorted water-laid deposits with graded bedding in entrance room Sp47 Building 5, T10 (C1604 SA1794.4).

(Fig. 12.2d). Rare comparative water-laid deposits at other sites include seasonally unused open rooftop surfaces adjacent to an oven at Neolithic Çatalhöyük (W. Matthews 2012).

A diverse range of natural sediments have been identified as aggregates in construction materials, packing and occupation deposits. In thin-section these include: water-laid oxidised orange brown clays (T8 C1158 SA450); sandy silt loam with opaque staining SA2301.1; marl-like aggregates SA2301.2; yellowish silty clay aggregate SA2301.4, 6; and deep reddish brown silty clay in T10 B9 Sp53 SA2314.6.

Construction material aggregates

Construction material aggregates with plant impressions occur widely and are particularly abundant in ashy midden-like layer in T9 Open area Sp15 (C1158 SA286.3), packing deposits and occupation deposits in T12 (with *in situ* phytoliths in T12 C1519 SA1499.6)

Pigments and pigmented materials

Flecks of red pigment were commonly encountered on surfaces and in occupation deposits both in the field and in thin-section, notably in Building 5 in: the entrance Sp47 close to the threshold to Sp50 in several contexts (C1558, C1599, 1C605), next to a muller SF369; reception room Sp50 (Fig. 12.30). Red pigment and flecks were also identified in occupation deposits in other neighbouring smaller buildings, including B9 (Fig. 12.11f), and spaces such as Sp63 (Fig. 12.32); and all other sectors notably T12 (Chapter 9, and below). Other pigment colours noted at the site include: possible purple pigment in occupation deposits in B5 entrance room Sp47 close to the threshold stone into Sp50 (C1599, SA1567); and traces of fugitive yellowish pigment during excavation of the fragments of coloured matting in Sp50. (Fig. 12.24). Traces of paint and pigment were identified on the walls of B8 and B5, and on matting and burial wrappings (Deposit-type 23 and 9 below). The significance of these pigments and the different coloured wall and floor plasters applied to buildings and surfaces are discussed below in the sections on Deposit-types, architectural materials and social and ritual life.

Micro-artefact diversity and biographies

As at many sites, during excavation it was difficult and, on occasions, too time-consuming to excavate individual occupation layers separately, as these were often thin and multi-layered. At Bestansur, the built environment was particularly well-maintained and, as a consequence, many accumulated occupation deposits and sequences are <1–2cm thick, and separated by deliberately laid packing, *c.* 3–20cm thick. The net result is that a range of bulk samples used to estimate the density of micro-artefactual and bioarchaeological remains represent concentrated lenses of occupation deposits mixed with thick layers of more sterile packing.

A major aim in analysis of intact sequences of deposits in thin-section, therefore, is to provide unique high-resolution insight into the precise contextual associations of components in occupation deposits, and thereby the activities and practices represented, as well as component and deposit taphonomy and biographies to determine their temporality and the timescales and specific events represented by the micro-assemblages (Matthews *et al.* 1997a; Lucas 2017). The ubiquity and abundance as a percentage by area of deposit in thin-section are examined here for the 70 units quantified (Figs 12.3–12.7), and observations from all micro-units analysed.

Micro-artefact fragments in thin-section most commonly include fragments of chert and obsidian lithic fragments and debitage, and irregular fragments of clay shapes. No micro-artefacts have been identified in floor or wall plasters in thin-section, indicating that there is little 'background noise' from these deliberately prepared floor surfaces, in contrast to other Neolithic sites such as Çatalhöyük (Hodder and Cessford 2004).

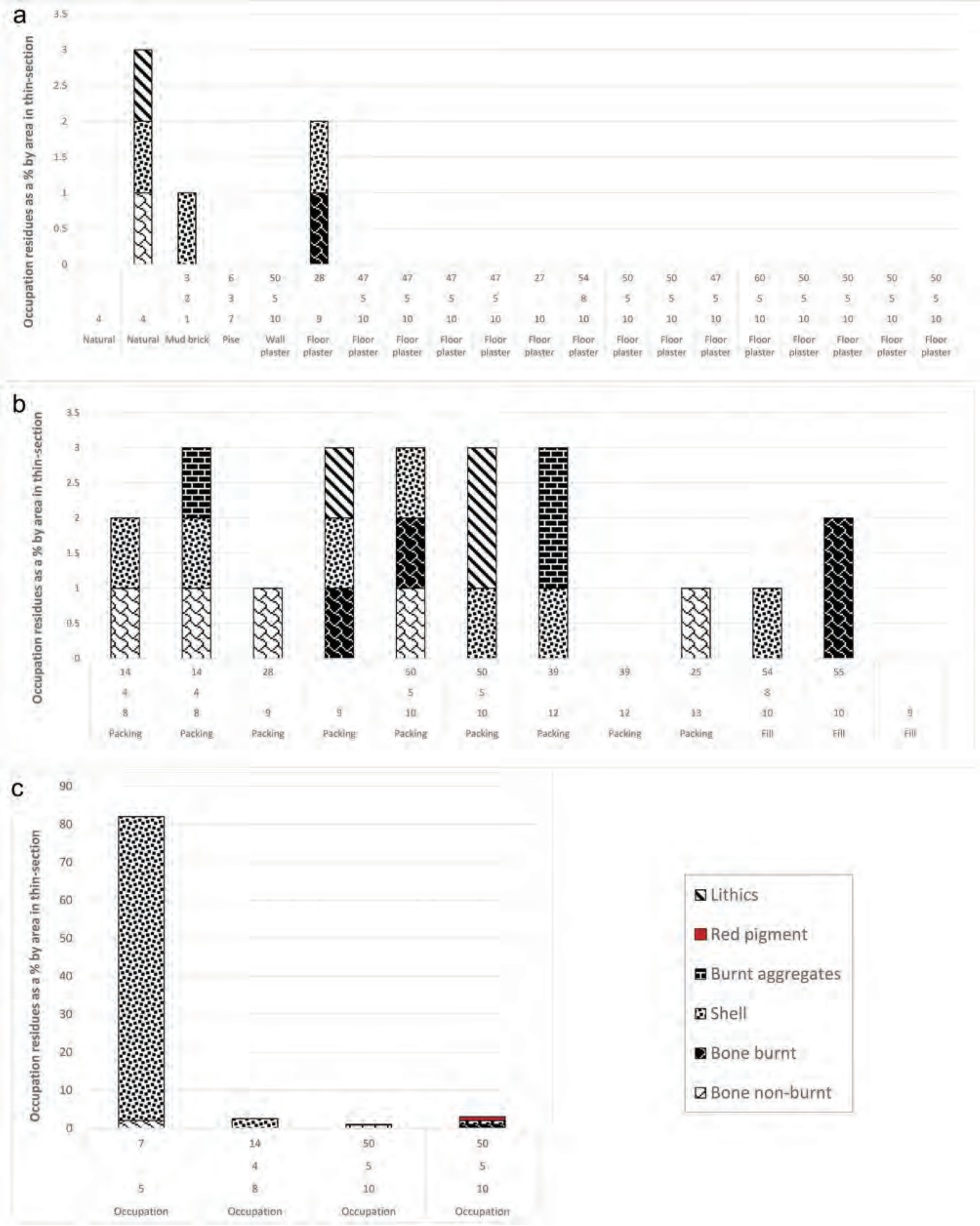


Figure 12.3. Micro-artefact and bioarchaeological remains as a percentage by area of deposit in thin-section in: a) natural and construction materials (Deposit-types 20, 1, 3, 5–7); b) packing (Deposit-type 4) and fill; and c) occupation deposits with <5% plant remains (Deposit-type 10).

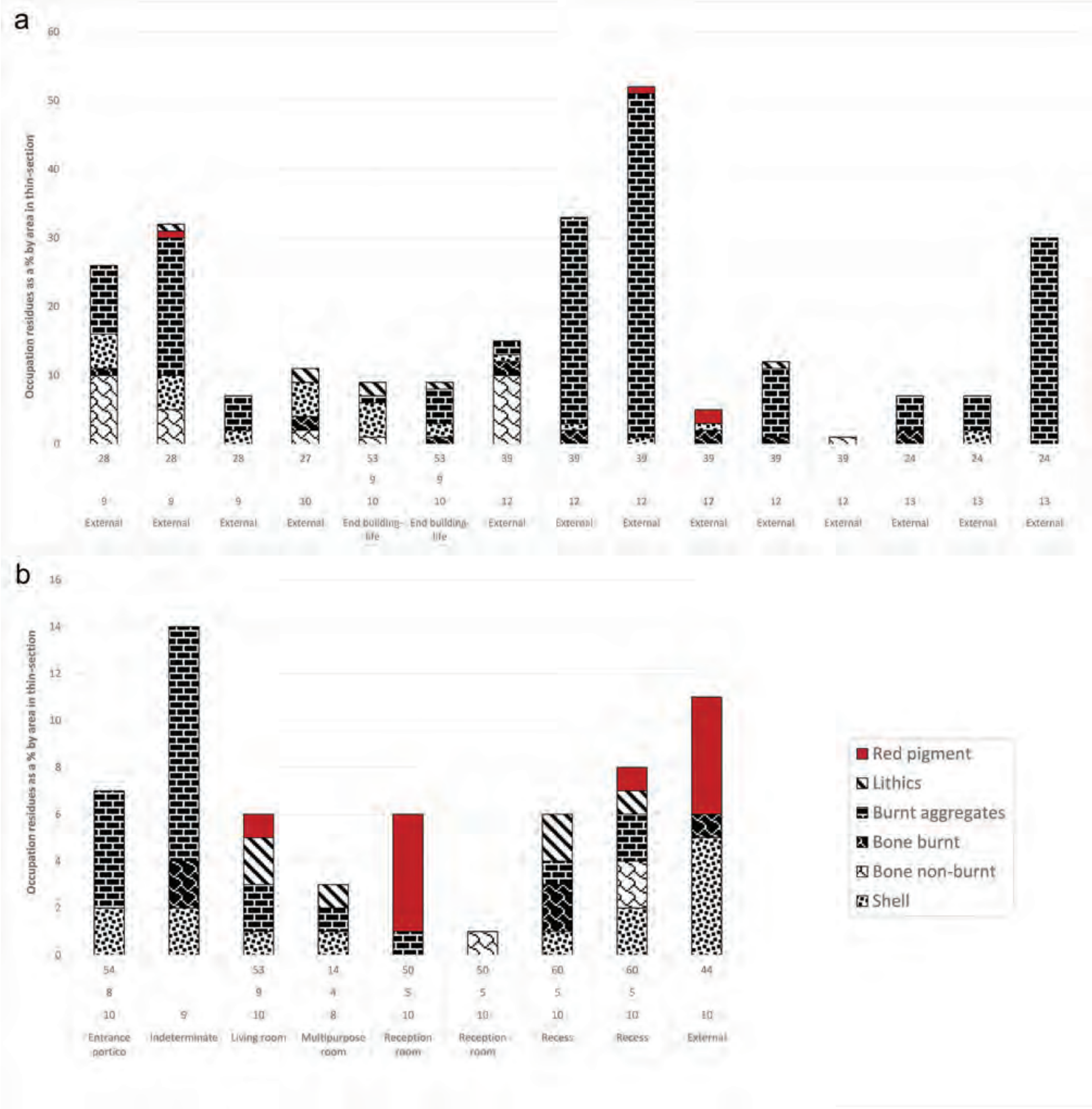


Figure 12.4. Micro-artefact and bioarchaeological remains in occupation deposits with >5<40% plant remains (Deposit-type 11) as a percentage by area in thin-section in: a) external areas; and b) interior areas within buildings and external area with oven Trench 10 Sp44 F16.

LITHICS

Lithic residues from chert and obsidian working or use occur in 20% of deposits quantified, in low abundance at 2% of deposit, and small fragment sizes ranging from 0.4–6mm in thin-section (Figs 12.3–12.5). They predominantly occur in occupation deposits, which represent 80% of deposits with lithics, both in exterior and interior areas within buildings B4, B5 and B9, predominantly in entrance, recess or multi-purpose rooms. Chert and obsidian are both most abundant in the deep sounding in T10 C1772 SA2302, C1752, and external area Sp27 SA1283.8 (Fig. 12.27). Lithics also occur in thick packing deposits and one fragment <0.8mm in natural deposits at the base of the mound.

Notably diverse rocks and minerals were identified in occupation deposits in T10 Sp63, SA2313.18 and T10 B9 Sp53 SA2314.2, 6.

GROUND STONE

Fragments of carved marble debitage/discard were identified in T10 external area Sp27 SA1283.7 with clear indications of grooved ridges (Fig. 12.32) and T12/13 C1386 SA1287.5, <5mm in size. More irregular

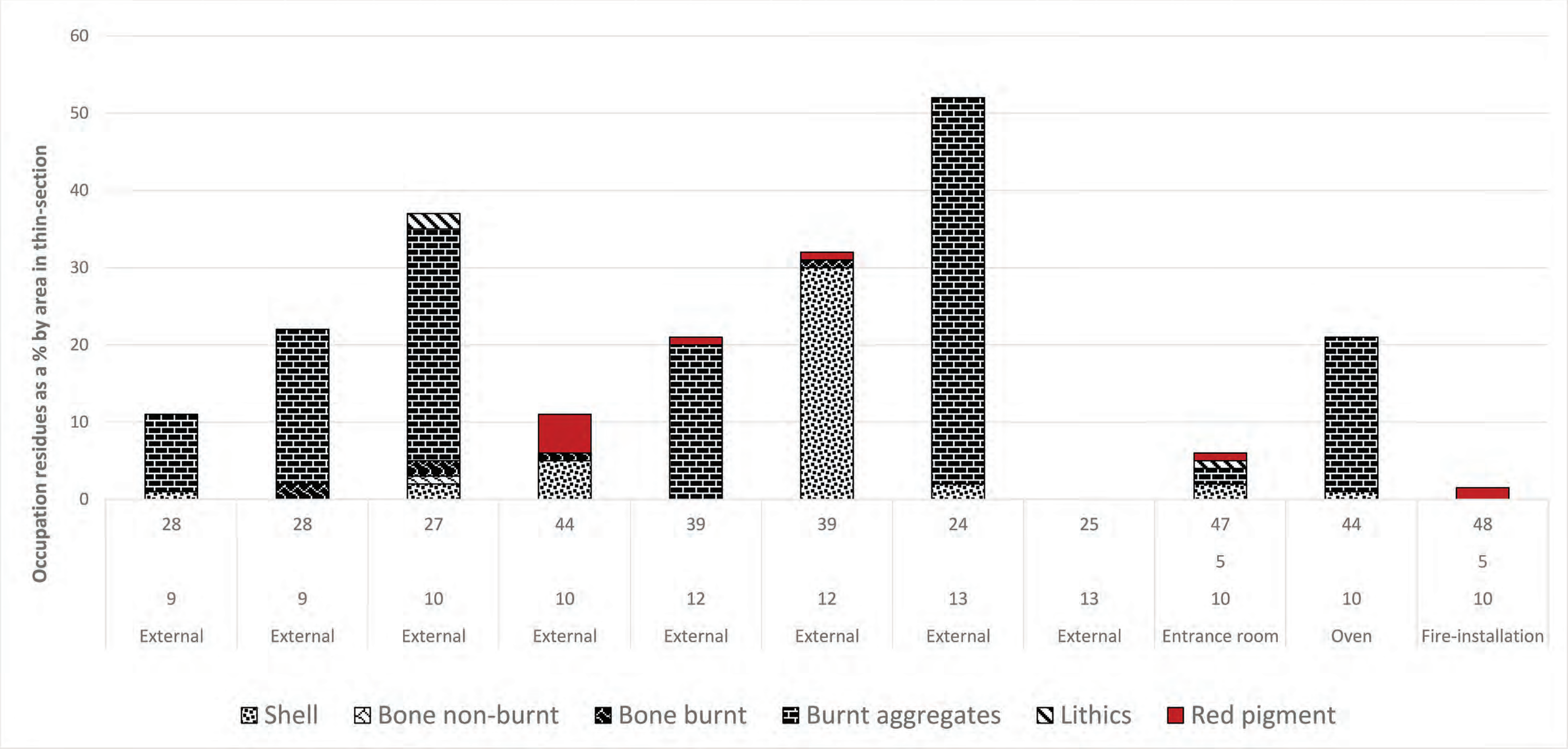


Figure 12.5. Micro-artefact and bioarchaeological remains in Deposits with >40% plant remains as a percentage by area in thin-section in: a) external areas (Deposit-type 12); and b) in situ-*fuel in fire-installations (Deposit-type 16).*

fragments/flakes of local limestone were identified across the settlement (Fig. 12.10e), associated in some instances with impressions from fine linear plant remains, which may represent grinding residues (SA2302.9) especially as limestone was used for >80% of the ground-stone tools at Bestansur (Chapter 22).

Clay shapes

A few possible clay shape fragments have been identified by the characteristic presence of a finished sharply curvilinear edge in thin-section, <1–4mm in size, including in in T10 Sp43 where they are common (Fig. 12.32 below; Chapters 9 and 21).

Burnt aggregates

Burnt aggregates occur in *c.* 40% of deposits in densities ranging from 2–50%, and from *c.* 1–10mm in size. They are common in deposits with >40% plant remains, notably those derived from fuel rake-out (Fig. 12.32 below) or *in situ* in fuel rake-out, some of which may be partially vitrified as in T10 F18 SA1778.10, attesting high temperature combustion.

Bitumen

Bitumen was used to line matting/baskets and as a fixative at Bestansur (Chapters 20 and 21) and sparse fragments have been identified in occupation deposits attesting to its use. Examples include T10 Sp27 SA2301.1 and T13 B7 Sp45 SA1503.3.

Plant remains biodiversity, taphonomy, resource management and use

A major aim in the micromorphological analyses is to examine the diversity of plant materials, parts and resources utilised by Early Neolithic communities at Bestansur. A principal concern was whether micromorphological analyses could inform on the scarcity, preservation and contamination of charred plant remains recovered by water-flotation at the site (Chapter 12), as plant resources and management are fundamental to studies of the early development of agriculture and often a mainstay in sustaining settled communities.

The following sections examine the potential factors affecting preservation and representation of plant remains, and how the development and application of integrated archaeobotanical approaches and micro-contextual analyses of plant remains can provide insights into the diversity, taphonomy and use of plant remains at Bestansur and more widely. The micromorphological data on the diversity of plant materials and parts is then examined, studying in turn the evidence for: charred plant remains; desiccated, humic and mineralised plant remains; pollen; phytoliths and melted silica; and calcitic ash. The data on plant remains are based only on analysis of areas of deposits in thin-section that have not been affected by post-depositional disturbance which has affected *c.* 20–30% of deposits.

Potential factors affecting preservation and representation of plant remains: issues and approaches

Scarcity of charred plant remains

One of the surprising results from investigations at Bestansur has been the sparsity and poor preservation of charred (carbonised) plant remains recovered by water flotation (Chapter 18). This is not an isolated phenomenon as unexpectedly low numbers of charred plants have been recorded at other sites: in Southwest Asia from the Epipalaeolithic and Neolithic (Morales *et al.* 2015; Arranz-Otaegui 2016b) to the Bronze Age at Saar, Bahrain 1800 BC, where 7000 litres of deposit were floated but only 70g of charred plant remains recovered (Nesbitt 1993), as well as in Europe and more widely (Braadbaart *et al.* 2009: 1673; Stevens *et al.* 2012; Pelling *et al.* 2015). The scarcity and poor preservation of charred plants recovered by water-flotation, therefore, is of concern not only to this project as plants are central of our understanding of the origins of agriculture, but to wider debates as plants are a major resource in many regions globally.

Analysis of charred plants recovered by water-flotation remains the principal method used in many excavations and archaeobotanical investigations. It is widely recognised, however, that carbonised plant remains often represent a small proportion of the plants utilised, in the order of 20% or less, when compared to desiccated or water-logged plant assemblages (Van der Veen 2007: 977). In addition, it is often only dense, comparatively small and lignified charred plant remains that are likely to be recovered by water-flotation (Van der Veen 2007: 978–979). Where preservation conditions are favourable, a wide range of other plant materials may be preserved including waterlogged (Jacomet 2016), desiccated (Van der Veen 2007) and phytolith remains or calcitic ashes, for example (W. Matthews 2010). A key aim in the integrated archaeobotanical analyses in this research, therefore, is to establish which factors are affecting the scarcity of charred plant remains recovered by water-flotation at Bestansur, through interdisciplinary micromorphology and phytolith analyses to assess the preservation and context of both charred plant remains and other plant materials and to compare the results with the macro-botanical and pollen analyses (Chapters 18 and 6).

Post-depositional alterations and burial environment

The action of burrowing fauna, insects and roots, and shrink-swell clay can result in mechanical disturbance and mixing of charred plants, as demonstrated in Chapter 18, and should be readily detectable in thin-section as carbonised remains are generally stable in many burial environments. Charred plant remains, however, are less inert and more susceptible to degradation, as they include a range of potentially unstable compounds, including polycyclic aromatic hydrocarbons (benzenoids) that can break down and result in charred plant remains become soft and fragmenting, particularly in alkaline conditions such as calcitic ash layers (Braadbaart and Poole 2008; Braadbaart *et al.* 2009; Weiner 2010; Ascough *et al.* 2011; Huisman *et al.* 2012: 995). Detectable effects of this in thin-section include fragmentation and, Huisman and colleagues (2012: 995) argue, dissolution features in charcoal associated with clay illuviation with limpid clear coatings, although all of these features may be produced by a range of other factors and are highly dependent on deposit types and highly localized depositional environments. Non-charred plant remains are also likely to have been affected by bioturbation and shrink-swell action, as well as a range of other post-depositional factors including pH as phytoliths dissolve in a pH >8.2 (Weiner 2010: 175) and calcitic ashes in a pH of <6.5 (Weiner *et al.* 2002; Canti 2003), dissolution, microbial action, and scavenging animals (Carbone and Keele 1985; Schiffer 1987; Weiner 2010).

Palaeoclimate and palaeoenvironment

It is increasingly apparent that "environmental variability in space and time seem to have strongly determined human choices in plant subsistence" in the Neolithic (Riehl *et al.* 2012: 512). The distribution of vegetation, and woodland and cereals in particular, in the Early Holocene varied significantly locally and between regions, influenced by soil substrates, water-availability, local climate and environment, competition with humans, animals and other plant species (Roberts 2002; Willcox 2005). A key question, therefore, is what was the local palaeoclimate, environment and vegetation and how can an integrated archaeobotanical approach contribute to our understanding of these aspects and of resource use and management?

Combustion

Combustion temperatures and conditions have a major effect on the nature and preservation of plant materials, as well as the species and parts represented as these are differentially affected by fire (Colledge and Conolly 2014). Black carbon in cereal chaff, grain and seeds and many plant species and parts, tends to oxidise and combust at temperatures above 350–500°C, which are rapidly reached in many domestic fires (Boardman and Jones 1990). The resultant plant remains principally comprise phytoliths, melted phytoliths and calcitic ashes (Boardman and Jones 1990; W. Matthews 2010; Chapter 13). Experimental burning of hearths and houses has demonstrated that up to 80% of cereal grains may not survive combustion and that there may be similar or higher losses for seeds of wild species (Colledge and Conolly 2014: 194). Carbonised remains of wood may survive well up to temperatures of *c.* 600°C but above this tend to be distorted and by 900°C fragmented and powdery and transformed to white calcitic ashes by 750–1000°C (Braadbaart and Poole 2008: table 1). Charred plant remains, therefore, only represent plant remains that have been burnt at low temperatures, and they will not survive in oxidised areas of fires that exceed 350–750°C, or 750–900°C for wood. One key objective in these micromorphological studies, therefore, is to examine the diversity of burnt plant materials in thin-section to inform on their taphonomy and identifiable residues after combustion.

Fuel and energy use

Whilst wood is a common source of fuel, especially at Neolithic sites in the temperate Anatolian uplands (Asouti and Kabukcu 2014), a wide range of other fuel sources may have been utilised and woodland conserved, as suggested at Ganj Dareh (Van Zeist *et al.* 1986; W. Matthews 2013; 2016). The widespread use of dung as fuel from the Epipalaeolithic to the Neolithic is likely to impact the composition and interpretation of charred plant assemblages (Hesse 1984; W. Matthews 2010; 2016; Elliott *et al.* 2015; Chapters 7 and 16). Firstly, dung is difficult to identify in charred plant assemblages; dung pellets often break down during water-flotation, not only making dung difficult to detect but resulting in the release of dung contents into the charred plant assemblage, compounding interpretation of whether the seeds recovered represent human or animal diet and plant utilisation strategies (Miller and Smart 1984; Miller 1996). Secondly, if animal diet and thereby faecal matter principally comprised leaves and stems, as observed in ethnoarchaeological studies in Greece (Halstead and Tierney 1998) and the Zagros (Chapter 7), there will be few of the characteristic seeds that are normally present in charred archaeobotanical assemblages and used statistically to infer the presence of dung in the archaeobotanical record, based on their likelihood to survive ruminant digestion and not have entered the archaeobotanical record through common pathways such as arable weed seeds (Charles 1998; Whitlam *et al.* 2018: 826). Third, dung, when dry, burns evenly and oxidises readily, capable of reaching temperatures >850–1000°C, due to its porous but robust interbedded matrix of partially digested plant remains, and is the preferred source of fuel for a wide range of communities and crafts people, for example (Sillar 1998: 46–47; Shahack-Gross 2011; Portillo *et al.* 2019; Chapter 16). In these circumstances, little residual carbon or carbonised plants are likely to remain and be detectable in charred archaeobotanical assemblages.

Food plant types, parts and processing

It is increasingly recognised that wild plant foods are likely to have continued to be an important component of early sedentary and agricultural communities (Arranz-Otaegui 2016a; 2018b; Whitlam *et al*. 2018; Wallace *et al.* 2019)). The potential range and variety of wild foods utilised for construction, bedding, food, fuel, fodder and medicinal values is considerable (e.g. Plants for a Future https://pfaf.org/) but as yet understudied. The plant species and parts utilised, however, will also be a factor in whether charred remains survive water-flotation and whether and how they may be detected in the archaeobotanical record. Larger, less dense and non-lignified plant parts such as leaves, stems and roots of wild plants for example are less likely to survive flotation and to be represented in the charred plant assemblages (Van der Veen 2007; Colledge and Conolly 2014; Jacomet 2016: 499–500; Whitlam *et al.* 2018: 818).

Food-processing is also likely to affect the nature and preservation of plant remains. Charred seeds and plant resources are likely to have been broken down and reworked by grinding, pounding and cooking for example, as suggested by the abundance of ground-stone at Bestansur, and are less likely to survive flotation or be readily identifiable in routine archaeobotanical analyses (Chapters 22 and 18; Whitlam *et al.* 2018: 819). New SEM EDX analyses, in particular, are revealing the exciting potential in study of foodstuff remains, identifying early bread, porridge and beer for example at a range of Epipalaeolithic and Neolithic sites in Southwest Asia (Arranz-Otaegui *et al.* 2018b); and phytolith analyses have revealed that ground-stone tools were being used to process wild cereal grains from the Upper Palaeolithic (Piperno *et al.* 2004). One aim in the archaeobotanical and micromorphological research at Bestansur, therefore, is to examine whether fragile plant parts such as stems, leaves and roots as well as foodstuffs are preserved in thin-section and to provide new insights into plant use and diet.

Discard practices and management of the built environment

Discard practices may have resulted in the removal of large quantities of refuse rich in plant remains from the site in order to maintain the habitability of spaces within the built environment, and for secondary use as fodder and/or compost and manure for example, as suggested by Nesbitt (1993) as a potential explanation for the scarcity of charred plant remains recovered by flotation from Saar, Bahrain, and are examined here as a potential factor.

Trampling and erosion

Trampling by humans and animals, and exposure to wind and water, can lead to extensive fragmentation and loss of charred plant remains which are fragile and cannot withstand much pressure or physical/mechanical disturbance (Mallol *et al.* 2007; Goldberg and Berna 2010).

Archaeobotany sampling and analytical techniques

It is widely recognised that it is often only dense small and lignified plant parts that survive flotation (Van der Veen 2007; Colledge and Conolly 2014; Jacomet 2016: 499–500), as excavation and collection of bulk samples and water-flotation results in a range of mechanical stresses that can result in fragmentation of carbonised plant remains. In addition, small fragments <250µm, the typical mesh size used in water-flotation and at Bestansur, may be lost as revealed by controlled micro-sieving at the Palaeolithic site of Mezhyrich where most charred remains recovered were <160µm (Marquer *et al*. 2012: 113, fig. 5). Fragments smaller than the flotation mesh size of 250µm and greater than 10µm, however, should remain detectable in thin-section at magnifications of ×400 using both transmitted and reflected light (Lebreton *et al.* 2019).

Development of integrated archaeobotany: micro-contextual analysis

The aim in this research, therefore, is to investigate whether the application of a wider range of integrated archaeobotanical analyses will reveal a greater diversity of plant materials, parts and types, and in turn provide a new perspective on early sedentary and agricultural plant management and use. The focus in this study is on evidence for use of plant resources in animal diet and management, as in Chapter 16, in plant cultivation, human diet, and energy supplies, which are often a major challenge to settlement in one place (Asouti and Austin 2005; Henry *et al*. 2018), as well as the use of plants in the built environment for construction, matting, and basketry which is particularly important in the Early Neolithic prior to more extensive use of pottery. Each of the potential factors affecting the scarcity of charred plant remains recovered by water-flotation outlined above is reviewed and examined in the discussion at the end of this section and chapter, and in Chapter 24, given the importance of plants in resource management, agriculture and sedentism, and human nutrition and health.

The specific objectives in the micromorphological analyses in this study are to investigate plant resources, management and use by analysis and quantification of first, the much wider range of plant materials that are potentially preserved in thin-section than are recoverable by water-flotation. These include not only charred plant remains, which only represent plants burnt at low temperatures <350–500°C (Boardman and Jones 1990; Huisman *et al.* 2012), but also plants that have not been burnt, represented as: impressions in deposits; humic, mineralised and desiccated remains, pollen, phytoliths, and calcium oxalates; as well as plants burnt at higher temperatures > *c.* 350–500°C which comprise phytoliths (< *c.* 750°C), calcitic ashes (> *c.* 500°C) and melted phytoliths (> *c.* 750°C; Boardman and Jones 1990; W. Matthews 2010; Huisman *et al.* 2012).

A second objective is to examine the range of plant parts that are represented in thin-section and whether fragile leaves and stems, for example, that may not survive water flotation are preserved (Van der Veen 2007). Third, by *in situ* analysis of the depositional context of plants, this research investigates whether plant remains have been affected by taphonomic processes including: food-processing, trampling, bioturbation, impact of shrink-swell action and cracks, and erosion and loss by wind or water (Mallol *et al.* 2007), as carbon even when fragmented and bioturbated is likely to remain in thin-section. This research also considers whether there is any evidence for dissolution of polycyclical aromatic hydrocarbons in charred plants in highly alkaline conditions such as calcitic plant ashes, by looking for micromorphological indicators observed by Huisman (2012), such as dissolution features in charred plant remains and limpid clay coatings although these may result from a range of processes. Lastly, micromorphology will enable study of the micro-contextual associations of plant remains in intact sequences and provide additional information on the significance, use and discard of plant remains and environmental conditions and management of the built environment, which will in turn inform on archaeobotanical assemblage formation (Colledge and Conolly 2014).

Plant remains diversity at Bestansur

It was immediately apparent in thin-section observations from the first seasons of excavation that plant remains are much more abundant at Bestansur than recovery of charred plant remains by water-flotation suggests (Chapter 18; W. Matthews 2012: 72, fig. 3.7; 2013: 62–65). Plants at Bestansur are preserved as a wide range of plant materials and traces as at many sites in different geobotanical zones in Southwest Asia and globally (W. Matthews 2010). At Bestansur in addition to charred remains, these include plant impressions, desiccated, humic and mineralised remains, charred remains and phytoliths, melted silica, and calcitic ashes. Each of these types is discussed in turn below, considering for each plant material: ubiquity, abundance as a percentage by area in thin-section, preservation and fragmentation, plant type/genera, plant part and specific contextual associations and activity markers of note. The implications of these diverse plant remains and materials are then considered for taphonomy and plant use.

ABUNDANCE OF PLANT REMAINS IN DEPOSITS AT BESTANSUR

In thin-section at Bestansur, charred plant remains represent on average only 22% of the total plant remains preserved in the deposits analysed (Fig. 12.6).

The highest proportion of plant remains in thin-section at Bestansur are preserved as calcitic ashes, at 40%. At least 8% of these ashes are derived from dung, identified by the presence of intact identifiable spherulites. Phytoliths constitute at least 18% of plants remains and melted silica *c.* 1%. Non-burnt plant remains include plant impressions, comprising 4% of deposits, and humic plant remains, also 4%. Desiccated plant remains were identified in at least three contexts representing *c.* 1% of deposits.

Yellowish organic matter from omnivore coprolites comprises up to 10% of the plant/organic matter in thin-section, and is included in these calculations and discussions as it often contains plant materials, many of which are desiccated/mineralized, and represents digested foodstuffs which are of increasing archaeobotanical importance and visibility (Arranz Otaegui *et al*. 2018b).

The total abundance of all plant/organic remains in deposits in thin-section varies significantly by context and deposit-type from <2–90%, as a percentage by area of deposit in thin-section (Figs 12.7–12.9). Thirty-seven percent of the deposits analysed have <5% plant remains (Fig. 12.7c). Plant remains are least common in natural deposits, occurring principally as <2% micro-charcoal, <50μm. Other deposits with consistently <5% plant remains include mudbricks and floor plasters, and occupation deposits in the shell midden and interior spaces in B5 Sp50 and B4 Sp14.

Deposits with 5–40% total plant remains represent

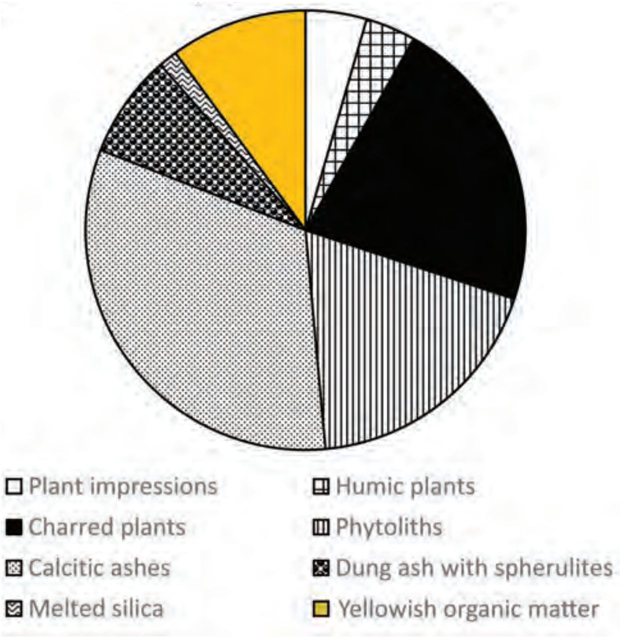


Figure 12.6. Plant remains as a percentage by area in thin-section at Bestansur (n=70 microstratigraphic units).

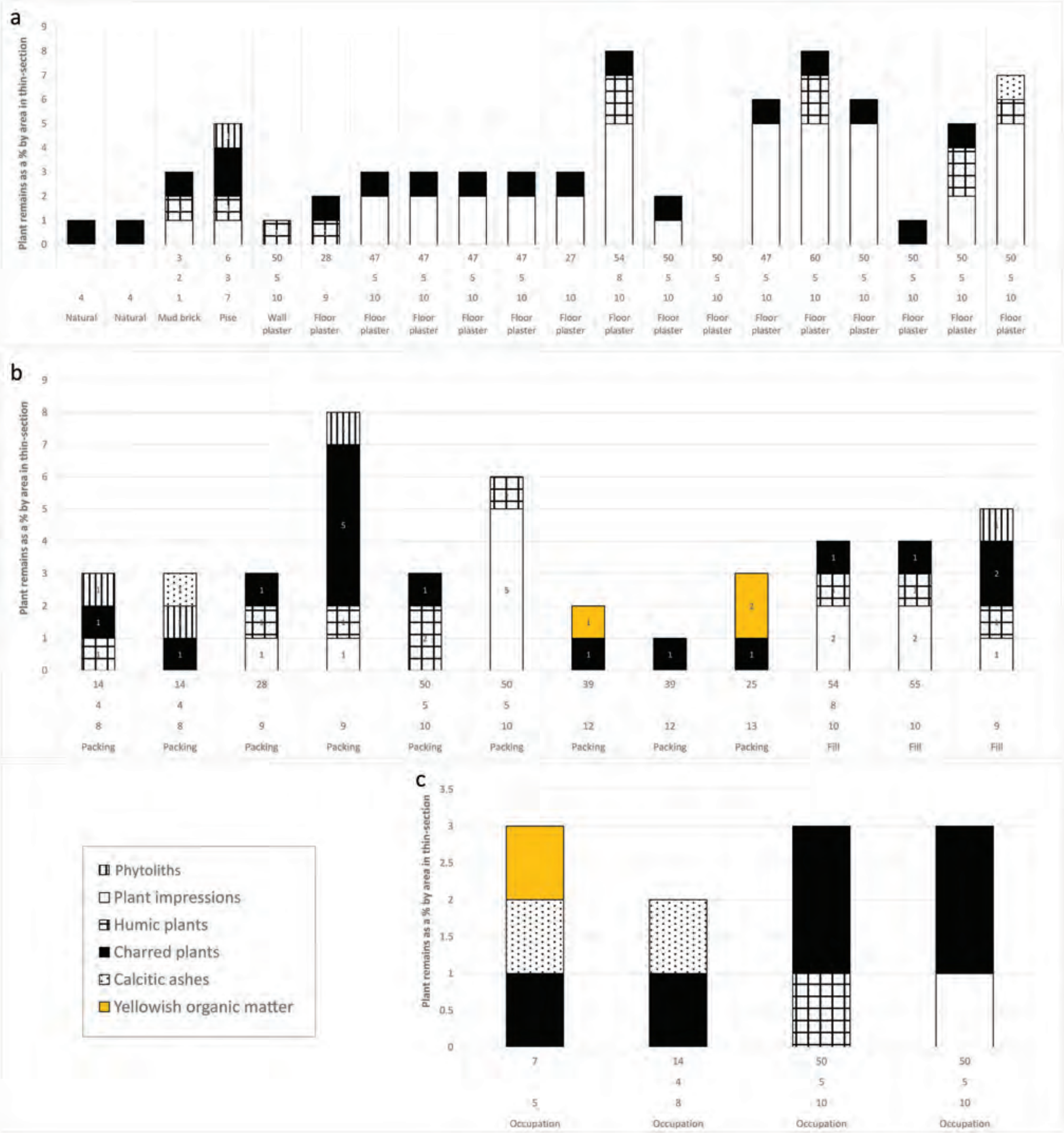


Figure 12.7. Plant remains as a percentage by area of deposit in thin-section in: a) natural and construction materials (Deposit-types 20, 1, 3, 5–7); b) packing (Deposit-type 4) and fill; and c) occupation deposits with <5% plant remains (Deposit-type 10).

44% of the deposits analysed and also include some construction materials: floor plasters, packing and fill (Fig. 12.8). A diverse range of occupation deposits comprise 5–40% plant remains. Many are in external areas, while some are within buildings notably in entrances, recesses, a multi-purpose room, and the latest occupation in B5 Sp50 where there is a thin lens of ash, <1.5mm thick.

Deposits with >40% plant remains predominantly occur in external areas, where plant remains comprise 40–80% occupation deposits, or as *in situ* fuel within fire installations, which comprise 60–90% plant remains (Fig. 12.9). The only interior occupation deposits with >40% plant remains include the entrance to B5 Sp47, where there was a thin-lens of predominantly dung ash, presumably from fire installation rake-out, comprising 55% plant remains and ash.

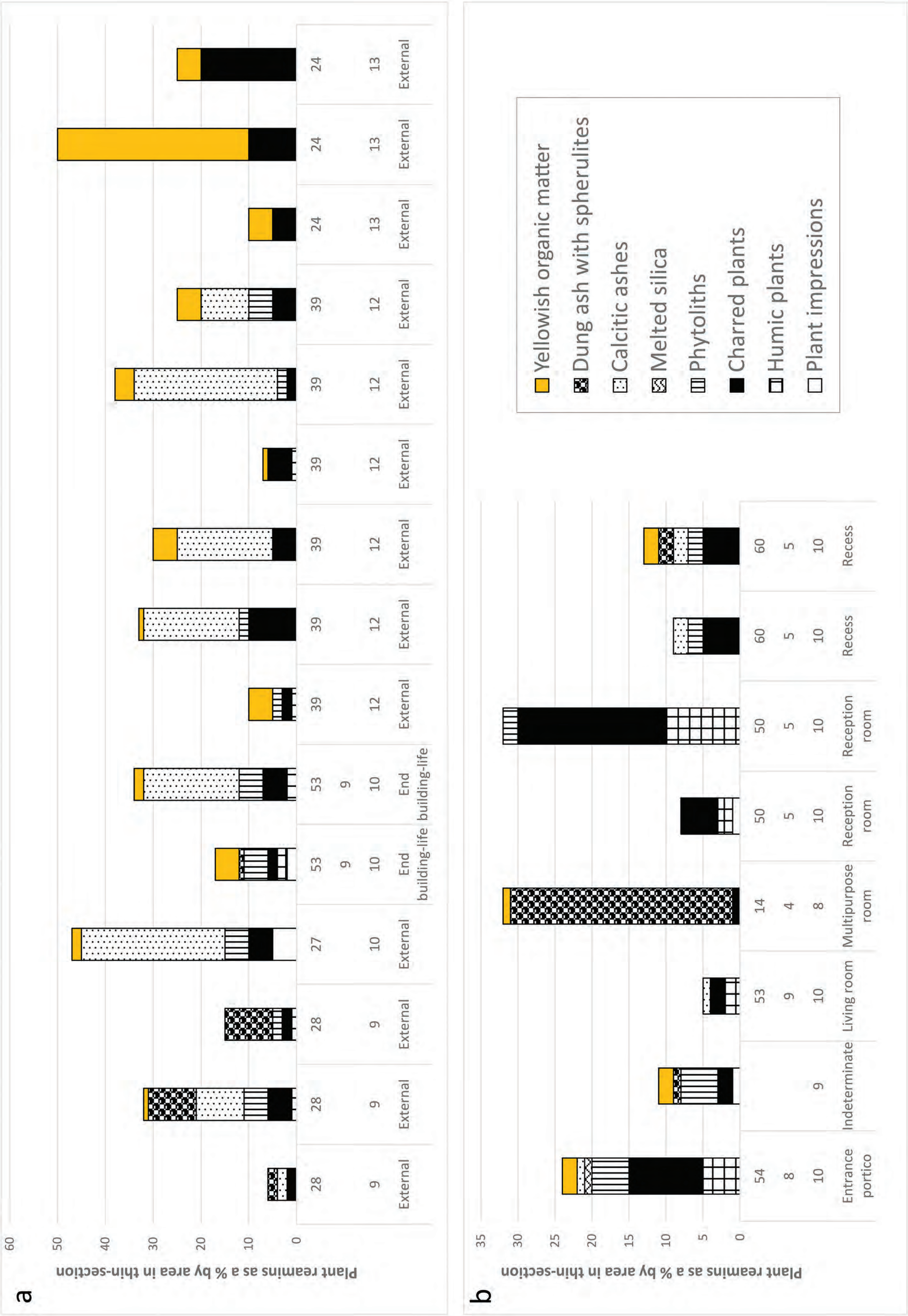


Figure 12.8. Occupation deposits with 5-40% plant remains (Deposit-type 11) as a percentage by area in thin-section in: a) external areas; and b) interior areas within buildings.

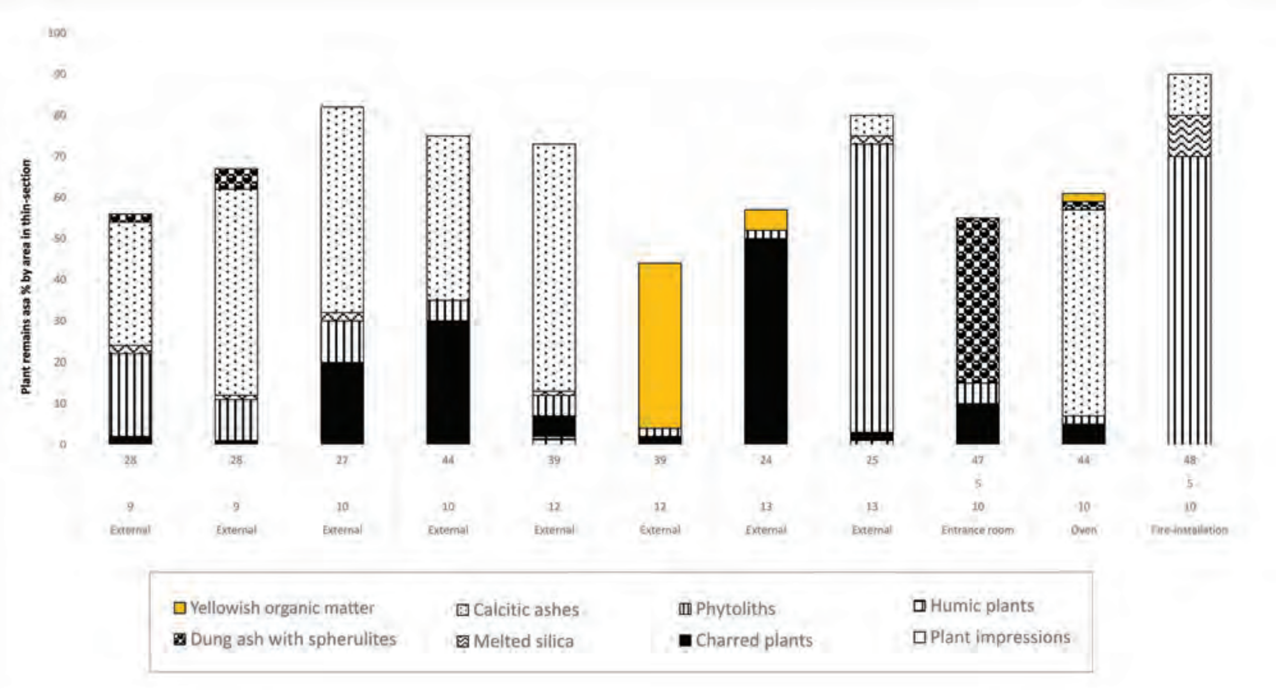


Figure 12.9. Deposits with >40% plant remains as a percentage by area in thin-section in: external areas (Deposit-type 12) and in situ *fuel in fire installations (Deposit-type 16).*

CHARRED PLANT REMAINS

The abundance of charred plant remains recovered by water-flotation at Bestansur was very low. Based on scanning of 511 samples: 20.5% had none, 64.2% 1–10 items, and only 5.0% more than 25–>100 items (Chapter 18, Fig. 18.1). The abundance of charred plant remains in thin-section is similarly often low (Figs 12.7–12.9): 7% of deposits had none, 62% had <5%, 30% had 5–40%, and only 1% had 50% as a percentage by area in thin-section (sample n=70). Of those with >5% charred plant remains, many were from external occupation deposits. It is possible that some charred plants were lost through bulk sampling and water-action if they were smaller than the 250µm mesh-size, as observed by Marquer and colleagues (2012) at Mezhyrich, Ukraine. This is likely as in thin-section it is evident that 10% of deposits have charred plant fragments which are only 200µm or less, and some of the fragments from *in situ* fragmentation were <20–50µm (Figs 12.1a and 12.11a). Charred plant remains in other deposits in thin-section were not large: in >85% of deposits charred plants are <5mm in size. The largest in thin-section are 5–9mm in external deposits in trenches T9, T10 and T12, often of woody materials.

As outlined above in discussion of post-depositional alterations more widely, bioturbated burrows and infilled cracks are clearly identifiable in thin-section by the burrow/crack boundary, unoriented randomly distributed fill and/or clay or carbonate secondary coatings, and resultant void spaces, with traces of modern plant root and soil micro-faunal pellets (Figs 12.1a and 12.10a). Charred plant remains within these bioturbated areas and cracks are fragmented as a result of turbation. These bioturbated areas and infilled cracks generally represent 20–30% of deposits at Bestansur as a percentage by area. Materials within these post-depositional features have been excluded from the analyses and quantification of plant and other remains in thin-section.

The remaining 70–80% of deposits have not been bioturbated and include remarkably well-preserved microstratigraphic sequences and boundaries (Fig. 12.10a), and intact fragile plant remains in a wide range of materials (Fig. 12.10c–d).

In thin-section it was clear that the action of shrink-swell clays and/or freeze-thaw has led to partial detachment of sections of *in situ* charred plant remains such as parts of outer seed coats (Fig. 12.10 [4–5]).

The pH of many construction materials and occupation deposits is generally slightly alkaline at 7.37–8.58 (Chapter 13), but likely to have been higher in calcitic ash rich fuel. This could have resulted in some degradation of polycyclic aromatic hydrocarbons and softening of charred remains in these contexts making them susceptible to fragmentation, as observed in *in situ* fuel (Fig. 12.11a; Braadbaart and Poole 2008; Braadbaart *et al.* 2009). No clear dissolution features in charred remains nor limpid translocated clays, however, were identified (Huisman *et al.* 2012: 995).

No middens have been identified to date at Bestansur, which is disappointing as middens are rich in diverse refuse and charred plant remains that are often well-preserved and not subject to compression and fragmentation by excessive trampling and

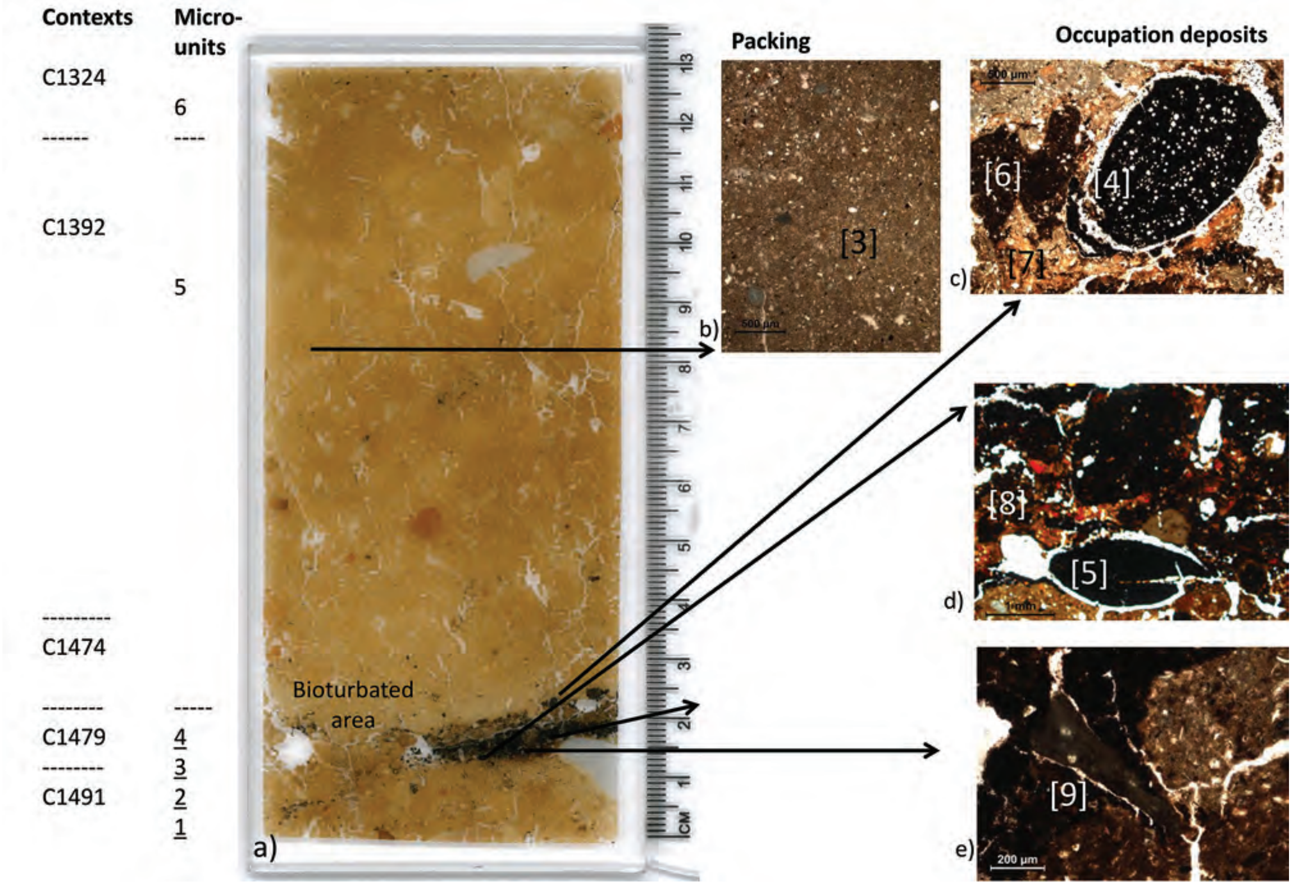


Figure 12.10 Plant remains taphonomy in T13 external area Sp24 SA1298: a) glass thin-section (SA1289) and example (lower left) of well-defined bioturbation channel with unoriented comminuted deposits, and (lower right) in situ *well-preserved burnt surface and overlying occupation deposits (see also Fig. 12.1b); b) packing C1392 with sparse charred flecks <2%, <0.2mm; c–d) charred seeds [4–5]; e) burnt aggregates [6]; yellowish organic matter [7–8], and carbonate rock flake (c. 0.7mm) possibly from ground-stone [9] in charred surface and occupation deposits (all photomicrographs PPL).*

loading. At sites such as Çatalhöyük middens contain abundant well-preserved charred plant remains, in contrast to floor sequences that contain "small, poorly preserved, highly comminuted plant-remain assemblages" with densities of only 0.002–0.100g/l (Hastorf 2005: 150–152, table 8.8), and that are more prevalent at Bestansur.

At Bestansur, charred plant remains genera and species in macrobotanical assemblages from flotation include sparse wood fragments, cereal grains, glume bases, grass seed and lentils (Chapter 18). With regard to the charred plant genera, types and parts represented in thin-section, few wood fragments or woody materials have been identified and all are small < 9mm in size, and dicotyledonous in origin. Examples of woody materials include Figure 12.11b, T10 Sp53 SA2297.2–3, associated with dicot phytoliths and T12/13 C1377 SA1288.6. The wood anatomy is not well-preserved, with few distinct characters, partly due to shrink-swell, freeze-thaw action and to thin-section manufacturing processes particularly in the more silty clay sediment rich deposits as the woody materials are soft.

Charred wild nut shells/fruits stones were also identified (Fig. 12.11c) and are present in all levels and sectors of the site. Charred seeds were identified in a range of deposits in thin-section but still only represent <2% deposits and are often <2.5mm in size (Fig. 12.10c–d and 12.11d). No clearly identifiable cereal-like fragments were observed. The majority of the charred seeds appear to be legumes as in external area Sp24 T13 (Fig. 12.10d–e). Parenchyma from a possible tuber fragment was identified (Fig. 12.11g) and may derive from *Bolboschoenus glaucus* which was identified in macrobotanical remains (Chapter 18). This club rush grows in wetlands, along rivers and in disturbed ground and produces edible tubers, nutlets and leaf, which Wollstonecroft and colleagues (2011: 68) argue could have provided a "dependable and possibly a staple food".

The most abundant charred plant parts represented in thin-section are charred leaf and stem epidermal fragments. The carbonised epidermal layer is often *c.* 20μm thick (SA1794.8), but up to 1.5–9mm in length in T12 C1519 SA1499.6. Many of these leaf and stem fragments are extremely fragile due to their thinness

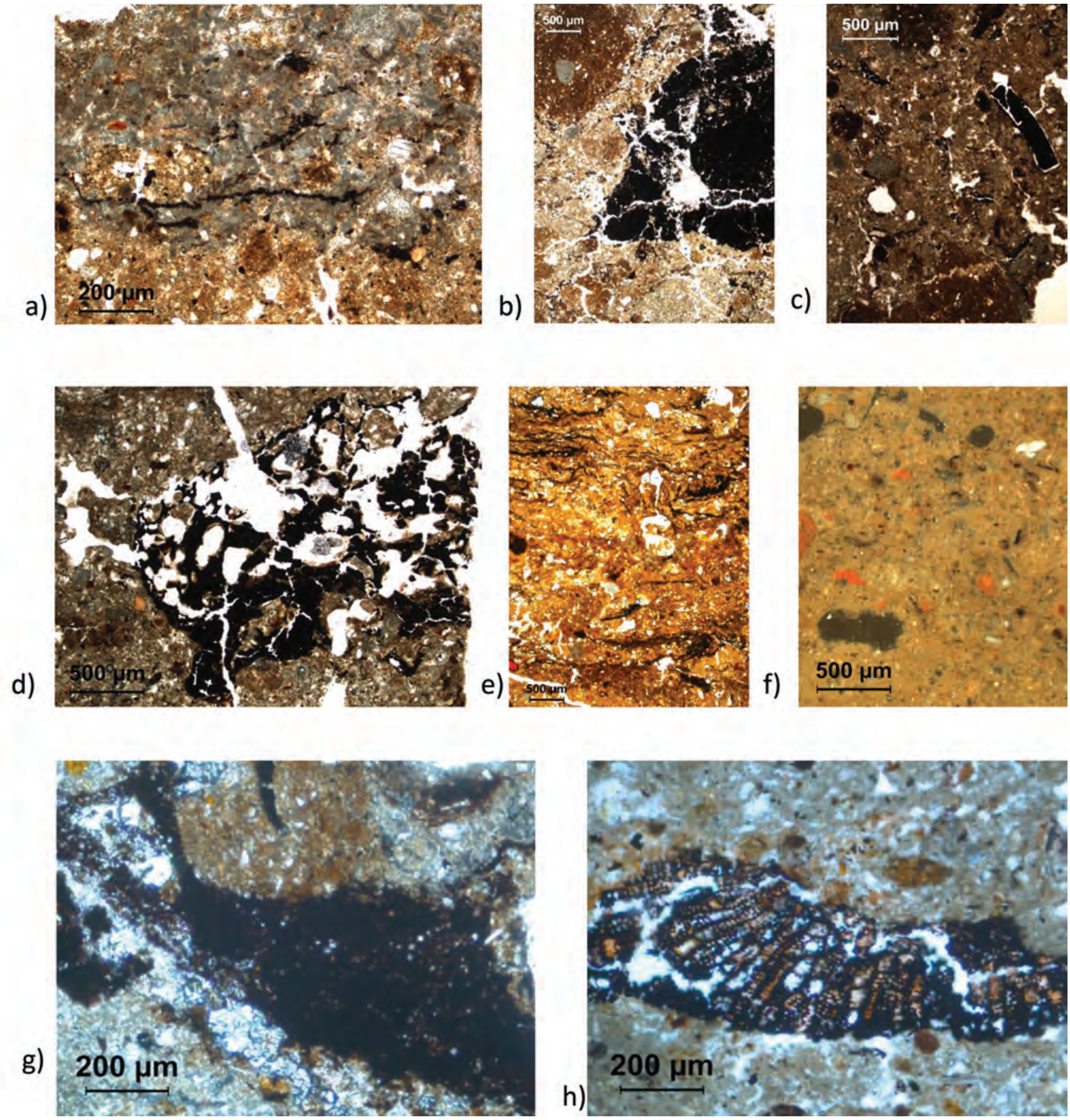


Figure 12.11. Charred plant remains types and in situ *fragmentation: a) charred epidermal fragments in calcitic ashes in* in situ *fuel in oven (T10 Sp44 F16 C1767 SA2298.3 PPL); b) charred wood c. 1cm in length in external occupation deposits (T13 Sp25 C1582 SA1501.4 PPL); c) charred nut shell/fruit stone in external occupation deposits (T10 Sp27 C1772 SA2303.1 PPL); d) charred cf. seed in external area occupation deposits (Sp44 T10 C1755 SA2312.4 PPL); e) fragile charred epidermal fragments in accumulated deposits (Sp27 T10 C1423 SA1283.6 PPL); f) comminuted charred plant remains in interior occupation deposits associated with red pigment flecks (B9 Sp53 C1763 SA2314.8 OIL); g) charred parenchyma (T13 Sp25 SA1501.4 XPL); h) charred plant (T10 B9 Sp53 C1758 SA2292.2 PPL).*

and evidence of micro-fractures and are unlikely to be recovered by flotation due to the impact of bulk sampling and water-flow. They often occur in external areas such as Sp24 T13 (C1521 SA1502.2) and Sp27 T10 (Fig. 12.11e). As some of these charred epidermal fragments do not appear to be adhering to silicified epidermises that commonly co-occur in examples of charred monocotyledonous stem and leaf fragments, it is possible that some of them are dicotyledonous plants which do not produce abundant phytoliths (Tsartsidou *et al*. 2007). Archaeobotanical blocks have been collected from across the site for ESEM investigation of plants *in situ* which is currently in progress.

A particularly diverse range of charred plants are noted in the end of building-life fill/open area in T10 B9 Sp53 C1756–8 SA2297.2–3; and in exterior open areas such as T10 Sp27 C1772 SA2302 and Sp44 C1755 SA2312.5; and T12 C1386 SA1287.5 and C1384 SA1287.8. This correlates with results from analyses of charred plant remains from flotation, which indicate that external areas were used for discard of plant processing residues (Chapter 18) as well as burnt fuel. Examples of trampled charred flecks in thin-sections of occupation deposits include accumulated occupation deposits <1cm thick associated with red pigment flecks in B9 Sp53 (Fig. 12.11f).

Plant impressions

Impressions of plant remains occur in 37% of all deposits analysed at 5% or less and may be up to 3.5mm in length in thin-section. Of these occurrences, 80% are in construction materials (Figs 12.7–12.9 and 12.12a), with 20% in exterior and interior occupation deposits. The association of fine impressions of plant remains with carbonate rock fragments <0.7mm may speculatively represent residues from grinding plant remains, as in external occupation deposits in Sp27 T10 (C1777 SA2302.4–5; see Fig. 12.27).

Desiccated, humic and mineralised plant remains

The presence of exceptionally well-preserved fragile desiccated/mineralised plant remains *in situ* in a range of deposits, whilst rare, attests to some remarkable preservation conditions at Bestansur, notably in the rare midden-like deposits in T13 Sp25 in phytolith rich-deposits and in omnivore coprolites (Figs 12.12b, 12.16a) and in *in situ* fuel in T10 Sp48 SA1778.5.

Other exceptionally well-preserved plant remains in thin-section include humic dark brown stained fragments of plant remains which were often visible and intact in the field. Their presence is surprising due to the generally semi-arid climate of the region and oxidising soil conditions (Chapter 3). Humic plant remains tend to occur in deposits with anaerobic conditions that inhibit microbial activity (Carbone and Keel 1985). At Bestansur these conditions tend to be locally present in fine-grained clay to silty clay deposits or in contexts rapidly buried by such deposits. The presence of the adjacent large spring at Bestansur is also likely to have contributed to the overall moisture content, water-table, and reduced oxygen content in the sediments and the exceptional preservation of humic remains.

Whilst humic plant remains only represent *c.* 4% of the recorded plant remains in thin-section by area, they are surprisingly ubiquitous, occurring in 41% of deposits, generally at <2–5% (Figs 12.7–12.9 and 12c). The most abundant humic plant remains, at 5–10%, are on the latest occupation deposits on the floor of Sp50 in B5. These deposits, <1.5mm thick, were rapidly sealed and preserved by extensive large-scale wall-collapse (Fig. 12.29). Exceptional remains of pigmented matting were also preserved on this floor (Deposit-type 9 below; Chapter 9).

Of the deposits with humic remains, 58% comprise construction materials, where plant remains would also have been rapidly incorporated and sealed in fine silty clay–silty clay loam deposits as temper, occurring in mudbricks, floor and wall plasters and packing for example (Fig. 12.12c) as well as probable roofing (Deposit-type 26). However, 46% occur in occupation deposits in both external and interior areas, in addition to a localised example of humified matting in B8 Sp54 (Fig. 12.22i–j). The preservation of humic remains in these contexts is likely to be due to rapid burial below subsequent layers of thick packing, which was commonly laid as a surface in exterior and foundation for plasters in interior areas.

Humic plant remains were also identified and

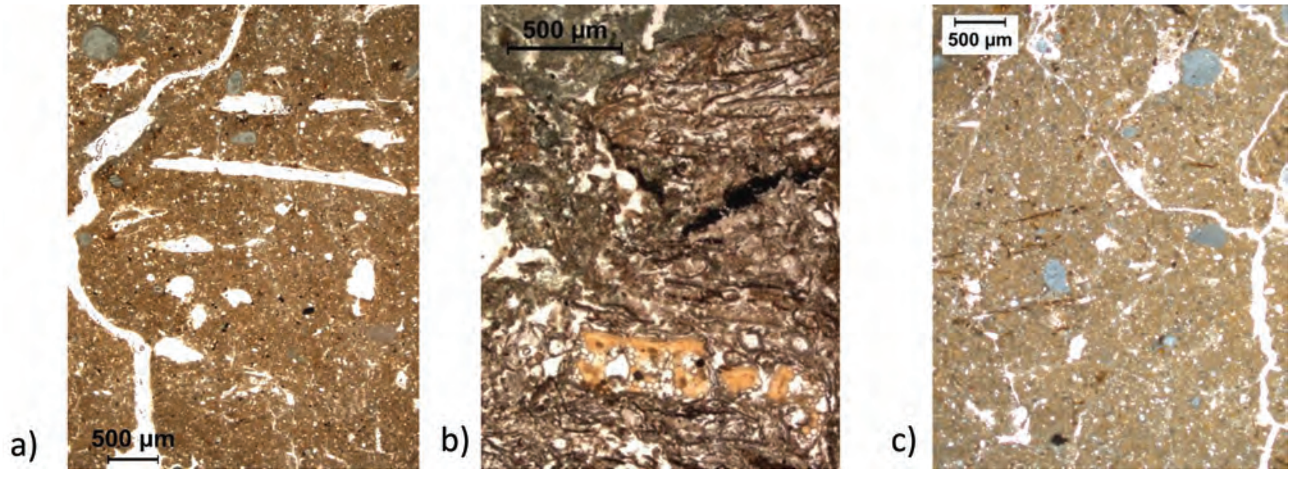


Figure 12.12. Well-preserved non-charred plant remains: a) plant impressions in plaster-floor in entrance room Sp47 B5 (C1620 SA1794.8. PPL); b) yellowish desiccated leaf/stem in external midden-like deposit Sp25 T13 (C1494=C1581 SA1286.2. PPL); c) humic plant remains in earthen wall W6 B3 T7 (C1202 SA448.1. PPL).

sampled in the grey silty clay deposits at the interface between natural deposits and occupation at Shimshara (Fig. 10.7; W. Matthews 2013: fig. 4.4).

No calcitic mineralised plant remains were represented in thin-section. This contrasts with Sheikh-e Abad in the high Zagros where traces of mineralised nut shell/fruit stone were identified (W. Matthews *et al*. 2013h: 73, fig. 7.3) and to Çatalhöyük, where calcitic pericarps of hackberry (*Celtis*) occur frequently, notably in omnivore and human coprolites (W. Matthews 2005: 381–382, table 19.2). Interestingly *Celtis* wood is present in on-site assemblages in highland Zagros sites including Ganj Dareh and Abdul Hosein, but is not represented in pollen records from Lake Zeribar at lower altitude (Hubbard 1990; van Zeist 2008).

Pollen

Pollen has been recovered in extracts from deposits from coring through the settlement and environs of Bestansur. Pollen occurs in low numbers and is poorly preserved as at other sites in this semi-arid region, such as Shanidar and Zawi Chemi Shanidar (Chapters 3 and 6; Leroi-Gourhan 1969). Pollen has not been detected to date in thin-section due perhaps to masking and to the general oxidising conditions.

Phytoliths

Phytoliths were present in a wide range of samples in thin-section and in abundances of up to 70% of deposit by area. Phytoliths are likely to be under-represented in this quantitative study as the focus was on articulated phytolith remains and a range of phytoliths may have been masked by silty clay sediments, calcitic ashes, and occluded carbon in charred plant remains and blackened surface deposits. Seventy-nine percent of the deposits analysed with phytoliths had <5% phytoliths, 19% 5–40%, and 3%–>40% phytoliths in external and *in situ* fuel deposits.

A range of phytoliths in thin-section was often well-preserved comprising multi-cell phytoliths up to *c.* 2cm in length in thin-section, and preserved areas of matting notably on several thin plaster floors in T10 B5 Sp50 and the entrance portico to B8 Sp54 (Deposit-type 9 below). Some of the best preserved phytoliths in thin-section at Bestansur are in short-lived midden-like deposits in Sp25 T13 (Fig. 12.12b, D13a; C1494=C1581 and C1485 SA1286) and in *in situ* fuel in the large fire-installation F18 in B5 Sp48 (Fig. 12.13b; C1674.1610 and C1673/1610 SA1778). Exceptionally well-preserved phytoliths and partially humic/desiccated and charred plant anatomy were also identified at Shimshara in a *c.* 1.5cm thick layer of partially burnt plant remains, some of which autofluoresce (Fig. 12.13c–e).

The number of phytoliths per gram of deposit is particularly high in the comparative analysis of phytoliths in the 22 selected spot samples for this study (Chapter 13). All samples have >0.5M phytoliths per gram which is a common density benchmark above which phytoliths are considered abundant, except two at 0.3–0.48M, and preservation was good. Sixty-three percent of samples have >1–3.5M/g, and 22% have >5.5–27M/g, attesting exceptionally high densities. This abundance and preservation is much greater than that from later sites in the Shahrizor Plain, which have <0.1M/g (Marsh *et al.* 2018, 961).

Many of these phytoliths were from reeds and grass leaves and stems, which comprised 42–88% of assemblages, with an average of *c.* 63% (Chapter 13). Monocotyledonous phytoliths from wetlands as well as dryland steppe/parkland reeds, sedges and Poaceae stems and leaves are the most abundant, often as articulated multi-cell phytoliths. Bulliform cells from reeds are particularly robust and ubiquitous. Some cereal or cereal-like phytoliths were identified, notably in phytolith spot sample analyses from deposits with herbivore and omnivore faecal matter (Chapter 16). Dendritic phytoliths from cereal-like husks were identified in thin-section T12 C1384 SA1288.2 in dung with spherulites.

Dicotyledonous leaves and bark, which are rarely recovered by water-flotation, represent *c.* 3–10% and 2–9% of phytolith assemblages respectively, and add to the evidence from charred plant remains for the presence of trees and woody plants, particularly as dicots produce far fewer phytoliths than monocots (Tsartsidou *et al*. 2007). Examples of dicot. phytoliths in thin-section include T10 Sp53 SA2297.3.

Of particular note, phytoliths commonly occur in both herbivore as well as omnivore coprolites and are providing new insights into Early Neolithic animal and human diet as discussed below and in Chapters 13 and 16.

Melted silica and phytolith rich 'ash'

Melted silica occurs in >10% of deposits, mostly in *in situ* fuel and in rake-out in external occupation deposits, and attests combustion temperatures > *c.* 750–850°C (Fig. 12.14a; Canti 1999: 2003; Portillo *et al*. 2019).

Calcitic ash

Calcitic ashes form as carbon is burnt off in temperatures *c.* >500–600°C (Fig. 12.14b; Boardman and Jones 1990; Wattez 1990). As a consequence, the presence of calcitic ashes is generally inversely proportional to that of charred plant remains. The abundance of calcitic ashes varies from 0–60% of deposits: 79% of deposits with calcitic ash have <5%, 14% have 5–40%, and 7%–>40%, the latter of which are all in occupation deposits in external areas and *in situ* fuel. Well-preserved partially articulated calcitic ashes that form a pseudomorph of the original plant structures have been identified in *in situ* ash (T10

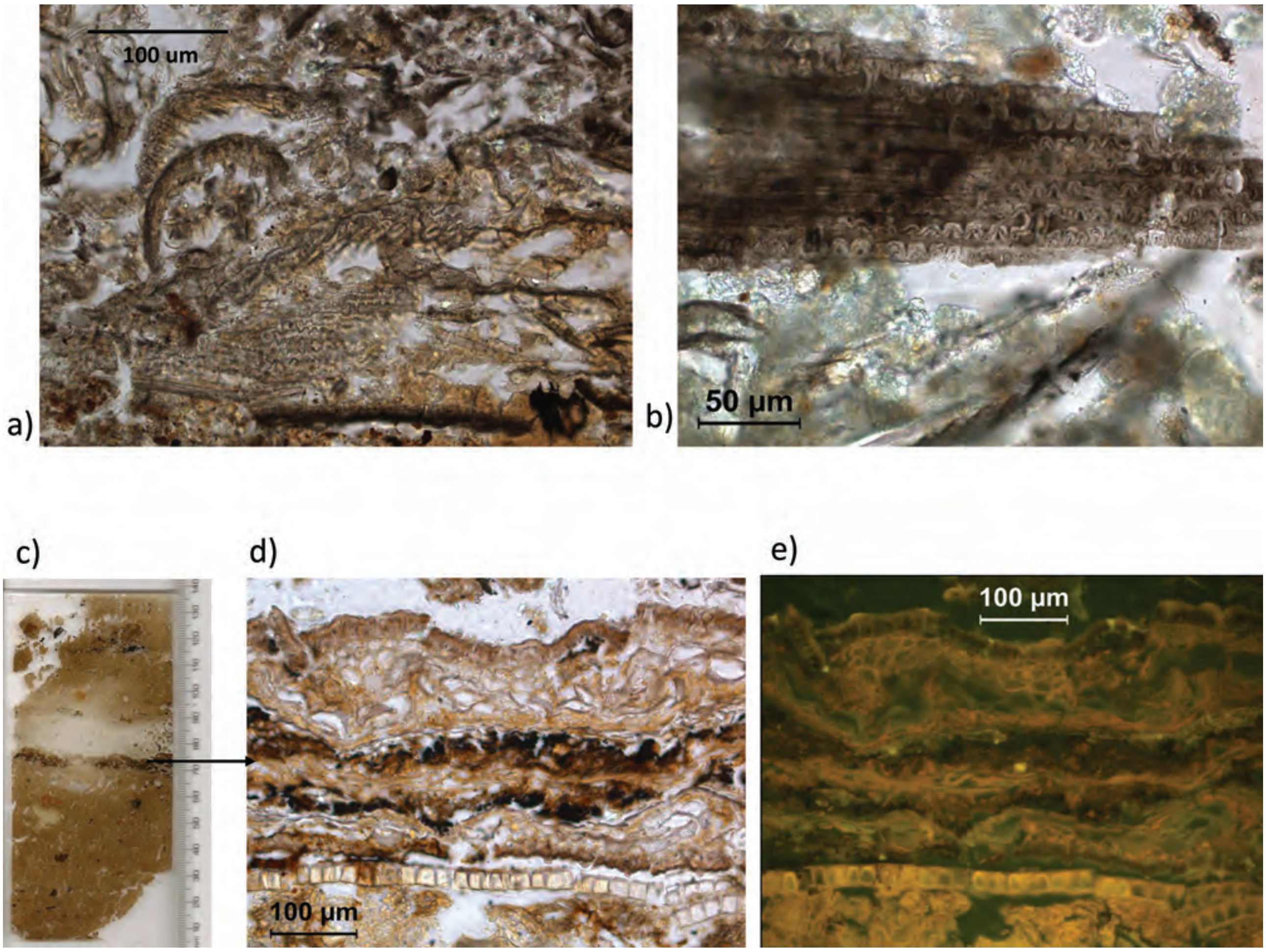


Figure 12.13. Well-preserved phytoliths: at Bestansur in a) midden-like deposits in T13 Sp25 (C1494=C1581 and C1485 SA1286. PPL); b) in situ *fuel in the large fire-installation F18 in B5 Sp48 (C1674.1610 and C1673/1610 SA1778 PPL); at Shimshara in burnt roofing/bedding deposits c) thin-section (scale in cm), d) PPL, e) ILF (SA763.4, Section 2, see Chapter 10; adapted from W. Matthews 2016: fig.7).*

Sp48 SA1782.10) and from rake-out in a midden-like layer of ash in T9 open area Sp15 (C1158 SA286.3), attesting excellent preservation and little disturbance.

Colour can be used as a rough guide in the field to assess the type of plant materials in ashes. As highlighted by Courty *et al.* (1989), 'ashes' comprise varying proportions of charred remains resulting in dark deposits, and phytoliths and calcitic ashes create paler ashes. At Bestansur many of the ashy deposits in fire-installations and fuel rake-out are pale indicating high phytolith/ash content.

Plant remains taphonomy and contextual variation

The factors affecting the scarcity of charred plant remains at Bestansur, therefore, are diverse. They range from bioturbation and *in situ* fragmentation due to shrink-swell clays and possible degradation of polycyclic aromatic hydrocarbons, to high combustion temperatures, trampling, and the availability, utilisation and discard of plant remains, all of which are explored further in the discussion sections. A wide range of non-charred plant remains have also been identified in thin-section in addition to charred plant remains, including plant impressions, desiccated, humic and mineralised remains, phytoliths and melted silica, and calcitic ashes and dung ash.

Micromorphological analyses of the depositional context of plant remains and micro-contextual associations with other residues from human activity are presented and examined in the following results sections on animal dung and coprolites, deposit-types and context-types. The wider significance of these results for our understanding of the nature and sustainability of early sedentism, ritual and the built environment, and resource management and use are explored in the concluding discussions in this chapter on these research themes.

Animal dung and omnivore and human coprolites

Coprolite studies are an emergent field that is

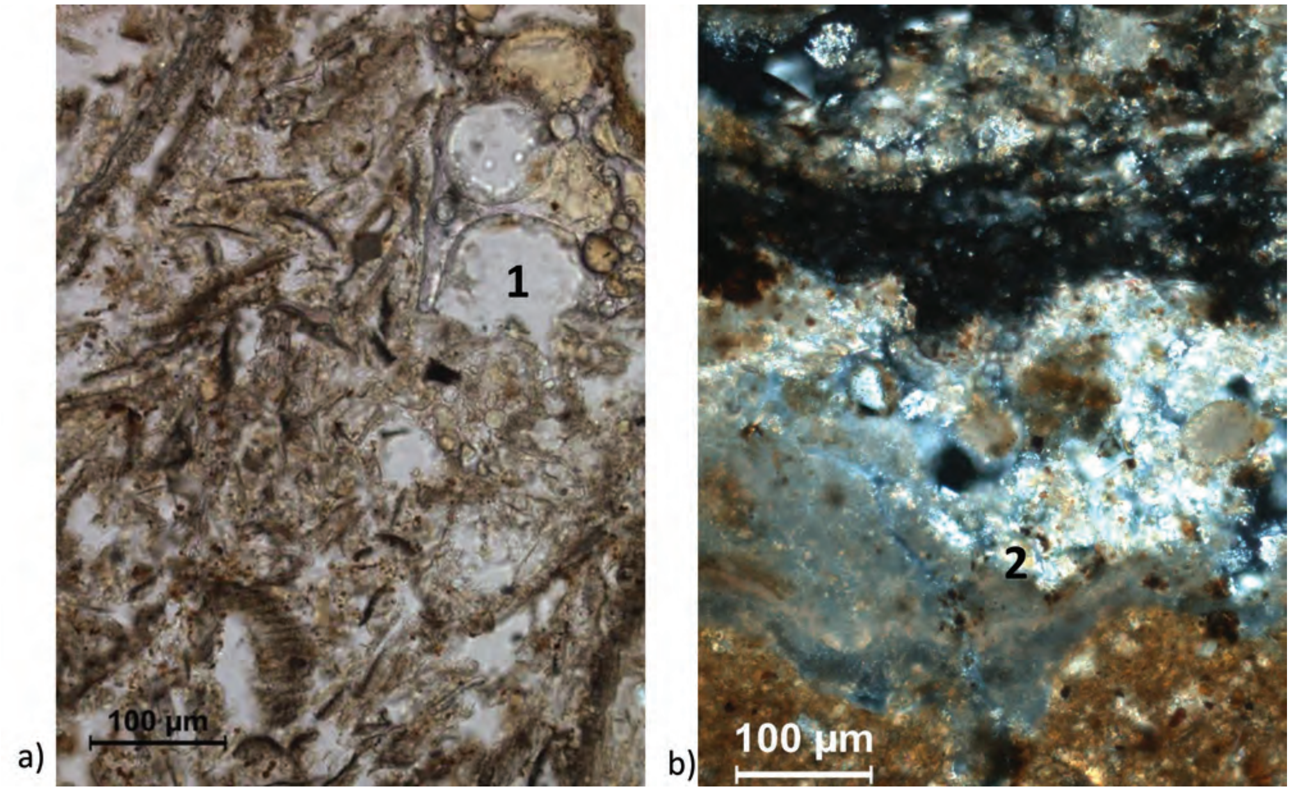


Figure 12.14. High-temperature combustion residues: a) melted silica [1] in midden-like deposits in Sp25 T13 (C1494=C1581 SA1286.2. PPL); b) calcitic ashes [2] in situ *fuel in the large fire-installation F18 in B5 Sp48 (SA1778 XPL).*

providing important new insights into environment, ecology, energy sources, animal and human diet and health, and the built environment (Shahack-Gross 2011; Portillo *et al.* 2019; 2020). Both herbivore and omnivore coprolites were identified at Bestansur and Shimshara by integrated ethnoarchaeological, pXRF, spot sampling, micromorphological, phytolith and GC-MS analyses (see also Chapters 13 and 16). Animal dung and omnivore and human coprolites have also been identified in the high Zagros using a similar integrated methodology (W. Matthews *et al.* 2013h; Shillito *et al*. 2013a), and through flotation and micromorphology at the base of the Zagros foothills at Choga Golan (Riehl *et al.* 2013). Animal dung and omnivore coprolites, therefore, are an important constituent of settlement deposits in the Zagros, and provide a new significant line of enquiry in studying sedentism, resource management and diet and health, as explored in the discussion section.

Animal dung

The identifications of animal dung at Bestansur are based on the co-association of spherulites with: abundant phytoliths from partially digested plant material, elevated phosphorous levels, and GC-MS traces of dung sterols and stanols, and are further supported by the sparsity of spherulites in other types of deposits (Chapters 13 and 16; Figs 12.7–12.9). These multi-proxy results confirm that the spherulites at Bestansur and Shimshara originate from dung, rather than other natural sources such as micro-fossils (Canti 1999), and can be used as a reliable indicator of dung in more rapid analysis of spot samples in the field and in the laboratory, as also conducted by Allistone, Portillo and Dudgeon (Chapter 13).

Spherulites are likely to have been more abundant and ubiquitous than recorded, as they calcine above 700°C, which many fires at Bestansur exceeded as attested by the melted silica and calcitic ash (Canti 1999: 256–257; Canti and Nicosia 2018; Chapter 13; Portillo *et al.* 2019). The spherulites at Bestansur tend to be small, *c.* 5–10µm, and masked by the calcitic sediments and ashes. Phytoliths within dung may also be under-represented at Bestansur in some contexts, as they dissolve in highly alkaline deposits such as calcitic ash if the pH is >8 (Piperno 2006: 22).

No intact herbivore dung *pellets* were identified in the thin-section samples analysed, suggesting dung was trampled and fragmented or used as fuel. Herbivore dung with abundant calcareous spherulites that form in the guts of animals during digestion, however, was identified in 16% of deposits analysed in this research, and commonly in ash in *in situ* fuel and fuel rake-out, generally in open areas (Fig. 12.15a–d). Contexts with traces of dung/dung ash span the earliest to the latest excavated levels at the site (Fig. 12.15a; Fig. 12.32 below). Examples include

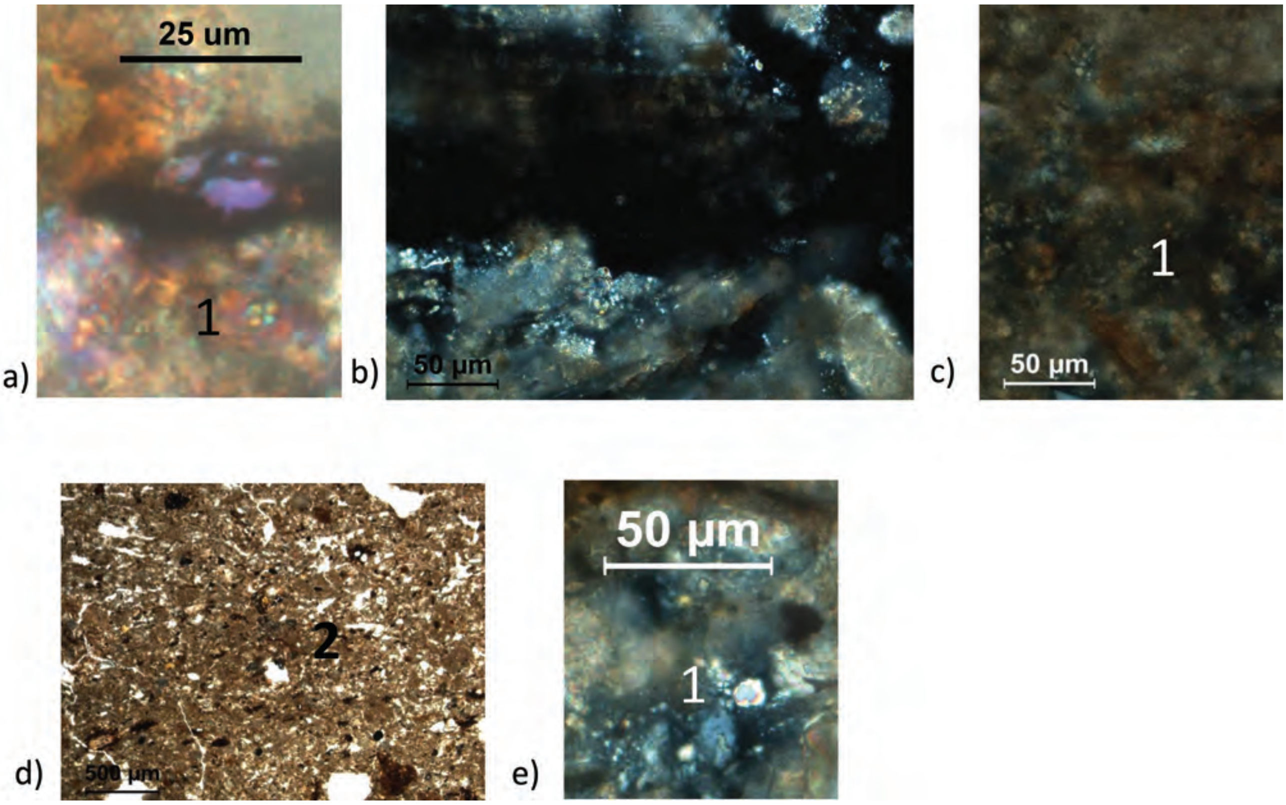


Figure 12.15. Traces of animal dung spherulites [1] in: a) early ash in Sp27 T10 (C1772 SA2302. XPL quarter-wave plate inserted); b) in situ *fuel in large rectilinear fire-installation F18 Sp48 B5 T10 (SA1778. XPL); c) occupation deposits in recess in entrance room recess Sp60 B5 T10 (C1785 SA2315.6. XPL); d–e) possible temporary pen/dung in multi-purpose area end-life building B9 Sp53 T10 (C1758 SA2297.2): d) parallel oriented finely comminuted non-burnt plant remains impressions (PPL); e) dung spherulites (XPL).*

traces of dung from: unexcavated levels 1.7m below the modern surface that were sampled at the base of a deep pit in T9 SA1290.3; and the deep sounding in T10 Sp27 SA2302.9; to the latest in T12/13 C1384 SA1288.1=SA1287.8 (Fig. 12.35).

No unequivocal traces of *in situ* herbivore penning were identified. One speculative candidate for a temporary pen is represented by a *c.* 1cm thick deposit at the end-life/post Building 9 Sp53, which may represent compacted dung based on some similarities with confirmed examples including parallel oriented plant impressions, phytoliths and dung-spherulites (Shahack-Gross 2011; W. Matthews *et al.* 2013h), although it is likely that this was a multi-purpose space as the spherulites are mixed with a range of sediment rich deposits and occupation residues (Fig. 12.15d–e).

Omnivore and human coprolites

Omnivore coprolites can be identified in the field as discrete patches or lenses of yellowish amorphous organic matter with a distinctive yellowish fine matrix, especially when combined with field-laboratory analysis of smear slides to test for isotropic fabric in XPL and the presence of phytoliths and occasionally, spherulites, although these are much rarer in omnivore than herbivore coprolites (Canti 1999; Figs 12.16a–b and 12.26). Omnivore coprolites were identified in low concentrations, <2–5%, in 34% of deposits quantified in thin-section across different sectors of the site including trenches T5, T8, T9, T10, T12/13 (see Chapter 16 for additional examples). Almost all the contexts in which they occur are external deposits.

Omnivore coprolites occur in high concentrations of up to *c.* 40% in finely stratified occupation deposits in two open areas in T13 Sp25 and in T12/13 Sp39, and are incorporated in low abundance, up to 2%, into the packing layers overlying these deposits in these areas (Figs 12.7–12.9). GC-MS results to date indicate that these coprolites are often of human origin, and in one instance from wild boar/pig (Chapter 16: Table 16.14; Chapter 13). The identification of these coprolites as human and wild boar/pig provides an important opportunity for insight into human and animal diet, health and the built environment as they contain traces of the plants, animals and fish consumed, as well as potentially microbiological components (Figs 12.16, 12.26, 12.34), as discussed in the concluding thematic sections below and Chapter 13. Omnivore coprolites with fish bone <1.5mm were identified in T12 Sp39 (Fig. 12.16b) in a range of lenses in T12/13

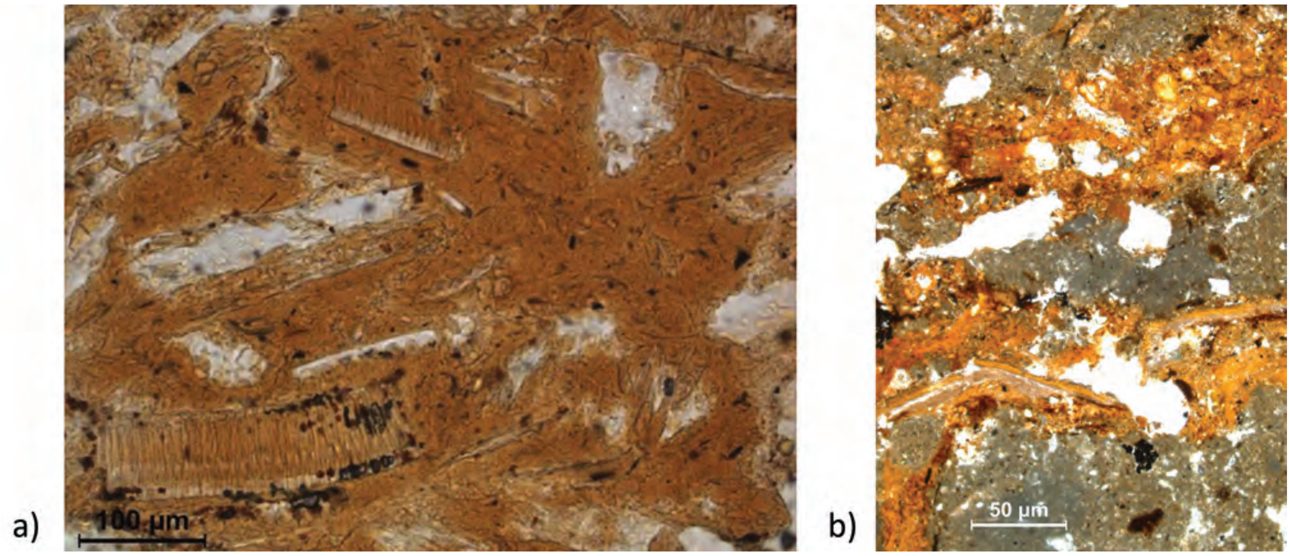


Figure 12.16. Omnivore coprolites, probably human, based on GC-MS analyses of similar lenses in accumulated deposits: a) with articulated phytoliths of tracheae and Poaceae epidermises, and dark framboids probably of microbiological origin (Sp25 C1494 SA1286.12 PPL); b) fish-bone and traces of plant remains T12 C1387 SA1287.3 (PPL).

Sp24 and Sp25, where omnivore coprolites containing mammal bone were also observed. Plant remains are a common component of omnivore coprolites and are exceptionally well-preserved, as many are articulated (Fig. 12.16a). In the samples studied in this chapter and Chapters 13 and 16, phytoliths in human coprolites are from monocotyledons including cereal (*Hordeum* and *Triticum*), dicotyledon leaves, and root tracheae, probably from plants such as a thistle, which are consumed in the region today along with a range of spring greens (Watson 1979: 69), as well as in some instances reeds.

Bone diversity and taphonomy

In thin-section it is evident that bone preservation is poorer closer to the surface, and improves with depth. Less than 30cm below the modern mound surface, in Trench 9 external area Sp15, for example, the internal structure of bone has been mineralised and the collagen replaced by carbonates (Fig. 12.17a–c, C1153–2 SA285.1). This replacement explains the poor collagen retrieval in isotope and dating assays from these levels (Huisman *et al.* 2017; Madden *et al.* 2018; Chapters 11 and 15). By contrast, >1.5m below the surface, in Trench 9 and Trench 10, the internal structure of bone is well-preserved with wavy apatite and well-defined haversian canals in cortical bone, suggesting that collagen may be better preserved in these levels (SA2302). Carbonate replacement, however, is also evident in a fragment in floors in interior space B5 Sp50 (Fig. 12.17d–e). A range of bones exhibit autofluorescence, although whether this is an indication of preservation of apatite and collagen or other factors is still under-researched (Fig. 12.17k; Villagran *et al.* 2017). A range of bones are surrounded by amorphous organic staining, which may indicate the presence of flesh when deposited and stages in bioerosion (Fig. 12.17d-e; Booth 2016; Villagran *et al.* 2017).

Bone occurs in at least 43% of deposits in thin-section in densities that range from 2–12% as a percentage by area and fragment sizes of 0.2–31mm (Figs 12.3–12.5). Deposits with the highest densities (>4–12%), largest size (<9–31mm), and diversity of bone, often both burnt and non-burnt, occur in external occupation deposits including T9 Sp28 C1153 SA285.1, T10 deep sounding Sp27 C1772 SA2303.5; T12/13 Sp39 SA1287.3 (Figs 12.4–12.5 and 12.17f–h). More than 80% of deposits with burnt bone are external occupation deposits with >5->40% plant remains. One exception is the interior thin lens of ashes on the last floor of B5 Sp50, in the north-west corner, associated with red pigment, with <2% burnt bone, <0.3mm (Fig. 12.30 below).

Burnt bone is mostly only moderately burnt at <650°C, suggesting burning in lower temperature fires after peak temperature has been reached either for cooking or for disposal of refuse as many plant remains are burnt at high temperatures above that at which bone calcines, >650–750°C (Villagran *et al.* 2017).

Both mammal bone and fish bone as well as teeth are represented in thin-section. Some bone is from micro-fauna and clearly *in situ* in undisturbed Neolithic deposits. The small size and sharp fracture of some fragments may be indicative of marrow extraction from larger mammals as observed in

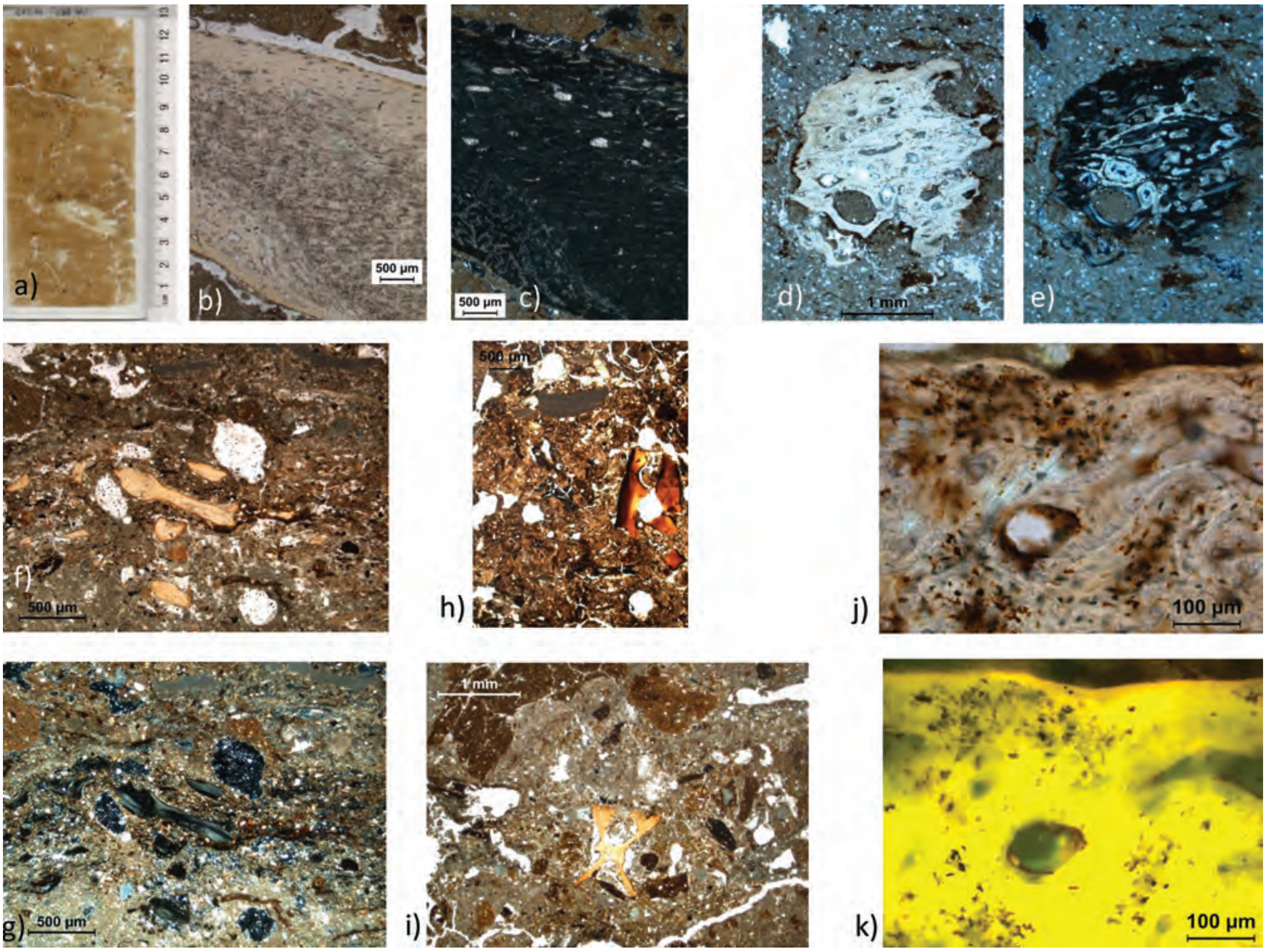


Figure 12.17. Bone diversity, preservation and taphonomy. Bestansur: a–c) replacement of collagen by carbonates in external area T9 (C1153 SA285.1 PPL, XPL) and within building in in d–e) T10 B5 Sp50 floors (SA2414.3 PPL, XPL); burnt and non-burnt micro-fauna and bone fragments in occupation deposits in: f–g) external 'midden-like' deposits in T13 Sp25 (C1485 SA1286.14 PPL, XPL), h) external fuel rake-out T10 Sp44 (C1755SA2312.5 PPL), i) microfauna vertebra in ashy deposits T9 (SA1290.3 PPL). Shimshara: j–k) well-preserved bone with haversian canals and autofluorescence (SA763.1 PPL, ILF).

the zooarchaeological assemblage (Fig. 12.17f–g; Chapter 15). Fish bone has been identified in many occupation deposits in T12 and 13 as also attested in the zooarchaeological assemblage (Chapter 15). Other sectors of the community where fish bone has been identified in thin-section in occupation deposits include: T9 C1153 SA285.1, and T10 B5 recess in entrance room Sp60 (C1742 SA2315.3). In thin-section, it is evident that at least some of the fish bones are clearly *in situ* in omnivore coprolites and were possibly consumed by humans as GC-MS analyses have identified similar coprolites from these deposits as predominantly human in origin (Fig. 12.16b; Chapters 13 and 16).

Mollusc shell diversity and taphonomy

Shell is more ubiquitous than bone, occurring in 53% of deposits quantified (Figs 12.7–12.9). Abundance is generally low as a percentage by area at 2% or less but *c.* 20% of deposits with shell have >5%. The two highest densities of shell are in occupation deposits in an external area in T12 Sp39 at 30% (C1514 SA1499.9-11), and in a midden-like deposit *c.* 7–10cm thick in T5 at 80% (Fig. 12.18a). Many of these are from *Helix salomonica*. River clam and crab shell have also been identified in many deposits in molluscan assemblages, as discussed in Chapters 15 and 17.

During excavation, a range of occupation surfaces and deposits, particularly in external areas, were identifiable in the field by the linear horizontal or slightly sloping distribution of trampled and fragmented mollusc shells, particularly of *Helix salomonica*. Clusters of shell, predominantly *Helix salomonica*, were identified on surfaces across external activity areas and in small fire-installations in T7 in particular.

Mollusc shells with indicators of probable pathologies from parasites were identified in external area occupation deposits in the deep sounding in T10

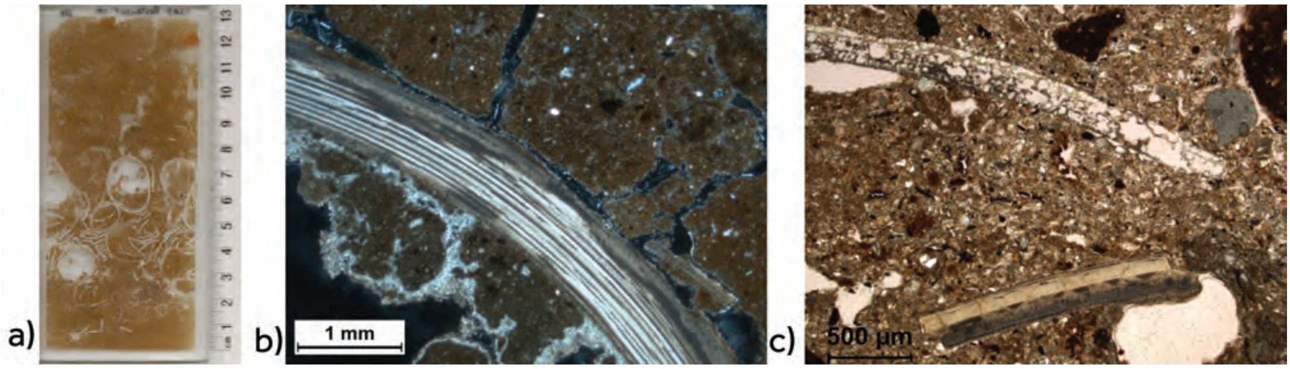


Figure 12.18. Molluscs: a–b) Trench 5 mollusc 'midden-like' deposit C1078 in thin-section SA285.2, predominantly Helix salomonica with banding (XPL); c) mollusc shells in T10 Sp27 C1772 with (upper) and without (lower) channels and chambers (SA2302.2 PPL).

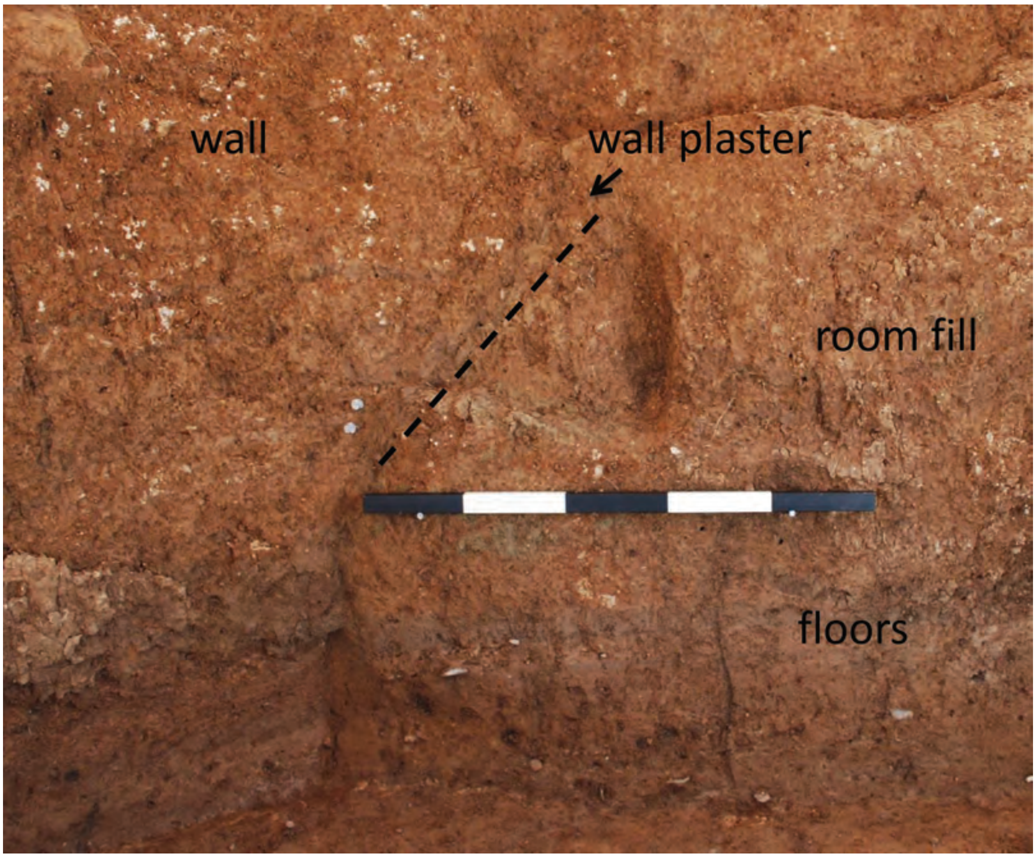


Figure 12.19. Building 5 construction materials in W52, Sp50. Inward sloping earthen wall made from reddish brown silty clay loam with white aggregates and thin grey mortar. Grey silty clay wall-plaster. Looking north east. Scale=50cm. Field sections 122 and 130.

Sp27, represented by channels and chambers up to *c.* 0.3m in length (Fig. 12.18c upper; C1772 SA2302.2), and T10 Sp44 (C1755 SA2312.6). These pathologies may not be from post-depositional dissolution as they occur alongside other molluscs with no indicators (Fig. 12.18c) and the chambers are very rounded likely from drilling. Despite consultation with mollusc specialists these features currently remain unidentified.

Some shells were clearly burnt and darker in colour (as in Fig. 12.18c), in ashy deposits in T9 open area Sp15 midden-like layer (C1158 SA286.3) and in *in situ* fuel in T10 Sp44 constructed oven F16 (C1767 SA2298.3), for example.

Deposit-types: characteristic attributes and spatial and temporal variation

Twenty-two major Deposit-type classes with sub-types were identified at Bestansur in micromorphological analyses (Table 12.1), as outlined in the methodology.

Table 12.1. Deposit-types identified at Bestansur (drawing on W. Matthews 1995, table 1).

Deposit-type no.	*Micromorphology deposit-type*	*Sub-type*
1.1	Packed earth /mudbrick	reddish brown silty clay–silty clay loam with white aggregates
1.2	Strip-chineh/mudbrick	reddish brown silty clay loam with white aggregates
1.3	Mudbrick	green silty clay loam
1.4	Strip-chineh/mudbrick	grey silty clay/clay loam
2.1	Mortar	reddish brown silty clay with white aggregates
2.2	Mortar	reddish brown silty clay
2.3	Mortar	yellowish brown silt loam
2.4	Mortar	greyish brown silty clay
3.1	Wall-plaster	reddish brown silty clay loam
3.2	Wall-plaster	green silty clay loam
3.3	Wall-plaster	grey silty clay
3.4	Wall-plaster	white silty clay
4.1	Packing	reddish brown silty clay–clay loam
4.2	Packing	heterogenous with construction aggregates and occupation debris
4.3	Packing	yellowish brown silty clay loam
5.1	Floor plaster	reddish brown silty clay–clay loam with abundant plant inclusions
5.2	Floor plaster	reddish brown
6.1	Floor plaster	green silty clay
7.1	Floor plaster	grey silty clay
7.2	Floor plaster	white silty clay
7.3	Floor plaster	fired-lime plaster
24.3	Packing with gravel	reddish brown silty clay with sub-angular river gravels and plant impressions
9.1	Floor covering/matting	phytoliths
9.2	Floor covering/matting	surface impressions
10.1	Occupation deposits with <5% plant remains	heterogeneous
10.2	Occupation deposits with <5% plant remains	mollusc cluster/spread
11.1	Occupation deposits with >5% <40% plant remains	heterogeneous
12.1	Occupation deposits with >40% plant remains	heterogeneous
15	Fire-installation structure	plaster lining
16.1	FI fuel (In-situ)	abundant phytoliths
16.2	FI fuel (In-situ)	abundant phytoliths
16.3	FI fuel (In-situ)	abundant calcitic ash
17	Destruction/room fill	–
20	Natural	yellowish brown silty clay loam
21.1	Miscellaneous	soot
22	Indeterminate	–
23.1	Wall-painting pigment	red pigment (haematite)
23.2	Pigmented plaster	red pigmented plaster
23.3	Pigment layer/material	red pigment
23.5	Wall-surface residue	soot
24.1	Stone cobbling	smooth flat stones
24.1	Gravel surface	sub-rounded river gravels, predominantly of limestone
26.1	Roofing	reddish brown with plant impressions and humic plant remains
26.2	Roofing	green silty clay loam with plant impressions, humic plant remains and charred flecks

These types are examined briefly in turn here before considering their wider significance with regard to built environment design, construction, use, sustainability and health.

The particle size, pH and XRD mineralogy of construction materials and occupation deposits were characterised for selected samples discussed in Chapter 13 and considered below. A range of construction material Deposit-types included traces of plant inclusions as linear-curvilinear humic staining or plant impressions up to *c.* 3.5mm in size in thin-section, which would have enhanced tensile strength and flexibility (Houben and Guillaud 1989; Walker *et al.* 2005). This factor is likely to have been important as the clay mineralogy includes up to 40–60% expandable shrink-swell clays (Chapter 13).

Wall-construction materials (Deposit-types 1–3) and pigments/wall-paintings (Deposit-type 23)

Some walls appear to have been constructed from

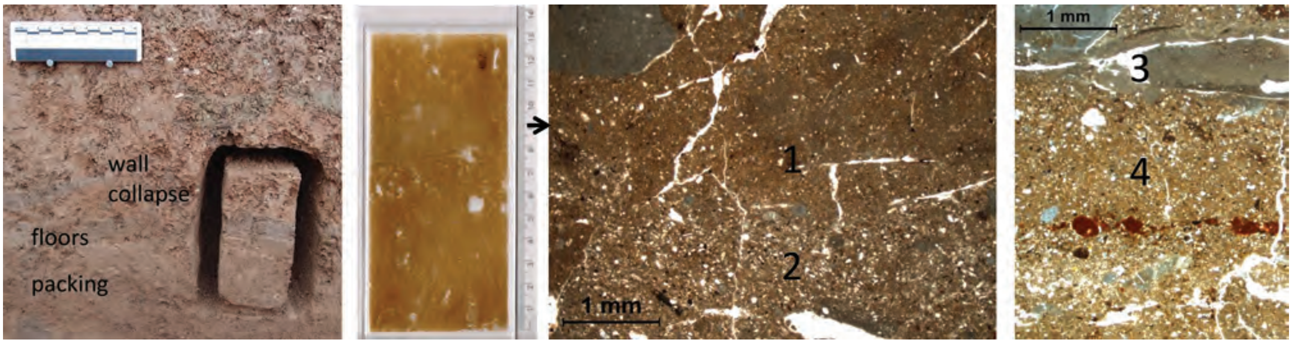


Figure 12.20. Building 5 construction materials in Sp50 NE corner (scale = 10cm). In thin-section: collapsed earthen wall made from reddish brown silty clay-silty clay loam with calcareous rock fragments, carbonate inclusions and 2% plant impressions [1]; adhering grey silty clay loam wall plaster [2] and white silty clay finishing coat [3]; traces of red pigment [4] overlying floor surface (SA2301.2-10 PPL).

Figure 12.21. Diverse construction materials in Trench 10: a) dark grey boat-shaped bricks in B9 Sp53; b) green silty clay loam bricks with <2% plant impressions [2] and reddish brown silty clay mortar with 2% plant impressions [1] in wall W64 Sp44 (SA2303.2–3 XPL).

packed earth (*pisé*/*chineh*), Deposit-type 1.1, as no mudbricks nor layers were discernible in the field. These walls were made from a reddish brown silty clay-silty clay loam with white aggregates, and constructed across the site as revealed in Trenches 7, 8, 9 and 13. In some instances dismantling of these walls may reveal mudbricks or layers within the structure of the wall. Other building walls, however, were made of discernible mudbricks, in Trenches 1, 8, 10, 12/13. Building 5, T10 was constructed from *c.* 8cm thick layers of reddish brown silty clay loam (Deposit-Type 1.2) and a thin greyish brown silty clay mortar (Deposit-type 2.4) (Figs 12.19–12.20 and 12.29).

Other walls, particularly in earlier levels, were constructed using more diverse materials including green silty clay loam, which has the lowest expandable clay content at *c.* 40% (Chapter 1; Deposit-type 1.3) in rectilinear mudbricks with reddish brown mortar (Deposit-type 2.2; Fig. 12.21b); grey silty clay/clay loam (Deposit-type 1.4) used for boat-shaped bricks (Fig. 12.21a) and for layers of packed earth laid in strips, *c.* 5–6cm thick (also known as 'strip-chineh' (Smith 1990) and/or very long mudbricks perhaps set *in situ* with reddish brown silty clay loam with white carbonate aggregates for T10 B5 W42 (Deposit-type 2.1) and with yellowish brown mortar (Deposit-type 2.3) for Building 8 (Fig. 12.22).

Wall plasters do not appear to have been applied to walls made from pisé (packed-earth; Deposit-type 1.1) nor to boundary walls for external areas. Plasters were applied to interior walls in Building 5, and to interior and exterior wall surfaces in Building 8. All these wall plasters have linear-curvilinear traces of plant temper, either as humic staining or plant impressions (Figs 12.19 and 12.20 [2]). In B8, wall W56, these plasters comprise a sequence 3.4cm thick of at least eight silty clay–silty clay loam reddish brown, brown and green plasters *c.* 2–6mm thick clay Deposit-types 3.1–3 (Fig. 12.22). The latest wall plasters comprise a sequence of at least six white washes *c.* 0.1–0.4mm thick (Deposit-types 3.4–5), the last of which had traces of soot on the surface (Deposit-type 23.2) (Godleman *et al*. 2016). In B5, wall plasters were made from a *c.* 10–15mm thick grey silty clay loam base with sparse humic plant remains <0.6mm in length and 20μm thick in thin-section (Deposit-type 3.3), and white-wash *c.* 0.3mm thick (Deposit-type 3.4; Fig. 12.20 [3]).

Traces of red paint (Deposit-type 23.1) were identified in the field and thin-section in B8 on the southeast face of wall W56, late in the sequence on the eighth plaster prior to the application of six subsequent

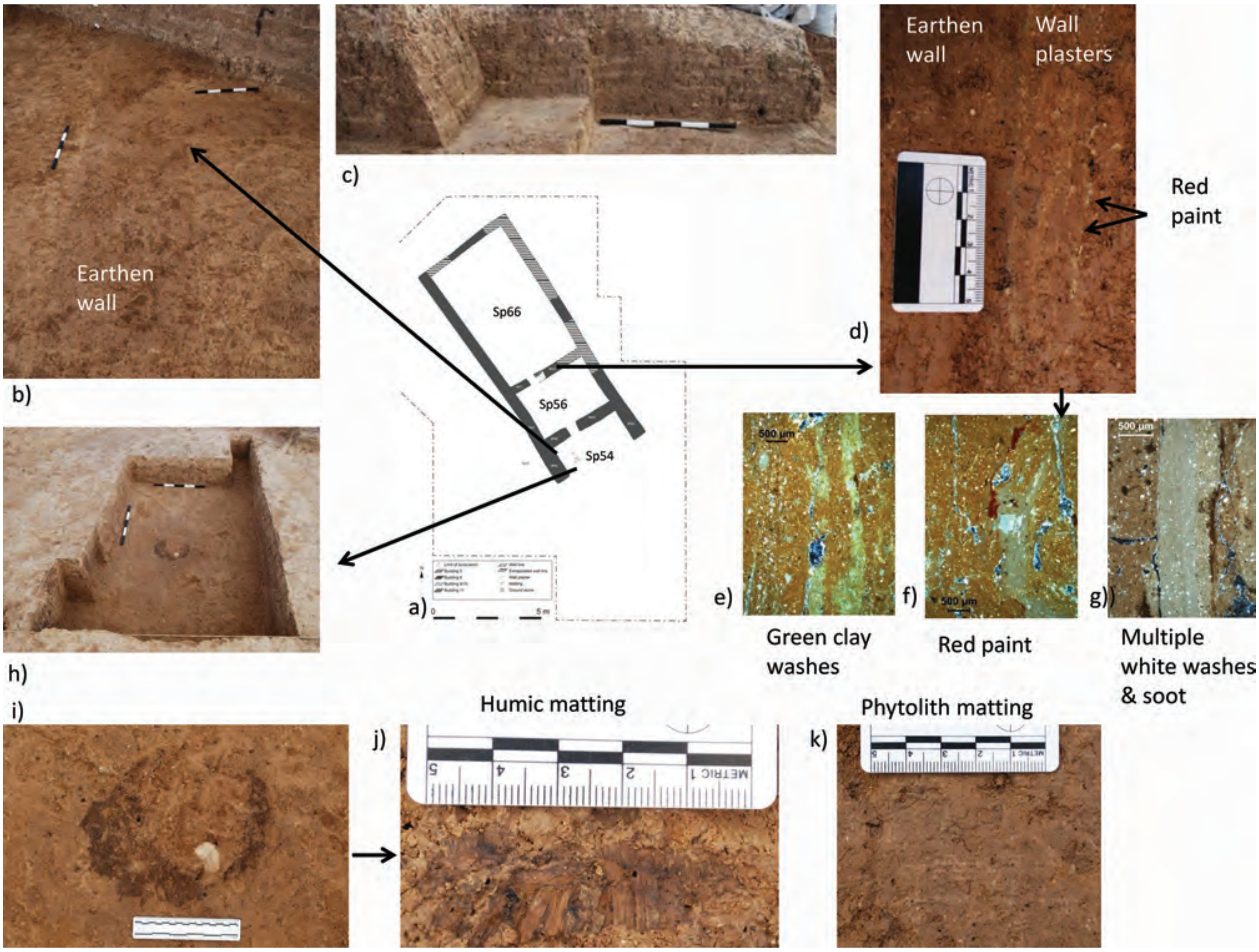


Figure 12.22. Building 8 construction materials and elaboration: a) Plan of B8; b–c) earthen walls constructed from very long and boat-shaped bricks comprising c) 8–10cm thick layers of dark greyish brown silty clay and c. 2–3cm thick pale brown mortar (W46–8; W50); d–g) 3.4cm thick sequence of multiple layers of green (celadonite), reddish brown and white wall plaster/silty clay–clay washes with traces of red haematite paint and soot on last wall surface on south of W56 in entrance room Sp56; h–k) entrance portico Sp54 east with humic and phytolith traces of matting and possible impression of a carved object/post [i].

layers of white-wash. Clear traces of this red wall-painting were visible in the field in plan-view and in thin-section (Fig. 12.22). This paint was applied in an, as yet uncovered, discontinuous design with areas of paint at least 2.5mm in width and height, 50–250µm thick, in thin-section. The pigment was analysed by Godleman and colleagues (2016) using integrated optical and IR microscopy and SEM EDX. It was prepared from haematite, the closest source of which is 40km distant as the crow flies, at Penjween/Mishaw, in the Shalair Group deposits (Yassim and Goff 2006: 337; Sissakian 2018: 27). Pending excavation, it is not known whether these traces of paint represent geometric or figurative paintings, such as those painted more than 500 years later at Tell Halula in Syria (Molist 2013: 112, fig. 1). One option in future fieldwork may be to apply terahertz imaging to detect the configuration of the painting prior to excavation to aid conservation and recovery, as demonstrated in pioneering research at Çatalhöyük (Walker *et al.* 2013).

Discontinuous traces of amorphous red paint/pigment were identified on walls in the entrance to B5 Sp50, but no discernible painting was detected (Chapter 9). Speculatively, these fugitive traces of red pigment may have been transferred by contact from the coloured mats or burial wrappings found in Sp50 onto the wall as they were brought through the narrow entrance into this large room. A segment of red-pigmented plaster was identified and lifted in occupation deposits in T12 C1382 (W. Matthews *et al.* 2013g: fig. 4.12; Chapter 9).

Floor construction materials (Deposit-types 4–8, 24)

Packing was laid as a foundation for many floor surfaces in interior and exterior areas across the site. It was often *c.* 5–30cm thick, and occasionally thinner, particularly in T12/13 Sp39. Many layers of packing were made from reddish brown silty clay–silty clay loam (Deposit-type 4.1) with fewer calcareous rock/

Figure 12.23. Building 5 Sp50 architecture: a–b) flat stones at northern and southern end of the space, which may have served as post-pads; b–d) gravel-lining in foundation packing along edge of walls, with carbonate river-gravels and plant-impressions (SA2603.2 PPL). Scales = a) 25cm, b) 50cm, c) 14cm.

aggregate inclusions than walls, and humic traces or impressions of plant inclusions in some deposits (Deposit-type 4.2a, <2-5%). Packing includes a low 'background noise' of occupation residues at *c.* 3% (Deposit-type 4.2) in contrast to little or none in floor plasters at Bestansur. The thick yellowish silty clay loam below B3 in T7 is likely to be packing (Deposit-type 4.3; Chapters 9 and 16; SA679). Some packing was used without finishing coats of plaster particularly in T13 Sp24–5. Packing within buildings, however, was frequently covered with plasters or stone-cobbling as in Buildings 1, 4, 5 and 9, for example.

Floor plasters were generally made from the same range of naturally occurring source materials as wall plasters and frequently include linear and curvilinear traces of fine plant/organic remains attested by humic staining or impressions, 2–5% and up to >3.5mm in length. The highest abundance of these plant/organic inclusions was in Building 5, entrance room Sp47 at 7% (Fig. 12.30 below) and the portico to Building 8 Sp54 (SA2585) (Deposit-type 5.1). The lowest abundance was in Building 9 Sp28 largest room and some of the thinner floors in Building 5 at 2% or less (Deposit-type 5.2). Plaster floors have been classified as three major types based on colour as the most readily distinguishing characteristic, as discussed in the methodology section: reddish brown (Deposit-type 5), green (Deposit type 6) and other, generally white and grey (Deposit-type 7.1). The white plasters were often laid as a thin coat (Deposit type 7.2) as in Building 5 Sp50 2.6mm thick close to the northwestern wall face (Fig. 12.30 below). White washes were also applied on a plastered surface in T9 visible in section, but not excavated below a cluster of fire-installations and in T12/13 (Chapters 9, 16).

Fired lime, identified by FTIR analysis, was used to manufacture the thick hard pinkish white plaster in front of and to the west of Building 8 (Deposit-type 7.3; Godleman *et al.* 2016: 199 fig. 7; Fig. 12.27 below). The surfaces were irregular and resemble archive samples of fired lime plaster from Abu Hureyra in Syria held at the University of Reading.

Stone cobbling (Deposit-type 24) was used to pave internal areas in some areas of the site using moderately sized flattish stones (Deposit-type 24.1) as in T7 Sp9/12, T10 Sp50 in an area *c.* 80 × 60cm close to the entrance (Chapter 9). Calcareous gravel (Deposit-type 24.2) was laid as a surface in the southeastern entrance portico T10 Sp42 and also used to line the inside edge of the walls in foundation packing in B5 Sp50 (Deposit-type 24.3) *c.* 15cm wide and 3cm deep, with 5% impressions and <2% humic remains of plants (Deposit-type 24.3; Fig. 12.23b–d).

Floor coverings, matting and burial wrappings (Deposit-types 9 and 23.3)

A range of floor coverings have been identified at the site. The clearest traces are from T10 Buildings 8 and 5. These include traces of mats represented by phytoliths and humic staining in B8 portico Sp54 (Fig. 12.22) as well as impressions and phytolith traces on floor surfaces in B5 Sp50 (Figs 12.24 and 12.30 below). Some traces of coloured mats were identified in the northwest corner of B5 Sp50 (Fig. 12.24b; Chapter 9). Traces of mats and burial wrappings were also identified in Sp50 (Chapter 19).

Other possible pigmented materials (Deposit-type 23.3) include traces of a possible felted material or pigmented surface in T12/13 on a 5cm thick layer of packing (Fig. 12.24d), and unusual pigmented striations in the area west of B5 in Sp63 (Fig. 12.32 below), some of which may represent fragments from artefacts such as baskets or matting.

Occupation deposits (Deposit-types 10–14)

Occupation deposits have been classified into five major groups. Three have been classified according to plant remains content as these are a major component and indicator of specific types of activities. Occupation deposits with <5% plant remains (Deposit-type 10; Figs 12.3c and 12.7c) include occasional thin lenses of 'dust' on floors in B5 Sp50 for example, or shell midden-like deposits in T5 that represent specific specialist discard associated with processing of molluscs (Fig. 12.18).

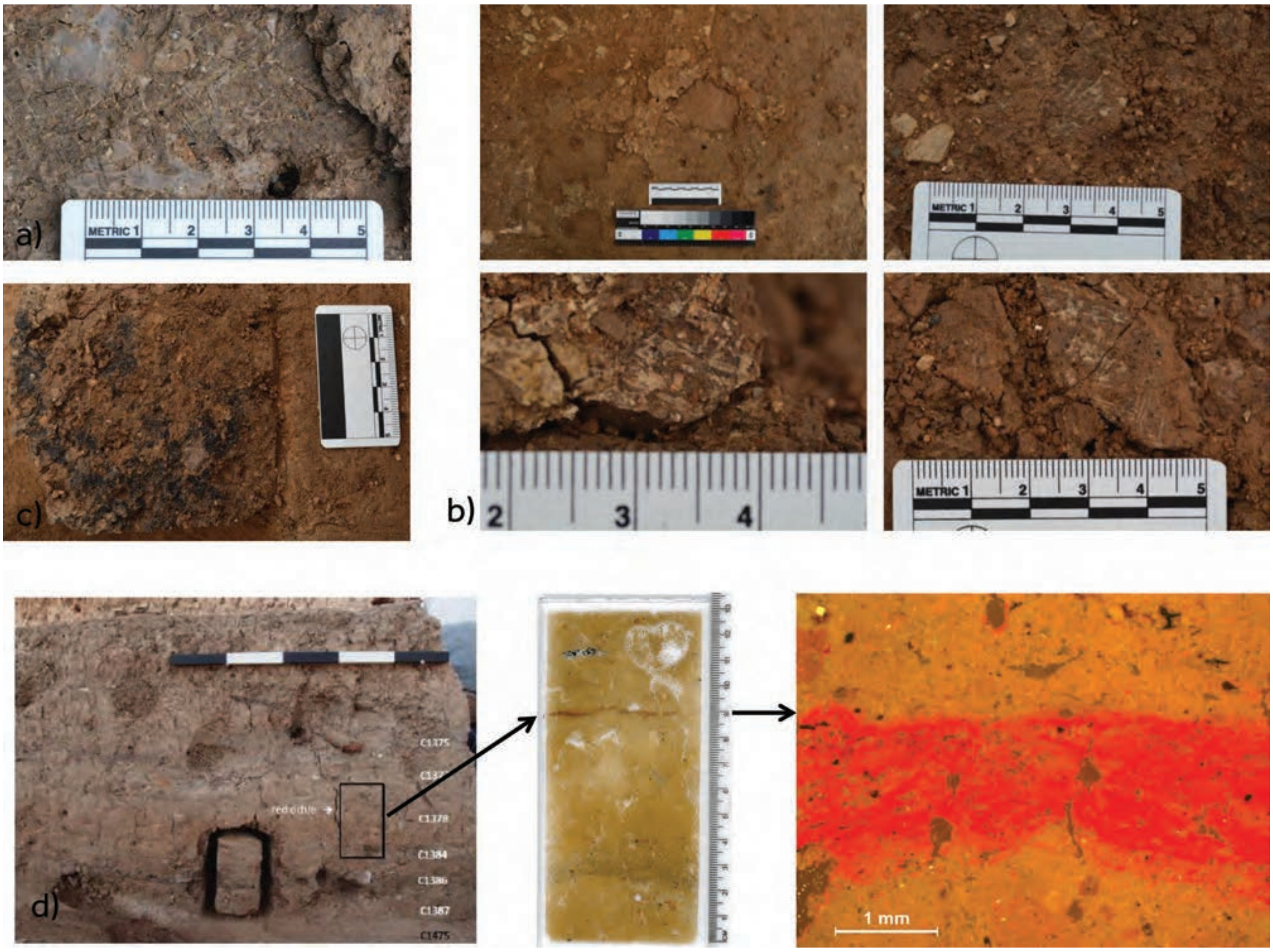


Figure 12.24. Matting and pigments on floors: in Building 5 Sp50 a) phytolith traces of matting C1746; b) with traces of red, black and yellow pigments C1877, and; c) locally as phytolith and carbonised remains C1878 in southwest of Sp50 close to the W52 (Scale = 5cm); d) in T12/13 Sp39 red pigment/material on surface (C1378 SA1288.4 OIL).

Occupation deposits with 5–40% (Deposit-type 11) are present in external and interior areas and include a diverse range of plant remains and micro-artefactual inclusions, discussed below in analysis of the contextual variations across different sectors of the site (Figs 12.4a–b and 12.8a–b).

Occupation deposits with >40% plant remains (Deposit-type 12) occur almost exclusively in external areas across different sectors of the site, including Trenches 9, 10, and 12/13, or in *in situ* fuel in fire-installations (Figs 12.5 and 12.9). The abundance and types of micro-artefactual inclusions in these deposits show the greatest variation. Some have none, as in external area Sp25 in T13 which was used exclusively for discard of organic waste comprising plant remains and omnivore coprolites, at least some of which are human (Chapter 13). Others have predominantly shell or burnt aggregates. The most diverse inclusions are in external area Sp27 in T10 deep sounding (Fig. 12.27).

Occupation deposits that include specific indicators of craft activities have been classified as Deposit-type 14 at other sites, such as a pottery-production area in the Bronze Age urban site of Abu Salabikh (W. Matthews 1995) but no clear craft-related only deposits have been identified at Bestansur.

Fire-installation structure and in situ *fuel (Deposit-types 15–16)*

Fire installation structures (Deposit-type 15) and *in situ* fuel were sampled across the site. Some Fire installations were small and lined with clay plaster that was rubified (Deposit-type 15.1) as found in T7 (Chapters 9 and 16). Larger installations were either ovoid and lined with thick clay packing as in T10 Sp44 F16 (Deposit-type 15.2; Fig. 12.11a), or constructed as a small rectilinear 'room' within a building such as B5 Sp48 F18 made from mudbricks with a plaster lining (Deposit-type 15.3; see Figs 12.30 and 12.33). *In situ* fuel in these larger installations comprises predominantly phytolith-rich ash (Deposit-type 16.1) as in F16 (Figs 12.13b and 12.33 below) and/or calcitic ash rich deposits (Deposit-type 16.2) as in F16 (Fig. 12.11a) and in F18 (Fig. 12.14b).

Destruction/room fill (Deposit-type 17) and roofing materials (Deposit-type 26)

Collapsed walls and room fill are grouped together as Deposit-type 17. Examples include: collapsed walls with adhering wall plaster in T10 B5 Sp50 (Fig. 12.20d) and possible roofing material with 10% plant impressions/humic remains either made from greenish silty clay (Deposit type 26.1; see Fig. 12.29) or orange-brown silty clay also in Sp50 (Deposit-type 26.1).

Miscellaneous (Deposit-type 21)/indeterminate (Deposit-type 22)

Soot accumulations on wall plasters have been classified as Deposit-type 21.1 and have been observed on the last wall surface of B8 Sp56 W56 (see below Fig. 12.33) and at Shimshara, discussed below. No other deposit-types in these categories have yet been assigned at Bestansur as most deposits to date have been classifiable.

Built environment: microstratigraphic analysis of space use

Interpretation of space use

Excavation and sampling of 13 trenches has enabled study of variation in the creation and use of space in this early built environment across different sectors of the community. Key characteristics of the built environment layout and uses of space are examined briefly here, with selective comparanda. Their wider environmental, economic, social, political and health implications are explored in greater detail in the discussion sections. This section examines first the general characteristics of the layout of the settlement and exterior and interior spaces, then highlights key observations on use of space in the different sectors of the site.

As at other sites, micromorphological analysis of surfaces and accumulated deposits is providing important insights into, firstly, how these sequences were formed and altered, as this is fundamental to interpretation of their significance and associations (W. Matthews 1995; Schiffer 1996; Shahack-Gross 2017) and, secondly, into built environment use of space, management, living conditions and health, and social relations and economic and cultural activities (W. Matthews *et al*. 1997a; Karkanas and van der Moortel 2014). There must be reservations about the precise representativeness of even micro-residues of *in situ* activities due to the ongoing removal and discard of materials from one place to another as argued by Milek (2001; 2012) and Shillito (2017). It nevertheless remains the case that surfaces are indicative of intended uses of space and bear the imprint of actual uses of space, and that accumulated residues document traces of the history of both the utilisation and concepts of place as architects themselves argue (Leatherbarrow and Mostafavi 2002; Littlefield and Lewis 2007).

The challenge is to evaluate and account for the diverse origin and deposition of materials, which can be inferred by study of their size, articulation, form and traces of alterations such as burning, abrasion, fragmentation and weathering (Schiffer 1996). Key indicators examined in this study include observations from case-studies in ethnoarchaeology, experiment and formation processes. As examples, the greater the intactness of fragile articulated remains, such as ash and phytoliths and charred epidermises for example, the greater the likelihood that these deposits represent *in situ* materials or materials that have not been transported far from their point of origin and represent specific activities (Butzer 1982; Schiffer 1996; Mallol *et al*. 2013). Discarded materials often exhibit unoriented random distribution (Shahack-Gross 2017); whilst comminuted deposits have been mechanically fragmented by trampling or other post-depositional disturbances (Eren *et al*. 2010; Mallol and Henry 2018). Rounded aggregates indicate abrasion, often by wind water or sweeping for example (Mallol *et al*. 2007).

Significant spatial variation was observed in the types of microstratigraphic sequences of floors/surfaces and occupation residues that were laid and accumulated in particular areas of the settlement at Bestansur in external and internal areas (Tables 12.2a–b). These variations in surfaces and accumulated residues and inclusions are used in interpretation of the built environment in different sectors of this early sedentary settlement at Bestansur in the following sections.

Built environment layout

Of the 11 sectors excavated with Neolithic occupation levels, ten included open areas and eight had buildings (Fig. 12.25). This suggests that exterior spaces were important loci for the community and many activities. All buildings were rectilinear and constructed on the same orientation, with corners aligned approximately to the cardinal points, suggesting shared community-wide concepts and co-operation in the organisation of the built environment. Buildings were constructed abutting one another in Trench 10, as at sites such as Çatalhöyük (Hodder 2010). This arrangement would have provided potential environmental and structural advantages and created dense habitation areas. Building units were often constructed and defined by separate walls, often of different construction material sources (Figs 12.25 and 12.33). No shared party-walls have been identified to date, unlike at Ganj Dareh *c.* 7900 BC and Jarmo *c.* 6500 BC. All buildings had access to at least one open area or thoroughfare. Few midden-like areas have yet been identified within the settlement, in contrast to a range of Neolithic sites such as Jarmo and Anatolian sites such as Aşıklı Höyük and Çatalhöyük.

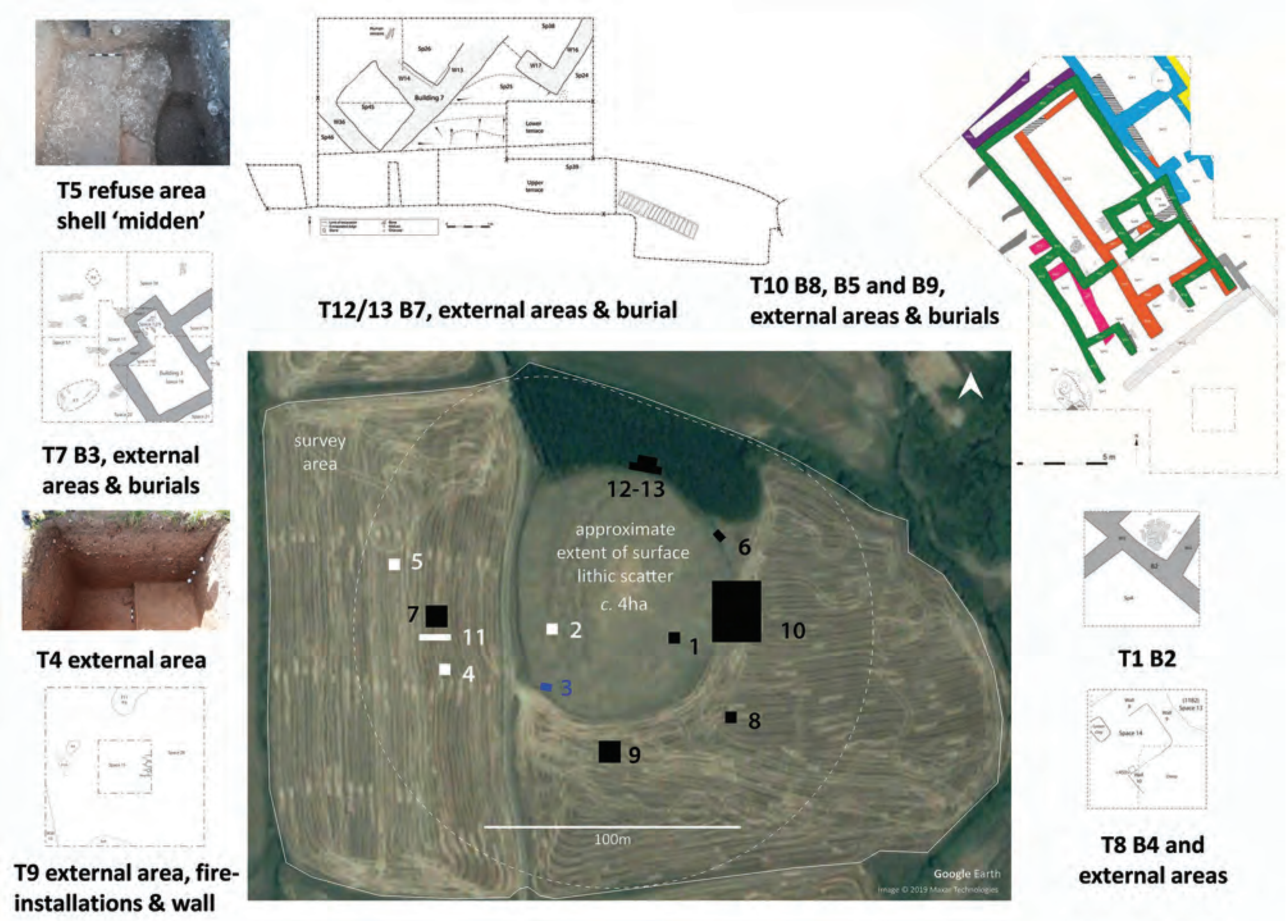


Figure 12.25. Built environment at Bestansur: Buildings and external areas. Trenches with Neolithic architecture highlighted in black. Note similar cardinal orientation of all buildings.

External spaces

No extensive or long-lived midden areas were identified in the first phase of the project, although possible areas with discard post-Building 5 are being exposed in the southwest of Trench 10 in the new phase of excavations (2019–2023). Only short-lived midden-like deposits were encountered during the first phase of the project. A linear spread of *in situ* molluscs in T5 Sp7 that covered >4m^2, represents specialist mollusc processing with few microscopic traces of any other activities (Figs 12.18a–b and 12.25), but is only 5–10cm thick, and does not form a shell midden characteristic of many hunter-gatherer sites, although assumptions about shell-middens are being deconstructed (Villagran and Ximena 2014). These T5 shell deposits resemble specialist midden/refuse deposits as they comprise *c.* 80% well-preserved shells and only sparse traces (2% or less) of other activities including omnivore coprolite fragments, burnt and non-burnt plant remains and traces of ash. Other midden-like deposits include discard of high-temperature fuel in a layer *c.* 10cm thick in T9 Sp15 (C1158 SA286.3), T8 Sp57 (C1180 SA350, Chapter 16), and >*c.* 25cm deep organic-rich deposits in T13 Sp25 (Fig. 12.26).

Otherwise, external occupation deposits often represent thin-accumulated lenses of trampled activity residues covered by the residues from the last activity prior to resurfacing, which may be better preserved as they were often not cleaned away and were covered by a layer of packing that protected the components. Examples of this include the oven rake-outs in T10 Sp44 (Fig. 12.32) and accumulations of diverse activity residues in T12/13 Sp39 and the clusters of *in situ* activities preserved in Trenches 7 and 9 (Chapters 9 and 16).

One distinctive exterior deposit at Bestansur is the blackened surfaces and thin lenses of charred plants observed in T8 Sp13 C1182, T10 Sp44, T12/13 Sp24, and T13 Sp24 C1794, C1491 (Fig. 12.26) and Sp25 C1485. These deposits resemble those described by Moore and colleagues (2000) at Abu Hureyra as 'black plasters'. At Bestansur it is the surfaces of underlying thick and thin packing that are blackened and the thin residues on them that can include up to 50% charred plant remains (Figs 12.10 and 12.26). Some surfaces appear to have been rubified or blackened intensely in patches, suggesting direct heat either from the charred material or fire-spots

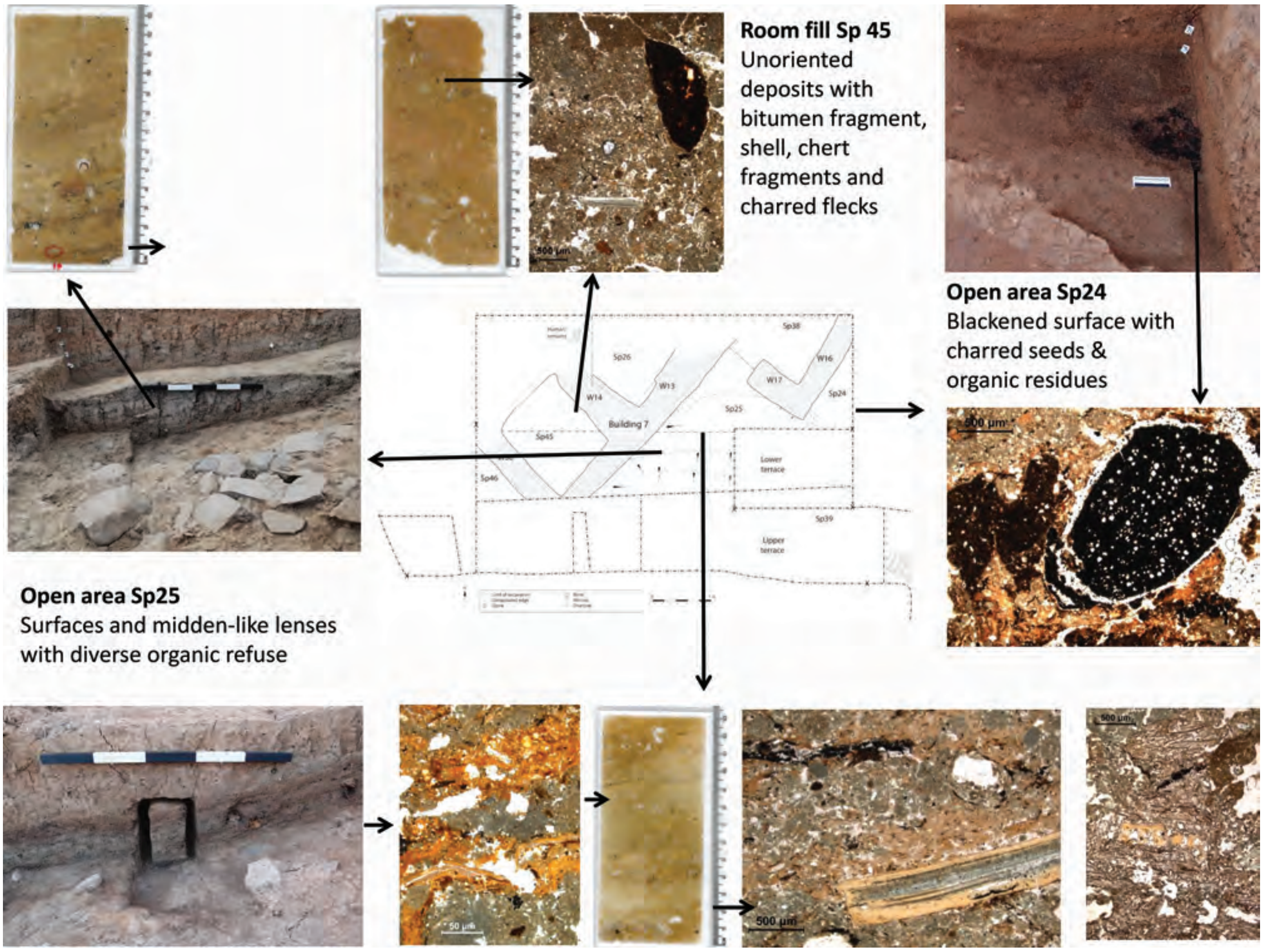


Figure 12.26. Trench 13 microstratigraphic sequences in built environment and thin-section samples. Open area Sp25: SA1501 C1581, C1582 (top); SA1503 C1580 (lower); Sp45: SA1503 C1580; Sp24 SA1289 C1479 (all PPL).

from *in situ* burning or use of hot rocks, discussed above and below. Mallol and colleagues (2007; 2018) have highlighted the importance of distinguishing between surfaces underlying fires that have been blackened by heat transfer and charring, on the one hand, and blackened residues from deposits of fuel and fuel rake-out, on the other, as the underlying earlier blackened deposits may be unrelated to any burning event yet be all that remains. At Bestansur in the field and in thin-section it is often possible to distinguish between these types (Fig. 12.10), although the challenge is in how to sample them for bulk flotation as many accumulated residue deposits are <1–2cm thick. One solution at Bestansur was to collect duplicate archaeobotanical block samples for *in situ* analysis and dissecting in the field and specialist laboratories as outlined in the methodology and future direction sections.

All external spaces were paved with thick or thin-layers of silty clay loam referred to as 'packing', Deposit-type 4, usually repeatedly (Fig. 12.26). Fired lime was also used for external surface renders, notably in T10 Sp27 and in areas adjacent to Building 8 to the west and would have provided a durable water-proof surface (Fig. 12.27).

Gravel was used as hard core at the base of the slope in Sp27 (Fig. 12.27) along a routeway to B8 and B5, which had formed a slight depression likely to have retained moisture after rain, as used for many pathways and non-tarmacked roads today. Some entrance portico surfaces were plastered with silty clay loam plasters with plant impressions that would have provided considerable tensile strength and flexibility (e.g. T10 B8 Sp54 SA585.1; Fig. 12.34). Ethnoarchaeological research in the Zagros has shown that exterior surfaces may be plastered, especially close to buildings, and used for a range of domestic and food processing activities as well as for reception (Kasraian and Arshi 1993: fig. 15). Some surfaces were also covered with mats attested by extant traces of phytoliths and humic plant remains in the entrance portico (Fig. 12.22h–k; T10 B8 Sp54), and pigments T12/13 Sp39 (Fig. 12.24d).

Accumulations of occupation deposits on packing layer surfaces and between packing layers are currently often only *c.* <2–4cm thick. These occupation

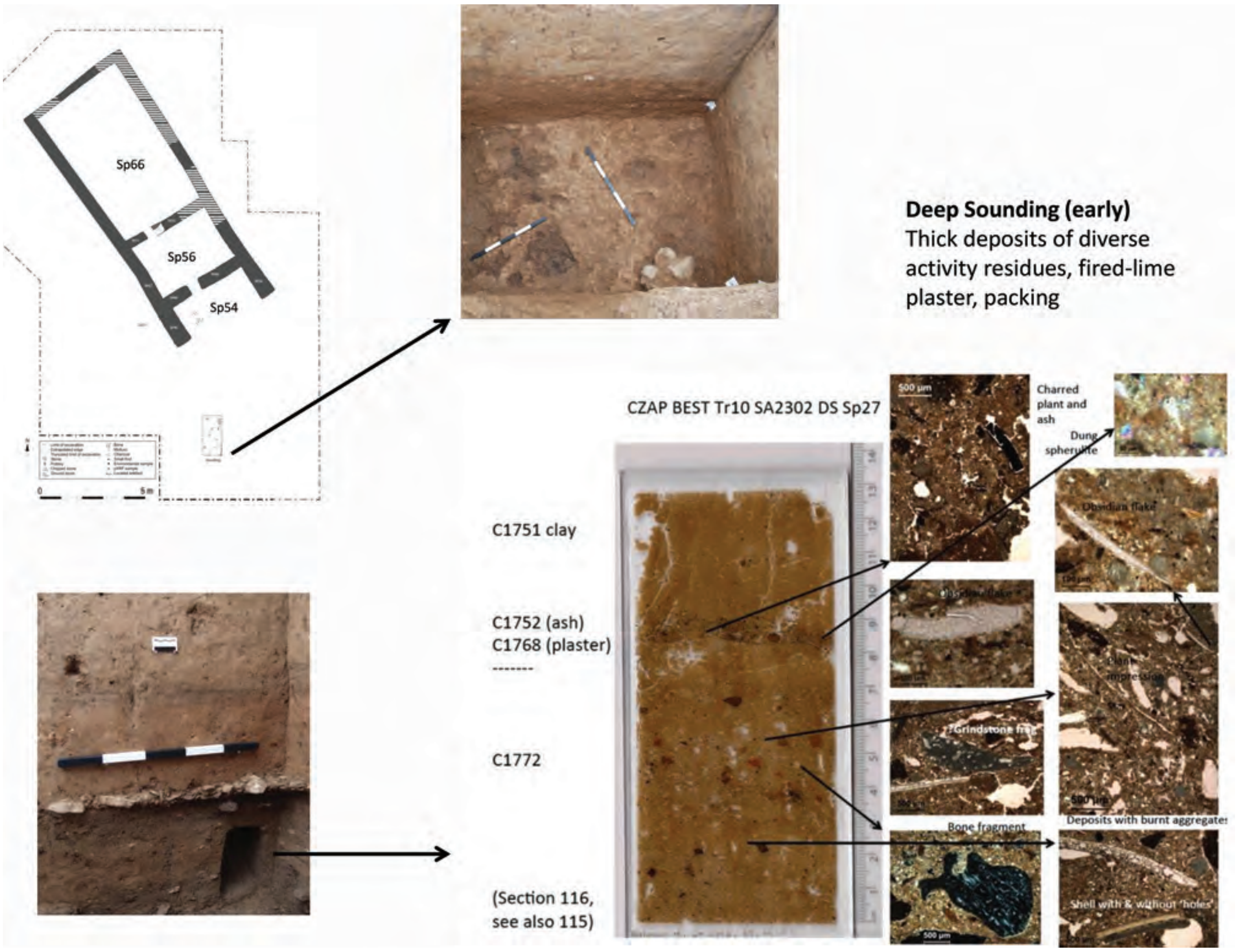


Figure 12.27. Deep Sounding Sp27 Trench 10. Microstratigraphic sequences and built environment, including surfaces of fired lime plaster (top) and gravel (lower left), and thick accumulations of diverse activity residues.

layers are likely to have been thicker when originally discarded due to degradation of organic materials (Schiffer 1996; Stein and Deo 2003) but still do not represent the extensive midden-like deposits found on many sites, that can be up to several metres deep, as at Jarmo, Çatalhöyük and Aşıklı Höyük.

Only one speculative temporary *in situ* animal penning area has been identified to date within the settlement, towards the end-life of B9 Sp53, although this is mixed with sediments and a range of micro-artefacts and was a multi-purpose area.

Other specific activities identified within external areas include: lithic and worked stone debitage in T10 Sp27 early and late (Figs 12.27 and 12.32 below) from craft working; fragments of lightly burnt clay shapes in T10 Sp44 mixed with other burnt aggregates and oven rake-out (Fig. 12.32). Red pigment has been identified widely scattered in deposits and may have been used to pigment object and materials, as a symbolic material in its own right (discussed below), as well as to start fires as it can help to ignite sparks. Large bone from butchery waste was identified in samples from T9 (Fig. 12.17a–c).

Building spaces

Eight Neolithic buildings were excavated in the first phase of the project (Fig. 12.25). Seven were sampled for micromorphological analysis, Buildings 2–5 and 7–9. The results from analyses of these are summarised in Table 12.2, and reviewed for each sector here and in the discussion section on the built environment and social relations.

Cross-sector comparisons (Fig. 12.25)

Western and south-western sectors

The western and south-western sectors of the mound comprise a range of at least partly free-standing buildings surrounded by open areas up to at least 6 × 5m in extent.

Trench 5: 'Shell-midden'

An open area, at least 2 × 2m in Trench 5 was used

Table 12.2a. (continued on next two pages) External area use of space interpretations at Bestansur based on floors surfaces, micro-residues, space location and size and associated features.

Floors/ surfaces	*Occupation deposits*	*Location*	*Type-sample Thin-section SA*	*Adjacent features*	*Use of space Interpretation*	*External/ Internal*
EXTERIOR SPACES						
None	40–80% molluscs, <5% charred wood and ash, <2% omnivore coprolite	T5 Sp7 C1078	447		Mollusc processing and discard	External
Packing (heterogeneous)	thin layer of compacted non-burnt microlaminated animal dung	T10 Sp53 Late C1758	2297		Temporary animal pen/multi-purpose room	External/end-life of building
	thick layers of ash with burnt aggregates, and sparse burnt occupation residues including omnivore coprolites	T10 Sp53 Late C1757	2297		Discard of burnt fuel and occupation residues	External/end-life of building
	a) 10–30% charred plants and seeds, with ashes, burnt bone; b) micro–lenses	T10 Sp44	2312	F16 (SA2298)	Food preparation and cooking area	External
	Fragmented molluscs, patches of ash and charred remains, burnt and non–burnt aggregates, sparse lithics and bone, sparse red ochre flecks	T4 Sp6	SE352-3		Open trampled area adjacent to places with FIs, mollusc processing, craft activities	External
	b) >40% plant remains predominantly ash and phytoliths, 2% charred epidermises and dung spherulites and 5–10% burnt aggregates	T9 Sp15/28 C1158	286		Short-lived fuel discard area from high-temperature burning	External
	Clusters: molluscs, fire-spots, ash and probable omnivore coprolite (SE)	T7	SE 354, 652, 657, 673, 675, 678-9, ?818	Fire-spots	Open area with places for fire-spots, mollusc processing, lithic working, butchery, marrow extraction	External
	a) 10% large bone fragments, 2–5% molluscs, 2% charred plants; b) 10–20% burnt aggregates, 2–5% burnt bone, 2–5% molluscs ,>32% burnt plant remains, red pigment flecks (C1152), <2% omnivore coprolite	T9 C1151-3	285		a) butchery and bone-processing areas; b) discard from cooking of meat and fish and molluscs, and burning of domestic waste including coprolites	External
Packing reddish brown/brown (thick)	a) Ash layer with well-preserved articulated phytoliths; b) burnt/blackened occupation deposits and surface	T10 Sp29 a) C1330; b) C1409	SE Type 3.3. 3.1	Fire-spots	Area with fire-spots for diverse food and craft activities	External
	Thick ash layer	T8 Sp57 C1180	SE350		Fuel discard area	External

Table 12.2a. (continued from previous page, and overleaf) External area use of space interpretations at Bestansur based on floors surfaces, micro-residues, space location and size and associated features.

Floors/ surfaces	*Occupation deposits*	*Location*	*Type-sample Thin-section SA*	*Adjacent features*	*Use of space Interpretation*	*External/ Internal*
	Discrete lenses of FI rake-out: a) 50% burnt aggregates, 5% charred plants and 10–20% ashes; b) well preserved phytoliths (C1384); c) 50–60% ashes, with melted silica	T12/13 Sp39 (a) C1523, C1386; b) C1384 c) C1519;	1499 1287-1288		Well-preserved fuel-rake-out from a) low-moderate temperature burning, ; b) moderate temperature burning c. 400-750C ; c) high temperature burning	External/ Indeterminate
	a) *c*. 50% charred plants including seeds with sparse organic remains; b) linear charred plants, organic residues and diverse occupation	T13 Sp24 C1479 b) T13 Sp24 (C1521)	1289 1502		a) Food cooking, low temperature burning b) Diverse activities	External
	Charred plant remains and burnt aggregates	T8 Sp13 C1182	SE360		Area with low-temperature burning fire-spots, rake-out	External
	a) lens with >50% ash, 10% phytoliths some melted, sparse bone and shell; b) micro-lenses with ash and sparse burnt bone and red pigment flecks	T9 (basal edge of pit F11)	1290		a) Traces of fuel rake-out from high temperature burning; b) Dust and occupation residues compacted below mats	Indeterminate
	Unoriented layer of burnt plant remains and sparse lithic and bone	T12/13 Sp39 C1514	1499		Trampled fuel rake-out and occupation deposits	Indeterminate
	Water-laid lenses and micro–banded finely comminuted occupation residues	T10 Sp52 C1609	1635		Rain-wash and trampled occupation deposits adjacent to wall face	External
	Surface/floor covering: red pigment	T12/13 Sp39 C1378	1288		External reception area	External
Packing reddish brown/pale brown (thin)	Discrete micro–lenses with a) omnivore coprolites 20–40%; b) molluscs 10–30%, burnt plant remains, bone and red flecks C1514	T12/13 Sp39	1499 [9-12]		Diverse short-lived activities and discard, probably from everyday activities and domestic refuse	
	Ash and craft debris	T10 Sp27	1283		Cooking and craft debris	
with plaster floor and mat impressions	a) Well-preserved ashes and burnt aggregates with chipped stone (C1732, C1627); b) micro-lenses (C1725, C1627)	T10 Sp43	1798		a) FI rake-out b) Trampled compacted surfaces	
Packing pale grey silty clay loam	Discrete lenses of a) omnivore coprolites >30–50% (C1494, C1581); b) phytolith-rich layers up to 50–60% – some desiccated some melted (C1494, C1581); c) burnt bone in ashes (C1485)	T12/13 Sp25	1286, 1501		Open area with periodic discard of burnt and non-burnt plant waste and omnivore coprolites, and covering with lime rich surface	External

Table 12.2a. (continued from previous two pages) External area use of space interpretations at Bestansur based on floors surfaces, micro-residues, space location and size and associated features.

Floors/ surfaces	*Occupation deposits*	*Location*	*Type-sample Thin-section SA*	*Adjacent features*	*Use of space Interpretation*	*External/ Internal*
Fired-lime plaster and packing (heterogeneous)	Ash with charred plants and diverse occupation residues including abundant chipped stone, water–laid crusts	T10 Sp27 C1772	2302		Heavily used external activity surface with accumulating residues, from craft production, food preparation and cooking	External
Thick plaster floors with plant impressions	Thin ash lenses with charred plants and diverse occupation residues including ground and chipped stone	T10 Sp27 C1423	1283		Activity surface with accumulating residues, from craft production, food preparation and cooking	Indeterminate
Gravel	Ashy with burnt aggregates	T10 Sp43 C1540, C1627T10 Sp27 C1740	1798		External surface hard core on pathway	External

for discard of mollusc shells predominantly *Helix salomonica* (Fig. 12.18). The sparsity of microscopic traces of plant remains and bone in thin-section (Fig. 12.35) indicate that this *c.* 5–10cm deep deposit represents discard from intensive mollusc collection and probably extraction from their shells, as supported by the microarchaeological results above and discussion in Chapters 9 and 17.

Trench 7: Open area with activity clusters and Building 3

Twenty-five metres away to the southeast there was a large flat external area, >6m wide, with exceptionally well-preserved clusters of occupation residues that represent specific activity foci, including fire-spots, mollusc processing, butchery and knapping debitage caches, sampled as Spaces 17, 18 and 22 (Chapter 16, SA351). This external area surrounds at least three sides of Building 3, suggesting a comparatively open settlement plan. Building 3 has at least four rooms, including a moderately large room Sp16 with extensive ground-stone artefacts, probably a multi-purpose living/storage room. Other rooms in this building examined include a small room with stone cobbling, Sp12, which may have been used both for storage, based on its surface type, as well as a range of activities based on the diversity of residues, high phosphorus readings and shed goat milk tooth (Chapter 16).

Trench 4: Open area

Twenty metres further south, a long-lived open area, Sp6, was excavated and intensively sampled from the underlying natural, a yellowish brown silty clay loam (Fig. 12.2, SA447), through a deep sequence of heterogeneous packing/levelling layers and distinctive activity surfaces with diverse accumulated residues, notably mollusc shell fragments, lithics, bone, ash and burnt aggregates often lying flat on the surfaces (Chapter 16).

South-eastern sector

The southeastern sector of the settlement also comprises external areas adjacent to buildings, *c.* 80m east of the western sectors, and 100m south of the northern-most sector excavated in T12.

Trench 9: Open area for butchery, food processing and cooking and probable building wall

Most of this trench comprised an external open area with a large oven/fire-installation and distinctive set of hearths F3–5 (Chapter 16). Of the samples studied, here, of particular note is the discard of high-temperature ash (Fig. 12.35; C1158 SA285.3) and specific activity residues including butchery (Fig. 12.17a–c) and cooking of meat, fish and probably molluscs (Chapter 16). A substantial wall made from reddish brown silty clay loam with white aggregates,

Table 12.2b. (continued overleaf) Internal area use of space interpretations at Bestansur based on floors surfaces, micro-residues, space location and size and associated features.

Floors/ surfaces	*Occupation deposits*	*Location*	*Type-sample Thin-section SA*	*Adjacent features*	*Use of space interpretation*	*External/ Internal*
INTERIOR SPACES						
Gravel	Not sampled	T10 Sp42	––		Recess exposed to external areas	Exterior/ interior
Packing heterogeneous	Unoriented diverse occupation deposits including molluscs	T13 Sp45 C1580	1503		Storage room/multi-purpose room	Interior
Packing reddish brown with gravel and plant impressions	n/a (structural foundation)	T10 B5 Sp50	2300, 2603	Interior wall	Structural lining to provide protection against a) burrowing pests; b) damp	Interior
Packing with large stone inclusions	Mixed	T8 B4 Sp14	451, SE450		Storage room/multi-purpose room	Interior
Levelling/packing	None/truncated	T10 B5 Sp49	1799 (upper)		Storage room with scoured floor	Interior
Stone cobbling	Sparse, mixed	T1 B2 Sp3	SE		Storage room/multi-purpose room	Interior
		T7 B3 Sp12 (C1100)	SE351		Storage room/multi-purpose room	
		T7 B3 Sp16	SE375		Storage room/multi-purpose room	
Thick plaster floors and traces of matting	Compacted layers and micro-lenses of diverse burnt and non-burnt residues	T10 B8 Sp54	2585	Entrance portico	Entrance with deposits from exterior and interior spaces	Exterior/ interior
Thick plaster floors	a) Water-laid crusts; b) micro-banded occupation deposits	T10 B5 Sp41	1788		Alcove in front of building	Exterior/ Interior
	a) Water-laid lens; b) Heterogeneous fragmented occupation residues with burnt fuel, shell and red-pigment	T10 B5 Sp47	1794	Entrance	Entrance room	Interior
	Thin and thick (15mm) lenses of diverse occupation deposits with 2-5% burnt plants, dung ash, rounded burnt aggregates, 2% omnivore coprolite, sparse non-burnt bone some fish, shell, chipped stone, red pigment	T10 B5 Sp60	2315	Recess	Recess with diverse occupation deposits and sparse yellowish organic matter	Interior
	Micro-lenses of occupation deposits with sparse charred plants and heterogeneous occupation residues and sparse red pigment	T10 B9 Sp53 Early C1763	2314		Reception/living room	Interior
	Diverse occupation residues [18]	T10 Sp63 Late C1748	2313		Mixed activity	Indeterminate

Table 12.2b. (continued from previous page) Internal area use of space interpretations at Bestansur based on floors surfaces, micro-residues, space location and size and associated features.

Floors/ surfaces	*Occupation deposits*	*Location*	*Type-sample Thin-section SA*	*Adjacent features*	*Use of space interpretation*	*External/ Internal*
Thin plaster floors, irregular	Thin lenses with red pigment/floor covering, sparse finely cominuted occupation residues	T10 Sp63 Early	2313		?Ritual area	Indeterminate
Thin-plaster floors	Thin lenses with rounded rock fragments, sparse fragmented shell and bone	T10 B5 Sp50 WC	2300		Reception room	Interior
with traces of mat impressions	a) None/traces of compacted 'dust'	T10 B5 Sp50 C	1800		Reception room	Interior
	b) Human bone fragments identified during field microstratigraphic analysis	T10 B5 Sp50 CE	*2430*		Reception room with traces of laying out of human bodies/burial	Interior
Thin-plaster floors, one white	c) Thin lenses with sparse charred flecks, humic plants and red pigment	T10 B5 Sp50 NE	2301		Reception room with some traces of burning and burial	Interior
with traces of pigmented matting	d) Thin lenses with burnt plants and burnt fish bone, and non-burnt mammal/?human bone and red pigment	T10 B5 Sp50 NW	2414	burial cut	Reception room with some traces of burning and ritual	Interior
with traces of pigmented matting	a–c, e) <20% charred plant remains and 10% humic plant remains on latest floors with red and yellow pigment traces	T10 B5 Sp50 NW	2603	upright white stone SF764	Reception room with some traces of burning and ritual	Indeterminate
WALL SURFACES						
Burnt silty clay loam plaster lining	Well-preserved lenses of articulated phytoliths, ashes, melted silica and burnt orange aggregates	T10 Sp48	1782, 1778,		In-situ fuel from high-temperature burning	Indeterminate
White wash on grey silty clay plaster base		T10 B5 Sp50	2301		Reception room	Indeterminate
Multiple thin plasters of varying colour, white wash and red wall painting	Soot on last wall face	T10 B8 Sp56	1799		Entrance room	Indeterminate

W15, was revealed in the southwest corner of the trench, which is probably the external wall for a building, as it is >38cm wide (Aurenche 1997). It was aligned slightly northwest to southeast, like other buildings on the site, and made from the same reddish brown silty clay loam with white aggregates as many of the later buildings excavated across the site including Buildings 3, 4, 5 and 7 in Trenches 7, 8, 10 and 13.

Trench 8: Building 4 with small room and external areas

Approximately 20m northeast, Building 4 was constructed adjacent to an external area. The external area included a distinctive blackened surface with charred remains C1182, similar to surfaces recorded at Abu Hureyra, discussed above and below. Building 4 included a small room, with thick packing with large stone hard core (Fig. 12.35 below), probably used for storage given its small size, as well as multi-purpose activities given the traces of ash and lithics on the last surface (C1185 SA451). Prior to Building 4, there is evidence of earlier buildings and discard of ash in an adjacent external area, Sp57 C1180 (Chapter 16), probably from a nearby oven given the preservation of charred and ashy plant remains in these deposits (Chapter 9).

Eastern sector

The eastern sector comprises a neighbourhood of dense abutting buildings, with some open areas and thoroughfares, in contrast to the partly free-standing buildings in the western sector.

Trench 10 Dense abutting buildings, open areas and thoroughfares

In Trench 10 we have revealed at least four abutting rectilinear buildings. The focus of excavations was on a sequence of large buildings, Building 8 then 5, and the open area in front of them to the south, Spaces 27 and 44, where accumulated deposits from a diverse range of activities were identified in thin-section. Of particular note, the earlier building, B8 had multiple sequences of coloured wall plaster and whitewash and traces of an as yet unexcavated wall painting (Godleman *et al.* 2016). The later building, B5, was significantly enlarged from *c.* 55.7m^2 to *c.* 100m^2, with a wider more open entrance, and larger reception room, below which >78 individuals were buried, 65 of which are reported on in this volume. The micro-stratigraphic life-history and significance of these buildings are examined in detail in the discussion section on sedentism and ritual.

Northern sector

The earliest phase of occupation investigated in the north of the settlement includes external areas with organic rich refuse and the southern part of a multi-roomed building, Building 7. The use of these external areas varied spatially. Ash from high-temperature burning was discarded in the west, Sp45. Organic rich refuse with alternating lenses of omnivore coprolites, well-preserved and articulated burnt and non-burnt phytoliths from reeds and grasses, and activity residues such as burnt bone was discarded in Sp25 and periodically covered in lime-rich sediments. In the west, in Sp24 food was processed and cooked leaving charred residues and blackened surfaces that were periodically sealed by thicker layers of packing that also provided a new working surface.

The later phase of occupation in Sp39 T12/13 is characterised by remarkably rich sequences of fine surfaces made from a range of brown, grey and white silty clay–silty clay loam, *c.* 1–2cm thick, and accumulated lenses of diverse activity residues that represent everyday and seasonally specific activities (Chapter 9).

In thin-section, most notable from this sector are firstly, the omnivore coprolites (Fig. 12.16) some of which are human, one of wild boar/pig (Chapters 13 and 16), as these are providing new insight into diet and health, and secondly, the well-preserved phytoliths and blackened surfaces with charred remains as these are providing important new information on energy use, human and animal diet and plant taphonomy, all of which are discussed above and below in the respective sections on these materials and themes.

Cross-sector comparison: summary

In total 68% of the excavated area between 2012–2017 comprises external areas, 32% buildings. When different sectors are compared it can be seen that a diverse range of activities were conducted at Bestansur in exterior areas and within buildings, and that the eastern sector at least included a dense cluster of abutting buildings. At least one of these was elaborate and capable of hosting public-scale interactions, and was rebuilt and aggrandised, Building 8 succeeded by Building 5. No deep midden accumulations have yet been encountered, in contrast to many Early Neolithic sites.

Discussion

The following sections discuss in turn how this new high-resolution micro-contextual evidence is providing important insights into early sedentary built environment sustainability, social relations, and health as well as resource management, diet and sustainability.

Sustainability of early sedentary agricultural communities

A major aim in the micromorphological research detailed in the preceding sections is to investigate how early sedentary communities were created and sustained through high-resolution forensic-scale analysis of the built environments that they constructed and occupied, in order to increase the range of evidence and temporal resolution with which to examine ecology, social relations and health.

Built environments provide capacity to create shelter in diverse climates, environments and places, and to shape settled life, socio-cultural and political relations, living conditions and health (Lopez 2012). A major global challenge today is to construct housing and settlements that are sustainable environmentally, economically and socially and that improve rather than negatively impact living conditions and health as outlined in the 17 UN Sustainable Development Goals (SDGs; United Nations General Assembly 2015), notably SDG 6 'Clean water and sanitation' and SDG 11 Sustainable communities. Early sedentary communities would also have faced sustainability and health challenges, although for much smaller populations. Specific built environment challenges would have included the development and construction of buildings and settlements that could withstand and where possible mitigate extreme heat (>50°C) and cold (<–18°C), damaging storms and flooding, which characterise the region today and in the past (Chapter 3), and adaptation to changing social structures.

To support more year-round occupation, communities would also have to develop social networks and resource provision strategies and technologies and facilities for a range of needs that are examined in this research including: protection of food supplies and materials from environmental and pest damage; energy supplies as fuel scarcity was a major driver in hunter-forager mobility (Byrd *et al.* 2016); waste-management; and creation of healthy living conditions and sustainable communities and social relations.

The following discussion sections examine how microstratigraphic analyses at Bestansur are informing on firstly the nature of early sedentism, society and ritual and built environment design, use, sustainability and health, and secondly on resource management diet and sustainability.

Sedentism, society and ritual: built environment design, use, and sustainability

Sedentism and the built environment

Globally, there was a long history of experimentation and development of living structures in the Palaeolithic with a floruit in the Epipalaeolithic (Hosfield 2016; Maher and Conkey 2019), followed by sparser evidence for settlement in the Younger Dryas cold period. From the start of climatic amelioration in the Early Holocene, however, there was a dramatic increase in investment in built environments and innovation in materials and technology, and evidence of knowledge exchange along networks (Smith 1990; Kozlowski and Kempisty 1990; Özdoğan 1999). In Southwest Asia, these developments included changes in planning and design: from small to large settlements, less than 1ha to more than 20ha; from round to rectilinear architecture; from well-spaced to increasingly dense agglomerations of buildings, and increasingly well-defined often standardised structures/houses that have been argued to represent the emergence of the household as a fundamental social unit (Byrd 2000; Watkins 2004). The earliest structures in the Zagros to date are from Zawi Chemi Shanidar, *c.* 210km to the north (Solecki 1980). These comprise repeated construction of small round buildings *c.* 2m in diameter. During the Early Holocene increasingly large circular then rectilinear structures were built at sites such as Qermez Dere and Nemrik in north Mesopotamian plains *c.* 5–8m in diameter (Watkins 1990; Kozlowski 1990) and Asiab in the high Zagros (Darabi *et al.* 2018).

The buildings at Bestansur are the earliest to date in the Zagros foothills of Iraq and slightly pre-date those excavated at Jarmo. The buildings at Bestansur are much larger and more clearly demarcated, with no shared party-walls, than those at Jarmo (Braidwood *et al.* 1983). The architecture at Bestansur is also remarkably well constructed (Fig. 12.28) with evidence of multiple layers of plaster and traces of wall painting on some buildings. The nature and implications of this are discussed below examining in turn, building construction, design, sustainability, social relations and ritual, and health.

Architectural materials and construction: resource management, technology, and sustainability

The selection of particular sediments and materials from the surrounding environs for very specific architectural elements suggests considerable knowledge of the location and properties of local and regional soils and resources. It is likely that this knowledge was gained not only in prospection for construction materials but also through hunting, foraging and herding expeditions as well as increasing management and cultivation of crops. Through manipulation and preparation of soil for cultivation farmers would have been directly aware of their construction properties and potential such as particle size, stickiness and cohesion (Frodeman 1995; 2004). Key questions examined here include: what was the environmental impact and sustainability of construction and how were construction material resources managed in relation to changing land ownerships and land management strategies including increased cultivation, and can study of construction materials in turn inform on these? Another issue is what materials and technologies were employed and what were their performance

Figure 12.28. Built environment in Trench 10 and photogrammetry of Building 5 (courtesy of Sheri Pak) Scale = 2m. Looking northwest and southwest.

properties with regard to sustainability, living conditions and health, and sociocultural relations and creation of communities?

All Neolithic walls uncovered across the site were earthen, although stone is available in the adjacent foothills, <200m away, and was used in Iron Age and Sasanian construction at the site (Cooper 2019). This preference for earthen materials in the Neolithic may be due to its greater proximity, effective hygrothermal insulation properties, and knowledge of traditions elsewhere, discussed below. Some walls, particularly from earlier levels, were constructed from dark grey silty clay from wetland environs, yellowish silty clay that underlies and surrounds the settlement, as well as green silty derived from local local celadonite-bearing marine clays (Chapter 3; Saeed Ali 2008: 72–77, fig. 3.2, after Sissakian 2000).

Later walls, by contrast, were constructed from reddish brown silty clay with white aggregates (Fig. 12.29), from local hill slopes <200m from the site environs. This shift may be due to changing land use, access and ownership, and indicate community-scale decision-making, consensus and co-operation in selection of materials (DeMarrais 2016; Halperin 2017). The lower organic matter content of these soils may suggest they were less highly valued for agriculture and indicate increased cultivation on the more diverse soils used previously for building material sources, as argued for a similar shift in construction material selection at Çatalhöyük (W. Matthews 2005).

One of the challenges faced by the Neolithic builders would have been the high expandable clay content of the local earthen materials, identified by XRD analyses, as these are prone to shrink-swell action and potential cracking and instability (above and Chapter 13). Some walls were made from prefabricated sun-dried mudbricks, which would have reduced shrinking and cracking within the walls (Castrillo *et al.* 2017). Other walls at Bestansur were made from packed earth in strips 8–10cm thick (pisé/tauf/chineh), as in T7 B3, T10 B8 and T13 B7. Packed/rammed earth walls are formed from materials that dry *in situ* and require less water than mudbricks (Walker *et al.* 2005). These walls therefore may have shrunk less on drying than individual mudbricks and would also have placed less demand on water resources, potentially providing a more sustainable construction option (Walker *et al.* 2005). This aspect could have been a consideration at Bestansur, as the summer months are the preferred time for construction, due to labour availability and warm weather for drying construction materials, and there is evidence of climatic aridification *c.* 7200 BC during the later periods of occupation at the site (Chapter 3; Flohr *et al*. 2017).

Micromorphological analyses of both mudbricks and packed earth walls, as well as many earthen plasters, reveal that these construction materials included traces of linear and curvilinear plant and/or fibre remains, which would have provided added tensile strength and flexibility and helped to control shrink-swell action (Houben and Guillaud 1989; Cammas 2018). The highest concentrations were added to earthen plasters on floors in entrance rooms, which would have withstood more effectively heavy traffic (Fig. 12.30). As at many archaeological sites, these plant/fibres have since decayed leaving often only voids or humic traces, which results today in greater susceptibility to cracking and conservation challenges (Chapter 8).

The walls of the earliest building exposed to date, B8, are up to 60–70cm wide and could have supported a second storey, as they are >30cm thick (Aurenche *et al.* 1997). Many other building walls, however, are less than *c.* 40cm and may have had sufficient load-bearing strength, especially where walls abut adjacent buildings as notably in Trench 10.

Traces of roofing are rarely identified at archaeological sites (Friesem *et al.* 2014), probably due to re-use of timbers and the removal of roof material in timber retrieval, as well as the absence in many current open area excavation strategies of sections that may permit identification based on context.

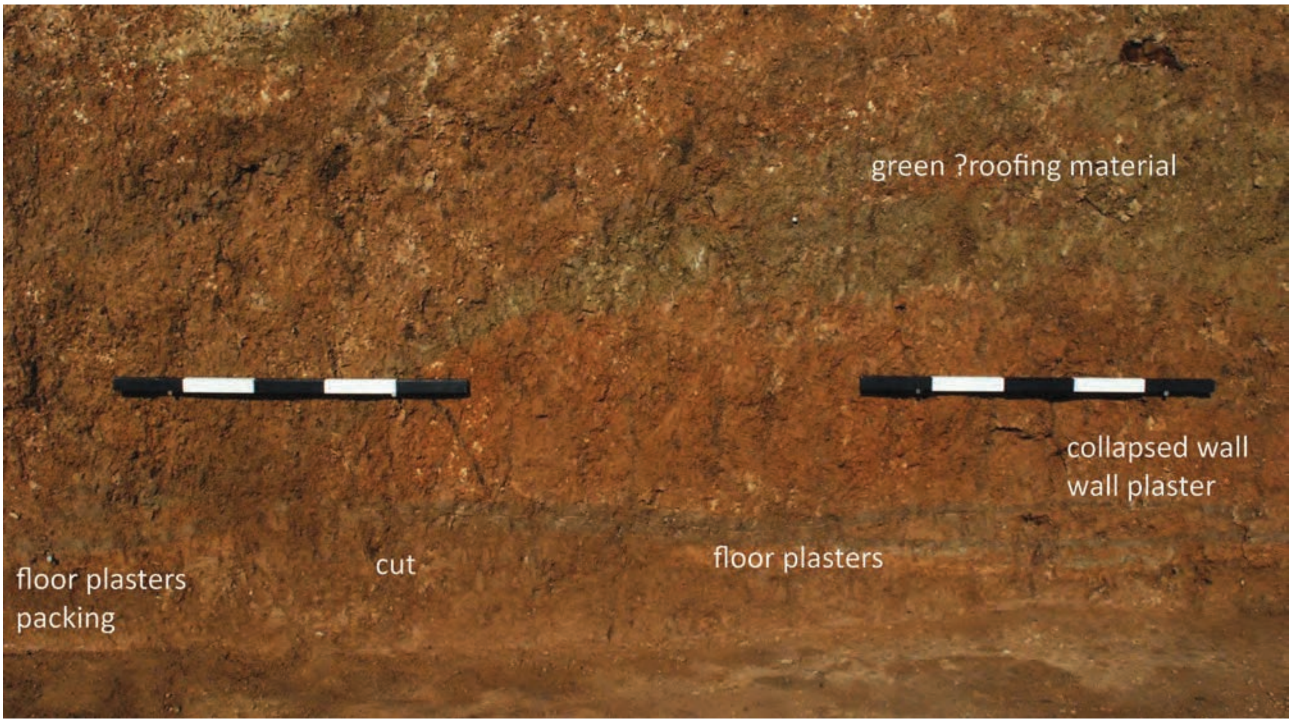


Figure 12.29. Building 5 construction materials and life-history in Space 50 NW corner illustrating packing, floors plasters, burial cut and fill, collapsed wall with grey wall-plaster adhering to surface of reddish brown silty clay loam earthen materials with white aggregates and thin grey mortar lines, collapsed green silty clay roofing material with plant inclusions. Looking northwest; scales = 50cm. Field section 122.

Probable roofing material amongst and on top of wall collapse, resembling ethnographic examples of collapse observed by the author in Cyprus, was identified in a section through room-fill in Sp50 B5 (Fig. 12.29). In the field this green silty clay had abundant traces of humic plant remains and plant impressions, and in the thin-section sample includes traces of these and 2% charred flecks (Deposit-type 26.1). It is likely that this deposit represents a very early example in the development of a lighter earth roof to reduce stress on roofing timbers, a concern in state-of-the-art earthen construction today (Volhard 2015) and to reduce shrink-swell action and cracking. No traces have yet been identified at Bestansur of collapsed sections of flat roof, which are rare on many sites, but can be exceptionally well preserved with traces of well-defined diverse activities on roof tops and an upper storey room as in Building 3 at Çatalhöyük (W. Matthews 2012).

No timbers for roofing or construction members have been found to date as these are often only encountered in burnt buildings, as at Ganj Dareh where poplar beams were identified (van Zeist *et al.* 1986; Smith 1990). A small pit in the northwest corner of B5, set into the wall and gravel edge and flat stones placed on the floor may have been for an interior post for roof support, as may have the flat stones on the latest floor (Fig. 12.23a). If present, interior roof supports may have also provided some wall support and resilience from seismic movement and shock (Walker *et al.* 2005). The roof span of Space 50, at >4.8–5.5m, is larger than that routinely borne by poplar beams whose limit is *c.* 3m (Aurenche *et al.* 1997). The pollen record from Zeribar and Hashilan suggest that the only other timbers that could have readily spanned 4m may have been cut from oak (van Zeist 2008).

The absence of plaster on many exterior wall faces suggests that the compact Neolithic mudbrick and earthen walls were relatively resistant to water ingress and erosion, as at Çatalhöyük (W. Matthews *et al.* 2013f), and supported by the sparsity of water-laid crusts in occupation deposits, discussed above. The exception was the application of multiple layers of coloured plaster on the entrance portico to Building 8, likely to mark its status, as discussed below.

In consideration of the sustainability and life-cycle cost analysis (LCA) and impact of construction, manufacture of earthen walls and plasters in the Neolithic had a very low carbon footprint in contrast to current use of fired bricks or cement, which is the third largest CO^2 producer today, requiring temperatures of up to 2000°C to manufacture (Andrew 2018). The bulk of the earthen source materials and water were available adjacent to the site and little energy other than labour was required to make them (Love 2013). The wetland and colluvial soils from which the bricks and rammed earth were extracted would have required several hundred years to form, and are not therefore readily renewable, and also had agricultural and pastoral value, as discussed above (Maskell *et al.* 2018). Quarry sites, yet to be identified by coring, may have created either unsightly scars and/or stagnant pools capable of breeding malaria, or created biodiverse wetlands that had the potential to enhance settlements as they can today (World Wetlands Day 2018), depending on management.

Manufacture of fired lime plaster, identified by FTIR at Bestansur (Godleman *et al*. 2016) and other Neolithic sites, by contrast would have been costly, requiring twice the amount of fuel as the finished quicklime product to reach temperatures >750°C for 24–48 hours, with the potential to place strain on vegetation and fuel resources needed for food, fodder, heating, cooking and craft production for example (Garfinkel 1987). At Bestansur the use of fired lime plaster was restricted to paving access to the probable high-status Buildings 8 and 5 (Fig. 12.27), due perhaps to these production fuel costs, as the raw material – limestone – was readily available in the immediate area within 200m.

Non-fired white silty clay wall plasters/white washes, <0.5mm thick, were also comparatively rare, and were only applied to the interior wall faces of Buildings 5 and 8, probably due to factors relating to cost-distance or supply chains and territories, as no sources of white silty clay have been identified in the vicinity of the site (Chapter 3; Byrd *et al.* 2016). Other plasters were made from a range of materials, discussed above, and indicate considerable experiment and innovation in materials. The variety of plasters on the walls of Building 8 are particularly exceptional, and possibly used to mark and transform the status (*sensu lato*) of this building and the places, items, events and people associated with it (Fig. 12.22; W. Matthews 1998; 2005; 2018; Boivin 2000).

The early earthen buildings at Bestansur are likely to have been very energy efficient to heat and to maintain and to have provided protection from the seasonal extremes of heat and cold and healthy interiors, as earthen walls have excellent insulation and hygrothermal properties (McGregor *et al.* 2016). The walls of Building 8 are exceptionally thick, at *c.* 70cm, and would have provided particularly effective insulation. The construction of adjacent buildings with abutting walls more widely at Bestansur would have further increased insulation and energy efficiency by reducing the number of wall surfaces exposed to heat and cold, and provided greater stability and resilience to seismic shock from earthquakes which are frequent in the region (Walker *et al.* 2005; Chapter 3). In addition, the orientation of buildings at Bestansur with corners at cardinal points across the site would have minimised exposure to solar radiation, deflecting heat in hot summer months, as practiced in later Mesopotamian settlements in the broader region (Shepperson 2009).

Earthen buildings are known to have stood for up to 50–100 years in the Neolithic at sites such as Çatalhöyük (Hodder and Cessford 2004). Pending more successful dating assays, Building 8 and Building 5 were probably used for at least two decades, as B8 walls were replastered more than 14 times, and B5 floors were plastered >13 times, and the high number of human burial events may attest a long period of use (Chapter 19). In addition, the fire installation in Space 48 had been heavily used with >75cm of finely-stratified *in situ* ash and highly fired walls. Earthen materials are also generally recyclable and were frequently used in Neolithic and later settlements, as at Bestansur, to infill buildings and create a foundation for subsequent building, creating a settlement mound or characteristic tell.

Built environment planning and household and community social relations and ritual

There is some evidence at Bestansur for collaboration in the construction, placement and clustering of buildings, as at a range of other Neolithic sites in the northern Fertile Crescent (Stordeur 2015; Halperin 2017). All buildings across different sectors of the settlement at Bestansur were placed on a similar orientation, suggesting shared community-wide concepts in spatial configurations (Fig. 12.25). The rationale for this may have included intersecting agreement on ways in which this orientation was preferable in relation to the impact of solar insolation or wind in the built environment, for example, and/or symbolic, cosmic or social worldviews as is common in many societies (Hastorf 2001; Shepperson 2009; Peuramaki-Brown 2013). This evidence of similarity provides some insight into how cooperation and collaboration (Halperin 2017) may have helped to create a community and social sustainability at the early sedentary settlement Bestansur, through coordinated agreement and construction of buildings on an approximately rectilinear grid.

At the same time, the community at Bestansur were creating clusters of well-defined rectilinear building units, with separate, often abutting walls and independent core facilities such as ovens. This architectural configuration suggests that the household as a community and network associated with particular buildings was emerging as a fundamental social unit, as in other regions of Southwest Asia (Byrd 2000; Bogaard *et al.* 2009). The concepts and configurations of households in the Neolithic are currently being revised as it is increasingly evident that individuals buried together within particular houses need not be genetically related (Pilloud and Larsen 2007; Chylenski *et al.* 2019). The high number of primary and secondary burials below the floor of

Table 12.3. Effect of distance on perception and social interactions (after Fisher 2009: table 1, which is based on Hall 1996: 116–129).

Proxemic threshold	Intimate	Personal	Social (near phase)	Social (far phase)	Public (near phase)	Public (far phase)
Distance	0–0.45m	>0.45–1.2m	>1.2–2.15m	>2.15–3.65m	>3.65–7.6m	>7.6m
Touch	Can touch easily; accidental contact is possible	Can reach out and grasp extremity at near phase; cannot touch beyond *c.* 0.75m	Two people can pass an object back and forth by both stretching (up to *c.* 3m)			
Oral/aural	Soft voice; intimate style	Soft to conventional voice	Conventional modified voice; casual or consultative style		Loud voice used when speaking to group	Full public speaking voice; frozen style
Detailed vision (foveal)	Details of eyes, pores on faces, finest hairs visible; vision can be distorted or blurred	Details of face clearly visible	Can see head hair clearly; wear on clothing apparent	Fine lines of face fade; lip movement seen clearly	Eye colour not discernible; smile vs. scowl visible	Difficult to see eyes or subtle expressions
60° Scanning vision	1/3 of face; some distortion	Takes in upper body	Upper body and gestures	Whole seated body visible		Whole body has space around it in viewshed; postural communication becomes important
200° Peripheral vision	Head against background visible	Head and shoulders visible	Whole body visible	Other people seen if present		Other people become important in vision

Building 5, at >78 to date (65 of which are reported on in this volume), indicate that at least some households at Bestansur were participants in extended networks.

Eight Neolithic buildings were at least partially excavated in the first phase of the project (Fig. 12.25). Seven were sampled for micromorphological analysis, Buildings 2–5 and 7–9 (Table 12.2). The plans of three buildings and 20 interior spaces were recovered in sufficient detail to enable quantitative assessment of building and room size, and the social interactions that these allowed based on proxemic distances and effects on communication (Table 12.3; Fisher 2009: fig. 2; Rappoport 1990: fig. 17; Hall 1966). The buildings at Bestansur range considerably in size from large at *c.* 81.5m^2 to moderate at 57.5m^2 and small at 34.6m^2. The size and plan of all three of these buildings in Trench 10, Buildings 5, 8 and 9 respectively, are similar to those at Tell Halula and Abu Hureyra as discussed below. The general plan of these buildings includes marked entrance porticos, sizeable entrance rooms and a large reception room beyond in the farthest reaches within the building, with additional storage spaces and an interior fire installation in Building 5. The plans of buildings in other trenches are more variable but are all multi-roomed.

Room sizes vary significantly (Table 12.4) from 0.56m^2 to 35.72m^2. With regard to the social interactions that these rooms might allow, five rooms would have provided personal to intimate scale social interactions, whereby one adult could touch another adult within 75cm of each other when standing or sitting. Five other spaces were also very small with a maximum floor space of 2 × 2m, that would have supported personal to social near-phase interactions. A range of these could have served as storage rooms as they were lined with thick packing or stone cobbling that would have restricted burrowing pests, notably Trench 7 B3 Sp12, Trench 10 B5 Sp49 as sparse residues were found on these floors. Stone cobbling in some of these rooms may have also served to raise objects off mud floors, preventing accumulation of any trapped moisture that would otherwise naturally breathe, and/or provided a surface that was partially water-resistant, such as a wash room, although no signs of this have been detected. Long flat stones were used to create a small platform, *c.* 80 × 60cm, within B5 Sp50, close to the entrance and speculatively may have been used to place objects or bodies of the individuals buried within this room. No traces of burning have yet been identified on top of stone cobbling, in contrast to Aşıklı Höyük where stone cobbling was used as a base for fire-spots within buildings (Esin and Harmankaya 1999). Four of these small spaces were entrance or front porticos providing shelter comfortably for at least one or two individuals from the sun or precipitation; one was a recess in an entrance room B5 Sp60. All were paved in tough surface materials: gravel, packing or thick

Table 12.4. Room size and effects on perception and social interactions at Bestansur based on Fisher (2009: tables 1 & 3), with general room-type interpretation based on size, location, surfaces and residues, accepting that rooms are likely to have been multi-functional.

Building no.	*Trench*	*Space no.*	*Room type (general, likely to be multi-functional)*	*Room width*	*Room length*	*Room area* m^2	*Maximum social distance*
3	7	12	Storage room	0.7	0.8	0.56	Intimate
4	8	14	?Storage room	0.7	1	0.7	Intimate
3	7	19	Storage room	1.2	1.25	1.5	Intimate–personal
7	13	45	Storage room/multi-purpose room	1.2	1.3	1.56	Personal
9	10	51	Entrance portico	1.25	1.3	1.625	Personal–social near
5	10	48	Fire installation	1	1.7	1.7	Personal–social near
5	10	49	Storage room	1.2	1.6	1.92	Personal–social near
5	10	60	Entrance room recess	1	2	2	Social near phase
5	10	41	Front alcove E	1.2	1.7	2.04	Personal–social near
5	10	42	Front alcove W	1.6	1.6	2.56	Personal–social near
3	7	16	Living/storage room	1.5	2.3	3.45	Social near–far
5	10	40	Entrance portico	1.6	3.2	5.12	Social far phase
8	10	54	Entrance portico	1.6	3.4	5.44	Social far phase
9	10	53	Entrance room	2.6	2.75	7.15	Social far phase
8	10	56	Entrance room	2.5	3.5	8.75	Social far phase
9	10	61	Reception/living room	2.6	3.8	9.88	Public near (just)
5	10	47	Entrance room	2.2	6.6	14.52	Public near
8	10	66	Reception/living room	4	6.6	26.4	Public near
5	10	50	Reception room and human burial	4.7	7.6	35.72	Public near to public far

plasters. Traces of water-laid crusts were detected in micro-banded deposits compacted below mats in the eastern front portico of Building 5.

Five spaces clearly enabled social-scale far phase interactions at >2.15m distance. Two of these are large entrance porticos to Buildings 8 and 5, and two served as entrance rooms for Buildings 8 and 9, suggesting that accessibility to social spaces was valued by a range of households for outward facing spaces at the front of the building, as discussed below. The microstratigraphic sequences in these spaces indicate that the floors were surfaced with thick durable plasters and traces of matting. The fifth of the social far-phase spaces is Sp16 in Building 3 Trench 7, with clusters of ground stones that was kept very clean (SA375) and may have served as a multi-purpose living/storage room.

All three of the buildings exposed in Trench 10 have a large innermost room capable of hosting public-scale social interactions with room dimensions greater than 3.65m, at 3.8–7.6m in one length. Interestingly, the entrance room for Building 5 was constructed at this larger public-size scale, and its inner reception room was the largest, suggesting that this building was constructed to host the most populous and/or prestigious social gatherings at the site thus uncovered. The small size of many rooms is not unusual for the Neolithic of the Zagros. Many at Ganj Dareh and Jarmo are less than 2 × 2m, and no larger than 3.2 × 2.6m at Jarmo and 3.6 × 2m at Ganj Dareh, unable to host public-scale interactions based on studies of proxemics (Fisher 2009). Bestansur is exceptional for the Zagros, in the Early Neolithic period, for the large size of its rooms. No rooms at any other sites were constructed large enough to host public-scale social interactions.

At Bestansur there was a clear difference in the elaboration of rooms and buildings, marked notably by variation in the surface treatment of walls and floors, which corresponds in part to room size (Tables 12.2–12.4). The larger the room and building the more frequently it was plastered. Small spaces and storerooms were not plastered. The most elaborately rendered building was Building 8, Trench 10, which is the second largest encountered at 55.7m^2. Its entrance portico and interior walls were coated in multiple layers of plasters ranging in colour from reddish brown to brown, green and white. The wall opposite the doorway in the entrance room was painted in a red design, not yet exposed but analysed and sampled in plan (Fig. 12.22), and the portico corner partly plastered in fired lime. Traces of pigment have also been found on walls of Building 5 and in collapse on floors in Sp50 (Fig. 12.20). The floors of the largest room in Building 5 Sp50 were also coated in multiple layers of thin plaster ranging in colour from reddish brown to brown and green (see Fig. 12.30) and covered repeatedly in mats some of which were pigmented (Fig. 12.24). The wider implications of these attributes for social relations and the built environment are discussed further below.

Buildings with burials

Of particular relevance to the creation and histories of the built environment, arenas of burial were of key importance in the creation of particular communities and networks at Bestansur, as at other sites in Southwest Asia (Baird 2005). Pending further excavation of more buildings, it is uncertain whether Building 5 in which a high-number of burials occurs, and the underlying Building 8, are similar to others at the site. These buildings are comparatively large for the Neolithic, at *c.* 56–100m^2, and most closely resemble those at Tell Halula and Abu Hureyra in the northern Fertile Crescent, although the number of burials within a single building is lower at these sites in the northern Euphrates region at <15–24 (Moore *et al*. 2000; Molist 2013; Chapter 24).

A key question in this analysis of the spatial configuration and microstratigraphic histories of Buildings 8 and 5 at Bestansur is whether they were solely used for burial and associated activities, and/or were residential units. As the in-depth analyses above have shown, both buildings were well-constructed and maintained with evidence of significant elaboration in the form of multiple layers of wall plaster and traces of paint, although only Building 5 has been excavated to and below floor level. The cleanliness of Building 5 is problematic, but at high-resolution there is evidence of traces of ash, burnt bone and shell in all spaces, perhaps at least attesting traffic into the building and sharing of food, with most abundant residues in the recess in the entrance room Spaces 60/47 (Fig. 12.30). The cleanest floors with no microscopic traces of dust are in the centre-east of the room above skull C1625.1 (Fig. 12.30; SA1800). It is evident, however, that the spatial configuration and surface materials were used to create very specific arenas within these buildings.

Both buildings were accessed through a large portico to mark and shade the entrance, creating a transition zone between exterior areas, where there are abundant traces of diverse craft and food preparation activities, and interior spaces, with multiple plaster floors and traces of mats. The large stones in the portico to Building 5 may have provided seats as well as work surfaces (Chapter 22), as porticos are popular social and productive spaces today in the region (Watson 1979; Kramer 1979). The enlargement of the later Building 5 may indicate the increasing importance of the roles of this building and the arenas that they provided. Both buildings were constructed with sizeable interior entrance rooms and large back rooms that were capable of hosting public-scale (near) interactions, at >6.3–7.7m in length (Fisher 2009), and are likely to have been important social arenas (Chapter 24).

The floor surfaces and micro-residues in the entrance room in Building 5 (Sp47) indicate that this room was plastered with thick, generously tempered floor plasters that would have been resilient to heavy foot traffic. The overlying occupation deposits, 0.5–2cm thick, comprise low levels of activity residues mixed with sediments, and include traces of ash and sparse burnt bone including fish bone, 2–5%, in the northwest corner of this area (Sp60) indicating cooking/food consumption. The large back room (Sp50), by contrast, was plastered with much thinner plaster floors, <0.5–1mm thick, that were covered with mats, at least some of which were pigmented. It is possible that there were additional floor coverings, such as animal skins, as no dust or occupation deposits have percolated through the mats in the central area. The walls of this back room were plastered and white-washed, unlike a range of other rooms at Bestansur. This highly maintained, clean room with floor coverings is likely to have served as a large reception room and could have also served as a sleeping room based on ethnographic analogy (Watson 1979; Kramer 1979a).

One of the major functions of Sp50 was as an arena for the burials that were placed in the packing below the floors and cut periodically though the floors and plastered and covered over. Analysis of the microstratigraphic sequences created by the excavation grid squares and deposits close to the sloping wall faces has provided a major source of information in reconstruction of the history of burials in this space (Figs 12.29 and 12.31; Chapters 9 and 19), and confirmed from fragments of human bone recorded on floors that cadavers were laid out and/or re-wrapped in this room. Lenses of ash with sparse, <2% each, fragmented bone and shell and traces of red-pigment on the latest floors in the northwest corner suggest the building was less intensively maintained at the end of its life (Fig. 12.30; C1884 SA2302.7–8).

In constructing and enlarging Building 5, in comparison to the underlying Building 8, two additional small rooms were built. One, Sp48, was used as a large 'clay-lined' fire installation that speculatively may have been used at least occasionally to burn burial wrappings and ritual paraphernalia as no micro-traces of food refuse were recovered in either the micro-archaeological residues or the micromorphological thin-sections, and burnt finds included a human finger bone and large bird wing bone similar to those found in a ritual hoard at Zawi Chemi Shanidar in the northern Zagros (Solecki 1981). The other small room may have been used for storage of items in containers as no plasters nor residues were found in this room.

The aggrandisement of B5 with increased storage and a high social capital in the number of burials may suggest increasing wealth across the community, if other buildings attest a similar development and are equally elaborate. If, however, they are not, as initial excavations of other sectors suggest, then Buildings 8 and 5 may represent evidence for increasing inequality in the Neolithic (Wengrow and Graeber 2015; Kohler and Smith 2018) and privatization of resources (Byrd 2000; Bogaard *et al.* 2009), which ongoing excavations at the site aim to investigate in the context of wider research on the creation of

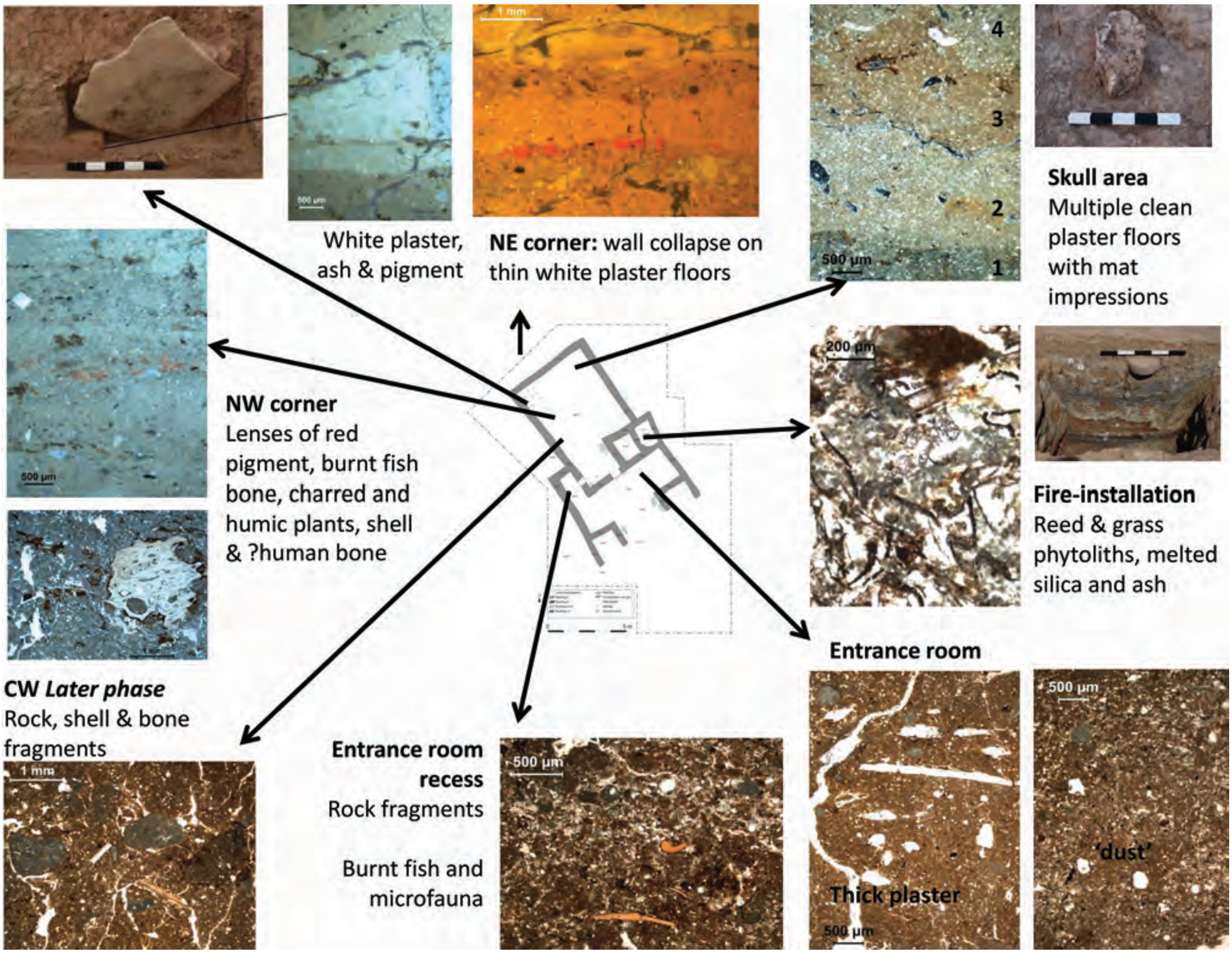


Figure 12.30. Building 5 microstratigraphic sequences and built environment.

communities. Alternately and/or additionally, they may also suggest creation of community-centred arenas, discussed below.

The remarkable repetition of specific types of selected surfaces and accumulated occupation deposits in all contexts in both exterior and interior areas (Table 12.2) indicates considerable continuity and stability in social roles and relations at least within particular building levels. This research confirms therefore that buildings, fixtures and fittings, by their permanence, both created as well as represented key arenas and markers for particular roles and relations, as well as predictability in social and political relations (Jenkins 2004) and navigation (Muryy and Glennerster 2018) as at other early sedentary sites (W. Matthews 2018). Where they were sustained, in these cases they represent continuity. As a corollary, discontinuity in these attributes represent change and/or disruption (Courty and Coqueugniot 2013; W. Matthews 2018).

The end-life of the earlier Building 8 was controlled. A wall, W12 was constructed in front of its entrance and the wall rubble used to create a platform for an enlarged entrance and footprint for the overlying Building 5 which was expanded to the east over a former thoroughfare. Building 5 appears to have come to an abrupt end with large sections of collapsed wall on the floors and traces of roofing material and human skeletal remains in the rubble (Chapter 19). This destruction may be the result of conflict and violence, as attested at some other early sedentary settlements (Hodder 2019). No buildings were constructed on this plot, which in its stead was turned into an external area covered repeatedly by thick layers of packing, suggesting major discontinuity in social succession.

Built environment living conditions and health

Built environment design: living conditions, air-quality and disease pathways

In this section we examine how the built environment may have encouraged or restricted disease reservoirs, carriers and pathways by analysis of architectural form, access, materials and surfaces and their potential antimicrobial and pest resistant properties and hygro-thermal performance as these fundamentally

Figure 12.31. Microstratigraphic sequence of multiple plaster floors and burial cuts in southeast corner of B5 Sp50. Looking southeast, scale = 50cm. Field section 127.

affect both disease spread and control (Lopez 2012; McGregor *et al.* 2016). We then discuss how use of indoor and built environment spaces affect or mitigate disease proliferation and transmission through analyses of accumulated and discarded activity residues and their potential to create and reduce disease reservoirs and their risk. The specific focus here is on waste-management, human-animal interactions and human burials.

Disease reservoirs, vectors and pathways

Built environment disease reservoirs and vectors (carriers) include: refuse; faecal matter; animals, commensals, birds, humans (living and dead), surfaces (architectural, objects); water and aerosols (Lopez 2012; Fournié *et al.* 2017). The potential disease contexts and pathways examined here include areas for: food storage, butchery, preparation, cooking, consumption; sitting/sleeping/reception; death and burial; industry/craft areas; latrines, pens and refuse; open air activities; and routeways.

Local climate and environs

The placement of the settlement at Bestansur at the head of the second largest spring on the Shahrizor plain would have provided access to clean water for drinking, cooking and cleaning, and, if well-managed, could have limited the potential for contamination of water supplies with waste and restricted the development of water-borne diseases.

Exterior area living conditions

The architectural layout suggests that some exterior open areas were at least partly enclosed by walls, as in Sp44 with a large oven. These walls would have compartmentalised some compounds, restricting access by other members of the community and potential disease carriers, such as stray animals and dogs.

Many exterior floor surfaces were periodically covered by relatively sterile silty clay loam packing, *c.* 3–20cm thick (Figs 12.10 and 12.32). Such layers would have effectively sealed off accumulated occupation deposits and refuse and thereby disease reservoirs. This compact silty clay packing also provided an indurate activity surface, as many of the upper boundaries are very sharp. The sloping nature of many exterior surfaces away from the centre of the mound would have facilitated effective drainage after the torrential rains that are characteristic of the region during spring and autumn storms, thus reducing the formation of stagnant pools that may have bred diseases or insect carriers (Lopez 2012).

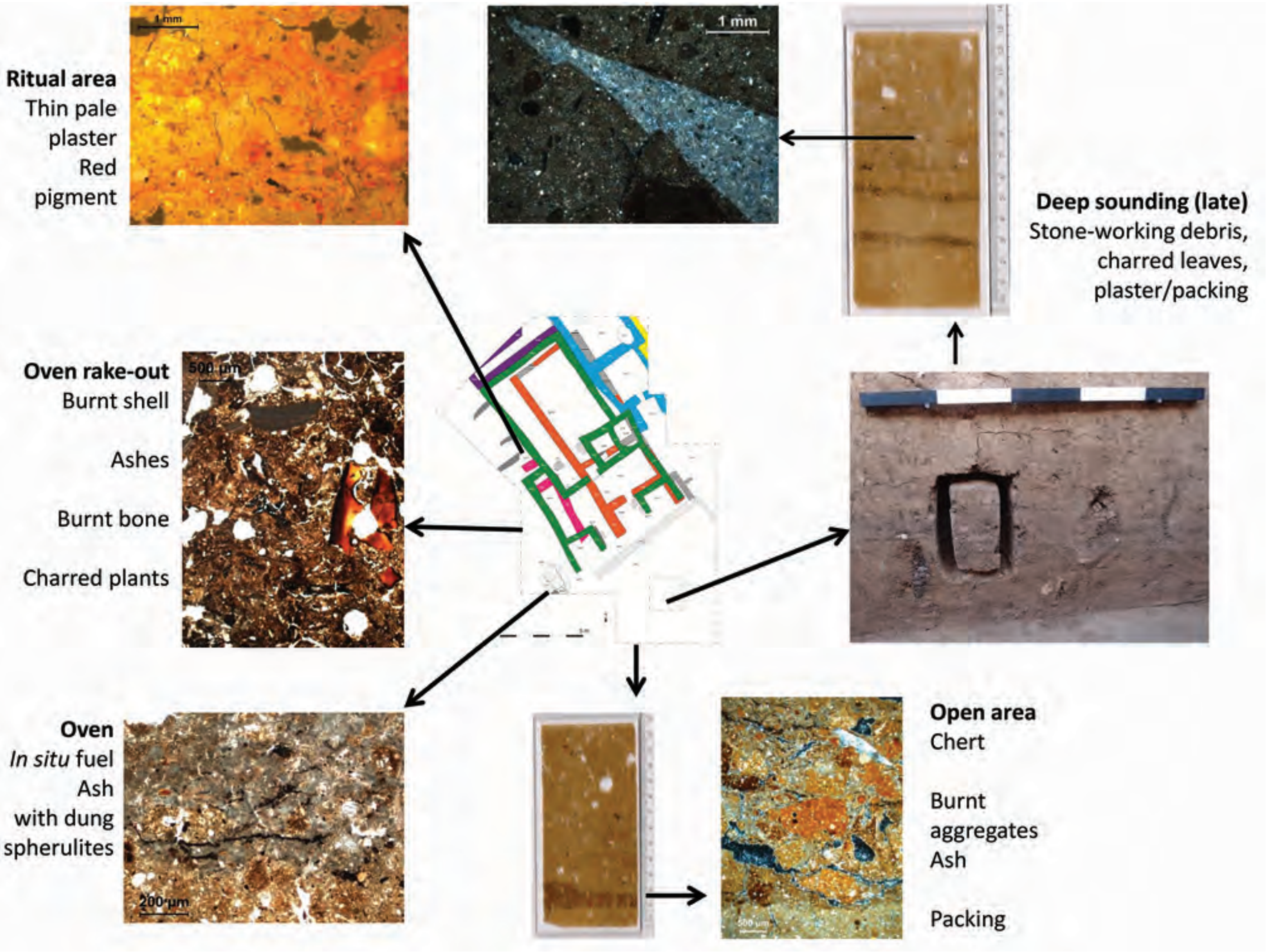


Figure 12.32. External areas outside Building 5: microstratigraphic sequences and built environment.

The fired lime that was applied to the front of and around Building 8 would have provided a weatherproof exterior surface, which could be cleaned with water. The high carbonate content of this material would also have provided anti-microbial surface properties (Fig. 12.27; Panagiotakopulu *et al.* 1995). Both of these characteristics reduce disease risks. However, the high energy cost of producing such material means that in general its use may have been restricted to high status buildings.

Interior area living conditions

The construction of buildings directly abutting one another restricted exposure to exterior heat, cold, rain, hail and wind and enhanced interior insulation, leading to reduced energy costs and surface erosion. The community-wide use of earthen building materials, despite the local availability of stone, also enhanced the comfort and healthiness of interior spaces. Earthen walls exceed current energy-efficiency ratings and earthen materials and surfaces have excellent passive moisture buffering properties and are breathable (Maskell *et al.* 2018). Earthen materials maintain interior humidity at 40–60%, which is below the humidity levels in which mould flourishes but sufficiently high to prevent tissue dehydration which makes individuals more vulnerable to infection (McGregor *et al.* 2016). The high carbonate content of the white wall interior surface washes inhibited microbial activity and acted as a pest-deterrent (Panagiotakopulu *et al.* 1995). The re-application of plasters on floors and walls would have periodically sealed in any diseases, pest eggs or contaminants (McGregor *et al.* 2016) as well as smells (Pawlowska 2014) and reflected light, thus enhancing safety.

The sparsity of micro-archaeological remains on interior floors, as shown by wet-screening and flotation (Chapter 14) and micromorphological analyses, indicates that interior areas in buildings were consistently kept cleaner than exterior areas. In many cases, the interior floors of buildings were plastered and covered in traces of mats and floor coverings identified in the field and in thin-section which, when renewed, would have restricted the spread of disease (Figs 12.24 and 12.30). The most well-constructed and maintained buildings were Building 8, exposed in plan but not yet excavated, and the later overlying Building 5 in Trench 10. Both Building 8 and 5 had large porticos that would have shaded the entrances and protected them from wind, rain, snow and dust. Both buildings have entrance rooms that would have controlled access to the large back room which was used, at least periodically, for burial and laying out of the individuals buried within this area in B5. The placement of these rooms would have limited access to these spaces and helped to isolate bodies and materials that could have transmitted disease. The surface of the back room in Building 5, Sp50, was repeatedly plastered (>11 times in any one area) and covered in mats and perhaps other floor coverings, that would have provided further disease barriers when renewed after each burial.

Air quality

Biofuels were the principal source of energy in the Neolithic and are a major contribution to air pollution today with serious consequences for health (Watts *et al.* 2017: 1157) as they produce harmful particulates and emissions (Scott and Damblon 2010; Christensen and Rhyl-Svendsen 2015; W. Matthews 2016: 124). This risk was mitigated at Bestansur by construction of ovens or access to their firing chambers outside buildings, as at Jarmo (Fig. 12.33). This placement would have limited direct inhalation of smoke and particulates within confined interior spaces, as attested by the absence of soot on wall plasters in Buildings 5 and 8. The exception was the last surface of Building 8 which is likely related to secondary use/ closure of the building (Fig. 12.33). The largely smoke-free situation at Bestansur contrasts with the repeated traces of air-borne soot on multiple layers of white wash on interior wall plaster at Shimshara, and also the wall sequences from Çatalhöyük which indicate soot accumulation especially in the winter months when cooking was conducted indoors and not on the flat roof tops (W. Matthews 2005; 2012). Like many Neolithic sites, ovens and hearths at Bestansur were constructed with earthen walls and roofs that would have created and retained radiant heat and thereby reduced fuel loading when compared to open fires, characteristic of earlier sites (W. Matthews 2016). Most *in situ* oven fuels and rake-outs at Bestansur attest highly efficient combustion in excess of 750–850°C, as evidenced by the calcitic ash residues with melted silica (Canti 2003), which would have reduced production of harmful smoke.

Pests and disease

Pest control is likely to have been a concern at Bestansur. House mouse has been identified at the site and would have presented a significant threat as, like other rodents, it destroys stored foodstuffs and materials and is a major carrier of disease (Chapter 15; Meerburg and Kijlstra 2007; Meerburg *et al.* 2009). The house mouse, *Mus musculus*, has been identified as early as the Epipalaeolithic (Cucchi *et al.* 2005) and is often found in early sedentary settlements, attracted by food, habitation waste and nesting opportunities (Hesse 1979a). Charred rodent pellets have been recovered by water-flotation alongside crops/crop by-products at Sheikh-e Abad (Whitlam *et al.* 2018) and Jerf el-Ahmar (Willcox and Stordeur 2012). Crop pathologies, if identified, could indicate whether other pests, such as insects, were also a threat to stored crops.

A range of innovative solutions to combat pests were developed by Neolithic communities at Bestansur and in the Central Zagros. Probable anti-rodent and anti-pest design solutions at Bestansur include laying of flat cobble surfaces on thick silty clay loam packing in small rooms that may have been store rooms. The flat cobbles would have restricted burrowing insects, kept stored goods off the earth and aided air circulation in the low spaces between the stones. Flat cobbles were also used to surface a small area, 0.7 × 1m, where remains of corpses/ funerary bundles may have been laid out just inside the entrance to Building 5 Sp50. The threshold to this space itself was marked and protected by a large stone (Fig. 12.23). A further unusual feature to this space, Sp50, was the lining of the interior edges of the wall with a strip of calcareous river gravels set into the sub-floor packing (Fig. 12.23). The function of this deposit is uncertain, but it may have served to restrict rodent or pest activity, which can be prevalent along wall edges and/or to prevent floor subsidence close to wall edges, as has been observed at other sites such as Çatalhöyük (W. Matthews 2005). In other regions of the Zagros, pest movement and access to stored materials was controlled by construction of portholes between storage compartments that could be closed off with thick earthen plugs at Ganj Dareh (Smith 1990), illustrating that pest-control was a region-wide concern and that communities developed a range of innovative solutions.

Human-animal interactions and zoonotic disease transmission

Human proximity to live animals is a major pathway for disease transmission through contact or aerosols from the animal or its faeces and fluids (Lopez 2012), including diseases such as brucellosis, tuberculosis and gastro-intestinal diseases (Fournié *et al.* 2017). No clear traces of *in situ* penning have been identified to date at Bestansur, either in the field or through micromorphological and GC-MS analyses (Chapter 16; W. Matthews *et al.* 2014; Bull *et al.* 2005; Shahack-Gross 2011). This absence is in contrast to contemporary levels at the site of Sheikh-e Abad in the high Zagros where high concentrations of animal dung were found within the settlement from penned and roaming herbivores, probably goats, and in a pen within a multi-roomed building (W. Matthews *et al.* 2013h; Shillito *et al.* 2013c). Pens have also been identified in the settlement at Aşıklı Höyük *c.* 8000 BC

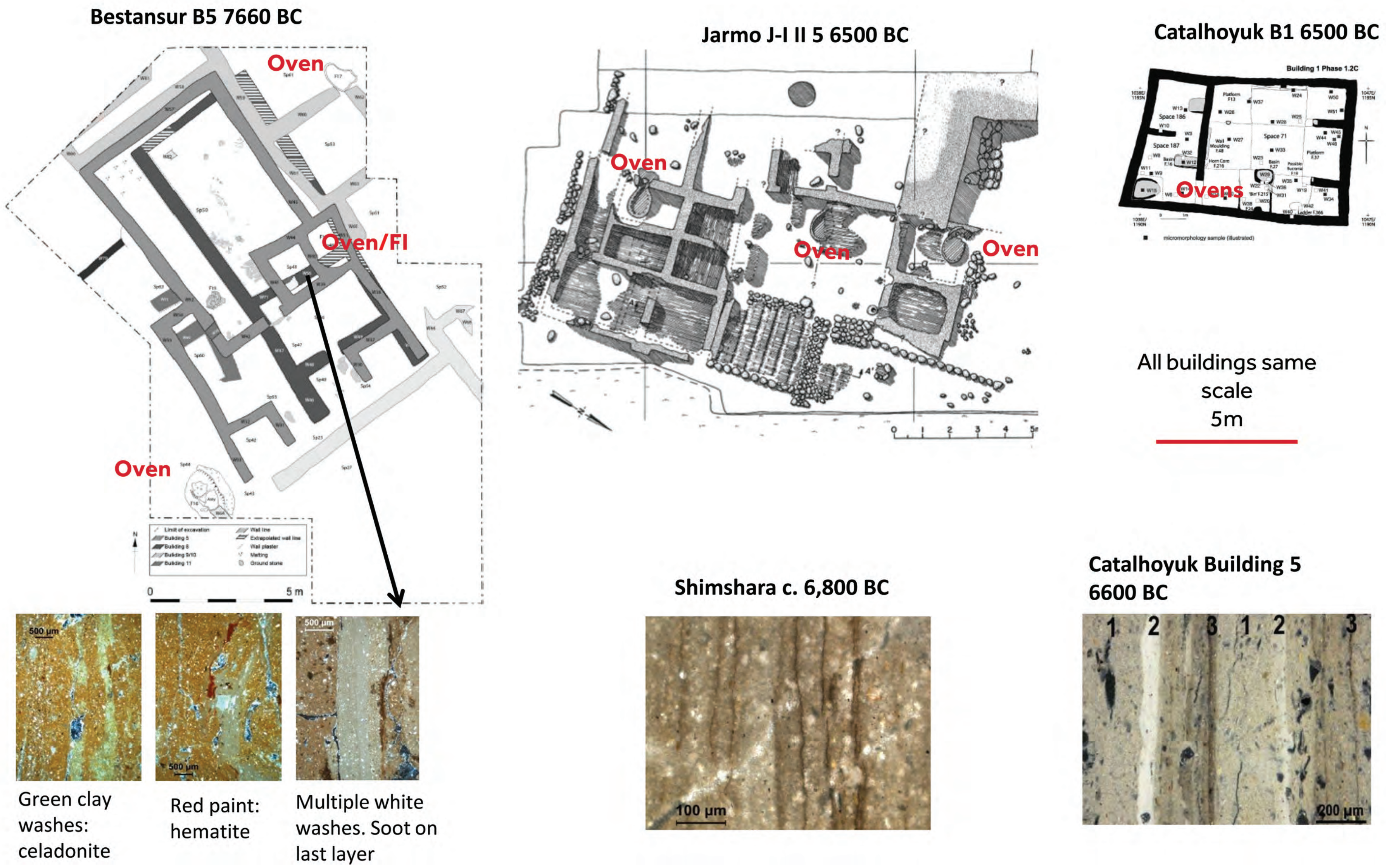


Figure 12.33. Comparative plans of building units, ovens and accumulations of particulates on interior wall-surfaces at Bestansur Buildings 5 and 8 (Sp56 wall W56 SA1505, Shimshara SA753 East-West Section; Jarmo J-I II 5 and Çatalhöyük ovens within interiors, soot on Çatalhöyük Building 5 wall (after Braidwood et al. 1983, fig. 51, courtesy of the Oriental Institute of the University of Chicago; W. Matthews 2005, fig. 19.36; Godleman et al. 2016, fig. 10).

(Stiner *et al.* 2014), and Çatalhöyük, *c.* 7000 and 6700 BC (W. Matthews *et al.* 1996; Bull *et al.* 2005; Portillo *et al.* 2019). The presence of compact organic rich layers at Ali Kosh in the south Zagros also suggests the presence of animals in the settlement (Hole *et al.* 1969; Hole pers. comm.). This absence of evidence at Bestansur suggests that animals may have been kept off-site, a practice that would have reduced exposure to zoonotic diseases. However, animal dung was widely used as a fuel source at Bestansur and handling of this material would have been a potential source of microbial diseases. The burnt fuel itself would have been less hazardous, as heating destroys microbiological organisms.

Refuse and waste-management

Refuse middens and thick accumulations of occupation deposits have not been identified yet at Bestansur, in contrast to many Neolithic sites where refuse was deposited in middens in separate sectors of the site, as at Jarmo, *c.* 90 × 20m (Braidwood *et al.* 1983: fig. 24), and at sites such as Aşıklı Höyük and Çatalhöyük, where refuse was repeatedly discarded next to clusters of houses in areas >6–10m in size, and 2–3m deep, as well as within abandoned houses (Martin and Russell 2000). It is also in contrast to many Epipalaeolithic sites, notably in Jordan, where refuse was often left or discarded within houses, perhaps during periodic absence from the site (Hardy-Smith *et al.* 2004). This absence of middens or accumulations of refuse >20cm thick at Bestansur would have reduced disease reservoirs and limited scavenging by commensals such as house mouse, as well as potentially larger predators such as foxes and wolves, attested in zooarchaeological remains from the site, which would not only have carried disease but in the case of wolves for example would have been a threat to herded animals (Chapter 15).

Some refuse, however, was allowed to accumulate on occupation surfaces at Bestansur and would have created a range of more localised disease sources and reservoirs. These types of refuse include: butchered and processed bone, particularly in areas away from the centre of the settlement, for example; snail shells; rotting plant remains; omnivore faeces, at least some of which are human as discussed above and below, notably in T13, Sp25, and fuel rake-out. A range of refuse and coprolites were burnt, which would have reduced their bulk, smell and disease risk (Lopez 2012), especially when converted to calcitic ashes as calcite itself is antimicrobial (Panagiotakopulu *et al.* 1995; Schotsmans *et al.* 2014; 2015) and absorbs smells. At least 69% of plant and organic matter preserved in thin-section has been burnt, 40% of which are calcitic or dung ashes (Fig. 12.6). Humic plant remains represent *c.* 4% of the total plant remains preserved and occur in *c.* 36% of occupation deposits and would have been a source of humus and organic matter. Organic refuse and fire rake-out are rich in phosphorous and other nutrients and may have been removed from the settlement for use as manure and compost for crops and garden agriculture (Bogaard 2005; 2012), and in villages today may be discarded or stored in quarry pits for earthen materials, for example (W. Matthews *et al.* 2000).

Human bodies and corpses: sanitation, disease sources, burial practices and health

Human bodies as well as buried corpses and partitioned body parts would also have been a major potential source of disease (Achtman 2017; Chapter 19). In semi-arid burial environments the principal diseases detected from archaeological remains are brucellosis and tuberculosis (Achtman 2016; 2017). No parasites have yet been identified at Bestansur as they tend to be poorly preserved. Six parasites, however, have recently been identified from the site of Çatalhöyük, also in a semi-arid region (Ledger *et al.* 2019), after previously unsuccessful earlier trials by Matthews and Mitchell. The parasites identified to date from Çatalhöyük are geohelminths that spread from human to human rather than from animals to humans (Ledger *et al.* 2019), and are present in later levels of the site from a midden area Space 329, Level South P, dating to *c.* 6410–6150 BC. Two of these were in human coprolites.

At Bestansur, human faeces have been identified by integrated field, micromorphological and biomolecular analyses by GC-MS in Trenches 12 and 13 in accumulated deposits on surfaces in Sp39 and Sp25 as well as one coprolite of wild boar/pig origin (Chapters 13 and 16). It is likely that the other omnivore coprolite remains identified in thin-section are also possibly of human in origin, as six out of the seven omnivore coprolites identified by GC-MS to date at Bestansur are human, and GC-MS analyses at other sites are repeatedly identifying similar coprolitic remains as human (Shillito *et al.* 2013a; 2013c). A surprising result from the micromorphological analyses has been the identification of traces of omnivore faecal matter in a wide range of deposit types and contexts across the settlement, often at <2%, but up to 40% (Figs 12.6–12.9 and 12.34).

Human coprolites are a rich new source of information on diet and health through analysis of bioarchaeological content and gut microbiome indicators and parasites using an array of analytical techniques notably aDNA (Warinner *et al.* 2015b; 2017). Light and confocal laser scanning microscopic analyses have identified a range of plant, bone and microbiological traces within the omnivore coprolites from Bestansur (Fig. 12.16; Chapter 13). Transferable diseases from faecal matter include many gastro-intestinal illnesses that are a major cause of infant mortality in children <5 years old (Bocquet-Appel

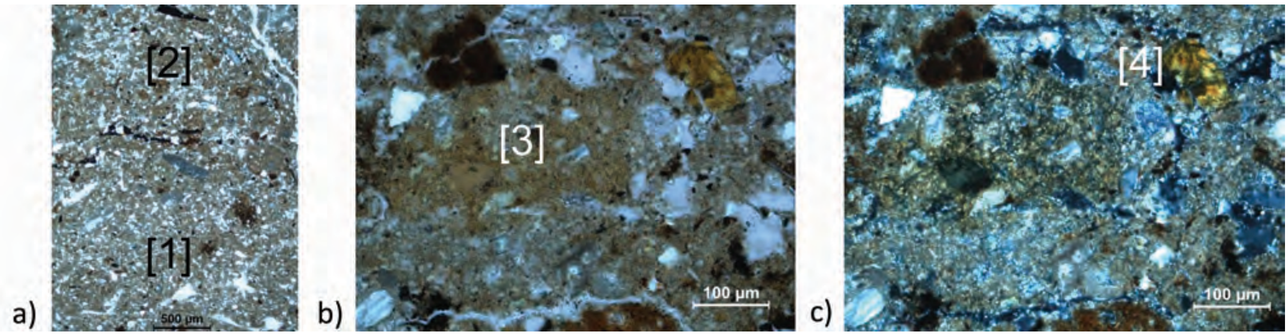


Figure 12.34. Building 8 entrance portico Sp54 with sequences of: a) floor plasters and mat-impressions [1] and diverse occupation residues [2] with finely fragmented charred plant remains, lithics, dung fuel rake-out and b–c) probable omnivore coprolites [3] and neo-formed vivianite [4] (SA2585.1-2 PPL, XPL).

2011a: 561), as well as the elderly. Faecal matter, even when present in low abundances, <2–5%, is likely to have been a widespread source of disease as, even in highly maintained urban apartments today faecal microbes are widely detected in built environment microbiomes (Ruiz-Caulderon *et al.* 2016), and are a major source of disease in village environments with little or no sanitation.

More than 80 human burials have been identified within the settlement, many below building floors and therefore in close proximity to the living (Chapter 19). Whilst human burial practices may have not been concerned to reduce disease risk, how corpses and body parts are handled is central to many disease reduction strategies. It is likely that burial practices were related to wider concerns about purification and taboos associated with the dead and the social relations associated with them (Croucher 2012; Hayden 2017). Of the corpses interred whole, many are complete, indicating rapid burial, reducing putrefaction and disease (Knusel and Robb 2016). Many burials of complete and incomplete human bodies were contained within wrappings, which would also reduce disease transmission. A number of these wrappings were coated in red pigment, which in the cases shown to be ochre (Chapter 21 and above) would have inhibited microbial activity (Rifkin 2011). The enclosed furnace in B5 Sp48 F18 (Fig. 12.13b) may been used at least periodically to burn burial wrappings and floor coverings in Space 50, where more than 78 individuals were interred below the floors of B5 and in the fill of B8, given the undisturbed remains of articulated reeds, sedges and grasses, fragments of human bone, and absence of micro-archaeological domestic debris in Sp48 (Chapter 14). Mats and mattresses from such plants are known ethnographically to be used to layout, carry and wrap the dead (MERL exhibit). However, taphonomic studies of the human remains indicate that some putrefied human remains would have been encountered during re-opening/digging of subsequent graves and in handling of body parts (Knusel and Robb 2016; Brönniman *et al.* 2018).

Resource management, diet and sustainability: a micro-contextual approach

Integrated micromorphological analyses have revealed that the community at Bestansur had knowledge of and access to a wide range of organic and inorganic resources and materials from diverse local, regional and more distant environments, and technological skills in management and manipulation of these. Analysis of architectural materials has revealed access to a diverse range of sediments and knowledge in selecting, combining and manufacturing materials whose properties were well suited to the context of their application, based on analysis of their architectural affordances (Knappett 2006), including production of fired lime (Godleman *et al.* 2016). A wide range of micro-artefactual residues were identified across the site, many including debitage from production and use of chert, obsidian, groundstone and stone artefacts, notably in the south of Trench 10, which attest to the presence of individuals with considerable skill within the community.

This discussion of resources begins with a brief review of sediment and stone resource access, management and use at Bestansur. It then focuses on how the discovery of a wide range of diverse plant materials, types and plant parts is providing new insight into local environment and management and use of a biodiverse range of plant resources for fuel and energy use, food security and diet, and construction, furnishings and artefacts. Management and use of animals and the resources from them is also discussed here and explored in full in Chapters 15 and 16.

Sediments and pigments

A wide range of sediments were selected for construction, suggesting access to diverse local environments. These sediments included dark grey silty clays for bricks, mortar and plasters from a reducing environment, perhaps close to wetlands and the nearby freshwater spring. Greenish silty clays used in some plasters and bricks include use of celadonite from local marls (Godleman *et al.* 2016). More yellowish brown silty clays used in bricks, mortars and plasters were from the environs of the site and are similar to natural deposits exposed below the settlement in Trench 4. The use of white silty clays for white-washing the interior walls of B5 Sp50 from more distant sources, corresponds with and marks the wide social network represented by more than 78 burials in this place. It is likely that the local limestone within 200m of the site was used in the manufacture of fired lime, which has slightly pinkish colouration, perhaps from the local colluvial soils on these slopes (Godleman *et al.* 2016).

The shift, particularly in later levels, to more extensive use of reddish brown silty clay loam colluvium with white carbonate aggregates from colluvial deposits on adjacent hills 200m from the site marks a major shift away from use of sediments within the vicinity of the site and spring. This shift probably relates to changes in resource use and management of the local environs more widely. As the colluvial soils are less fertile than those close to the spring, this change may relate to an increase in the value of cultivable soils and land in the vicinity of the site. A similar community wide shift in use of local sediments from dark grey to more reddish brown sediments was observed at Çatalhöyük in Levels VIII–VII corresponding with shifts in other practices (W. Matthews 2005; 2018; W. Matthews *et al.* 2014; Hodder 2011; 2018a).

Stones

Although limestone building material was available within 200m of the settlement on the local hillsides, earthen materials were the preferred construction material. Local river gravels and flat ovoid stones were used to provide indurate surfaces in exterior and interior areas respectively, probably to control for rain-water saturation and rising moisture or use of water in these rooms. Chipped and ground-stone is widely attested at the site (Chapters 20–22), and fragments of this have been identified in a wider range of contexts. Notable uses and associations include recurrent debris from both in external areas in front of Buildings 8 and 5 in T10 Sp27 SA1283 and SA2302, including debris from probable stone bowl production (Figs 12.32 and 12.27).

Plant remains taphonomy and preservation

The scarcity of charred plant remains recovered by water-flotation at Bestansur was unexpected and is disappointing (Chapter 18). Thin-section analysis, however, has revealed that a much wider range of plant materials, types and plants are represented in archaeological deposits from Bestansur than the charred plant remains recovered by water-flotation suggest. The abundance and diversity of plant materials, parts and types in thin-section, moreover, has helped in identifying the factors affecting plant survival, and has provided a range of insights into plant taphonomy in this more temperate clay-rich region of Southwest Asia, as well as more widely.

Micromorphological and integrated phytolith spot sample analyses (Chapter 13) and the discussions above have established that the factors affecting the scarcity of charred plant remains at Bestansur include: bioturbation, as argued in Chapter 18, establishing that bioturbation affects *c.* 20–30% of individual depositional units; *in situ* fragmentation from shrink–swell action of clays, as also argued in Chapter 18, as well as possible degradation of charred remains by oxidisation and dissolution of polycyclic aromatic hydrocarbons in alkaline conditions (Braadbaardt and Poole 2008; Weiner 2010).

In addition, micromorphology has established that the scarcity of charred plant remains is due to the prevalence of high combustion temperatures and well-ventilated oxidising combustion environments that left few carbonised remains and, as explored below, the availability and utilisation of plant resources, trampling and erosion in external areas, discard practices and management of the built environment, and abundance is highly dependent on deposit-type and context.

In thin-section, at Bestansur charred plant remains represent on average only 22% of the total plant remains preserved (Figs 12.6 and 12.35). The highest proportions of plant remains at Bestansur are preserved as calcitic ashes, at 40% (Fig. 12.14b). At least 8% of these ashes are derived from dung, identified by the presence of intact identifiable spherulites (Figs 12.15 and 12.35). The proportion of ash derived from dung is likely to have been higher as dung spherulites calcine at temperatures in the order of *c.* 650–750°C and lose their characteristic form and extinction cross in XPL. That temperatures >750–850°C were reached is confirmed by the presence of melted silica which represents up to *c.* 10% of plant remains in *in situ* fuel in T10 Sp48 SA1782.9 C1673, for example (Figs 12.14 and 12.35). In total therefore, at least 63% of the plant matter, including dung fuel, was burnt but only *c.* 35% of this material was burnt at temperatures low enough to preserve as carbonised remains.

Phytoliths also represent a significant proportion of plant remains in thin-section at 18%. At least some of these are also likely to have been burnt, as phytoliths occur in *in situ* fuel, representing up to 70% of plant residues. In these cases, carbon has often been burnt off leaving the underlying silica plant anatomy intact and relatively unaltered and indistinguishable from non-burnt phytoliths. Whilst it is possible in some cases to identify that they have been burnt based on refractive index of individual phytoliths (Elbaum *et al.* 2003) this criterion has not been applied in this research as many phytoliths are conjoined multi-cell, and in occupation deposits are embedded in a matrix,

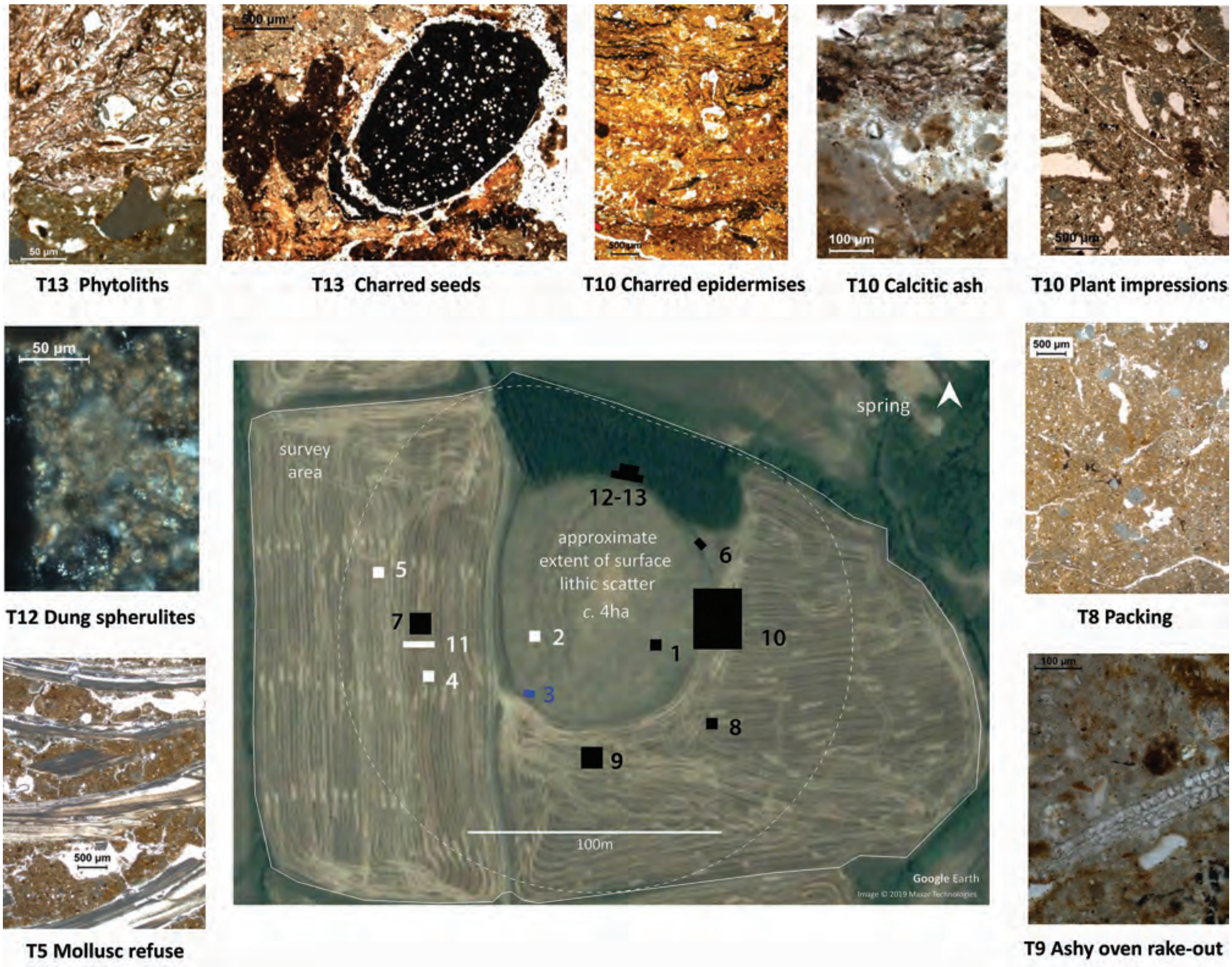

T13 Phytoliths
T13 Charred seeds
T10 Charred epidermises
T10 Calcitic ash
T10 Plant impressions
T12 Dung spherulites
T8 Packing
T5 Mollusc refuse
T9 Ashy oven rake-out

Figure 12.35. Diversity of plant materials, parts, types and abundance across different sectors, contexts and deposit-types at Bestansur in thin-section (all PPL except T12 dung spherulites XPL).

although this approach should be considered in future integrated archaeobotanical research.

Plants that were not burnt are represented by plant impressions, comprising 4% of deposits, and humic or very low temperature burnt plant remains, also 4%. Desiccated plant remains were identified in at least two contexts, representing <1% of deposits.

This research has also established that recovery methods and analytical techniques affect the type and abundance of plant materials, parts and types that are recoverable and identifiable. Integrated archaeobotanical approaches, are needed therefore as they provide important complementary strengths given the diversity of plant remains represented in the assemblages from Bestansur from water-flotation, thin-section micromorphology and phytolith spot samples. These differences are due fundamentally to variation in the anatomical structure and materials of different plant genera, species and parts, and their resilience to impacts from utilisation, combustion, post-depositional alterations and recovery methods as documented in other studies of plant taphonomy (Van der Veen 2007; W. Matthews 2010; Colledge and Conolly 2014). The higher representation of seeds, grains and pulses in water-flotation samples is due to the much larger sample size collected, in the order of tens of litres, in comparison to *c.* 40mg of deposits analysed in spot phytolith samples, and to thin sections of deposits which represent a *c.* 6.5cm wide section of deposits, 25–30µm thick, linked to microstratigraphic field section analyses. Analyses of charred macrobotanical remains are also able, generally, to provide more precise species identifications based on characteristic morphologies in three dimensions. There is certainly much greater scope for identification of plant remains in thin-section by plant anatomy specialists, although even then the anatomy of monocotyledons in particular is complex as the anatomy of leaves and stems of a range of plants are currently indistinguishable (W. Matthews *et al.* 1999; W. Matthews 2005). These differences, however, when examined in an integrated archaeobotanical approach together enable exploration of a wide range of plant remains, taphonomic processes and utilisation of plant resources.

The characteristics in thin-section of each of the diverse plant remains material, types and their ubiquity, abundance and contextual associations are discussed in detail above. The wider significance of the identification in thin-section of diverse plant materials, types and parts and their taphonomy are discussed below with regard to the new insights that micromorphological and phytolith analyses are providing in comparison to study of charred plant remains at Bestansur (Chapter 18) and other sites in the Zagros and Southwest Asia more widely.

Comparative archaeobotanical studies in the Zagros include analyses of pollen and micro-charcoal from Zeribar lake-core (van Zeist and Bottema 1977; Wasilikowa and Witkowski 2008); phytoliths from coring and on-site studies in the Sulaimaniyah region (Marsh *et al*. 2018; Chapter 6) and the Zagros more widely (Rosen 2003); and charred plant remains recovered by water-flotation from many sites in the Zagros including Abdul Hosein (Hubbard 1990); Ganj Dareh (van Zeist 1984); Jarmo (Watson 1983); Ali Kosh and the Deh Luran Plain (Helbaek 1969) summarised by Charles (2008), and more recently Chogha Golan (Riehl *et al.* 2013) and Sheikh-e Abad (Whitlam *et al.* 2018). These comparative studies are discussed in greater detail in Chapter 18 and in the conclusions to this volume in Chapter 24.

The focus in the following discussion examines the contribution of micromorphological and phytolith analyses at Bestansur to understanding of Early Holocene climate and environment and Neolithic plant resource use for construction, furnishing, food, fodder, fuel and craft materials.

Palaeoclimate, environment and biodiversity

Whilst the abundance of plant remains on archaeological sites is not a direct reflection of the vegetation of the local or regional environment, it does represent resources that were accessible to communities. The scarcity of charred wood recovered by water-flotation at Bestansur is mirrored by the low ubiquity and low abundance of charred wood in thin-section, suggesting that wood was not widely available or selected for burning in this region of the lower Zagros. This scarcity contrasts markedly with the greater abundance of wood in highland Iranian sites, discussed in Chapter 24 in examination of wider regional variations in environment and resource management and use.

Charred nut shells/fruit stones have been recovered from on-site contexts both by water-flotation and in thin-section, indicating presence of trees, although in comparatively low proportions and numbers. Leaves and bark from dicotyledons, including woody shrubs and trees, have also been detected in the thin-section and the phytolith record at 3–10% and 2–9% of phytolith assemblages from spot-samples (Chapter 13). As dicotyledons produce fewer phytoliths than monocotyledons such as reeds and grasses, it is likely that trees and shrubs were more abundant than their proportional representation suggests, and that they were present in sufficient numbers to produce a range of renewable food and fodder resources discussed below.

The on-site charred plant evidence for limited availability and use of wood corresponds with regional pollen data from Lake Zeribar that indicate delayed woodland expansion in the Zagros region even when the under-representation of insect and wind-pollinated trees is accounted for (Jones *et al.* 2019; Chapter 3). It is this regional delay in the spread of woodland that is likely to be a major factor in the scarcity of charred wood recovered by flotation, in addition to bioturbation and shrink-swell action highlighted in Chapter 18. The causes for this delay are likely to be complex and inter-related (Asouti and Kabukcu 2014; Jones *et al.* 2019: 13–14). Factors include: an increase in solar radiation and seasonality that resulted in an extended dry season in the Zagros (Djamali *et al.* 2010) despite ∂^{18}O evidence for increasing moisture after the end of the Younger Dryas (Stevens *et al*. 2001; 2008); increased wild fires (Turner *et al* 2008) and human competition (Roberts 2002). All of these factors would have favoured development of grassland over trees due to their different growth rates and habitat preferences and tolerances. The pollen data from Lake Zeribar indicate that grasslands were at their most extensive in the Zagros region in the Early Holocene increasing from *c.* 10% at the end of the Younger Dryas to *c.* 30–50% when Bestansur and Shimshara were occupied (van Zeist and Bottema 1977; van Zeist 2008; Wasylikowa and Witkowski 2008).

This relatively high percentage of grasslands in comparison to preceding and succeeding periods is reflected in a range of on-site archaeobotanical remains from the three major datasets examined at Bestansur. Of the identifiable charred plant remains recovered by flotation the most ubiquitous are cereal grain and cereal chaff at *c.* 30% each (sample n=511; Fig. 18.2). Grasses, including reeds, are also the most ubiquitous in the thin-section and phytolith spot samples, occurring in all phytolith spot samples (Chapter 13). Charred cereal remains and wild grasses recovered by water-flotation together represent a similar proportion of the identifiable plant remains as the lowest levels of pollen. Cereal remains (grain and chaff) represent *c.* 28% as proportion of total charred plant remains based on sorting data. Wild grasses (large-, medium-, and small-seeded) are also present, although these data exclude charred wood, and proportions of grasses recovered are therefore likely to be lower overall (sample n=35; see Table 18.4).

Grasses, including reeds, are the most ubiquitous and abundant plant remains in thin-section and in spot sample phytolith analyses, representing on average 63% of the spot sample phytolith assemblage, ranging from 42–88%, although they are likely to be over-represented as monocotyledons proportionately produce more phytoliths than other plant groups (Chapter 13; Tsartsidou 2007). Grasses and reeds in these thin-section and spot samples are predominantly represented as stem, leaf and inflorescence. The moderate to high proportional representation of the different grass and reed plant parts in all three integrated recovery methods, seeds, stem, leaf and inflorescence, together confirm the local availability and accessibility of grasslands and wetlands in the environs of Bestansur.

With regard to absolute items per litre, however, the number of charred cereal fragments at Bestansur both in thin-section and recovered by flotation is very low at only 284 from 35 of the fully sorted macro-botanical samples (Chapter 18). This scarcity of cereals in comparison to other Neolithic sites from the Zagros and Southwest Asia more widely, like woodland, was also likely to have been affected by Early Holocene palaeoclimate and environment. Riehl's (2016) ∂^{13}C isotopic analyses of wild cereals from Chogha Golan, also in the lower Zagros, 225km to the south at 485m asl, indicate that the cereals were affected by water stress until at least *c.* 8800 BC. Riehl also argues that region-wide palaeoclimate records indicate that moisture in Southwest Asia did not significantly increase to levels that could readily support cereal cultivation until *c.* 7600–7500 BC, and that archaeobotanical assemblages in the Zagros more widely, moreover, are not dominated by cereals until after 6500 BC, later than the occupation at Bestansur (Riehl 2016). Early Holocene wildfires detected in the region in the pollen records from 9800 BC (Turner *et al.* 2008) are likely to have favoured regeneration of competitor species to cereals such as legumes (Asouti 2017). In support of this argument, legume pulses represent *c.* 66% charred plant remains from the sorted samples recovered by flotation, and occur in 100% of these samples (n=35), although some of the lentils have been shown by radiometric dating to be intrusive (Chapter 18). Pulses are also present in a range of deposits in thin-section at Bestansur.

The representation of grasses, reeds and sedges from wetlands in thin-section and phytolith data is especially significant as the site of Bestansur is located next to a major spring and river source. This major spring and ensuing river would have provided a secure supply of water and the surrounding wetlands and riverine habitat sustained a rich and diverse habitat for many of the fauna attested at the site including river clams, crab, fish, water-birds and pig for example, as well as water for humans and animals. The role of such optimal locales within regions is a major factor both in settlement resilience in times of stress and sustainable development in more favourable climes, and at Bestansur is arguably comparable to the location of Abu Hureyra next to the Euphrates in the Syrian steppe, for example (Jones *et al.* 2019).

Plant management, processing and utilisation

How sustainably were plant resources from these limited woodlands, and more extensive grasslands and wetlands managed and utilised? How were they valued?

Fuel and energy use

Sustainable fuel and energy supplies are one of the greatest challenges to many communities and year-round settlement in particular (Asouti and Austin 2005; Henry *et al.* 2018). The integrated archaeobotanical analyses applied in this research has revealed considerable evidence with which to argue that fuel and energy use at Bestansur were sustainable and highly energy efficient. That little or no wood was burnt as fuel, attests not only to the scarcity of trees, but also to conservation of trees firstly for the habitat that they provided to the diverse wild and domesticated fauna that are attested in remains at the site, and secondly for the renewable tree resources that they provided including nuts/fruits and dicotyledonous bark and leaves identified at Bestansur discussed below. The principal sources of fuel at Bestansur comprised renewable reeds and grasses and second-generation dung. These materials must have been stored and dried as they burnt efficiently leaving little residual carbon and abundant phytoliths, calcitic ashes and melted silica.

The combustion environment must have also been very well ventilated and oxidising to enable this almost complete consumption during firing of black carbon, attested not only by the lack of charred remains in residual fuel but also by the burnt reddish brown fire installation plaster lining and silty clay aggregates in fuel. This oxidised firing enabled high temperatures to be reached in excess of 500–850°C, as attested by the high abundance of calcitic ashes and melted silica, and occasionally partially melted silty clay aggregates (Canti 2003). These temperatures would have been sufficient to manufacture the fired lime that was used in a range of surfaces at Bestansur (discussed above and in Godleman *et al.* 2016). This efficient burning would have also reduced the emission of hazardous particulates and smoke, improving the health of the built environment at Bestansur (Fig. 12.33).

A range of fire installation types and sizes were constructed that would have each afforded and enabled control and management of different fuel-loadings, combustion temperatures, durations and applications (W. Matthews 2016). The largest fire installations were small rectilinear mudbrick rooms with plaster linings, up to 0.8 × 1.7m in size, such as F18 in T10 B5 Sp48 (Fig. 12.33). Large ovoid ovens in external areas were also constructed, similar to the oval ovens constructed at Jarmo, described as 'baked in-place basins' (Braidwood *et* al. 1983: figs 26–29 and 75–76), such as F16 in T10 Sp44 (Fig. 12.33). The surrounding of the combustion chamber in both of these fire installation types with thick earthen walls would have aided retention of radiant energy and heat and minimised the amount of fuel needed to reach and sustain firing temperatures. This would have had the dual effect of aiding energy efficiency and retention within the firing chamber, as well as reducing the transmission of heat to external surfaces of the installation within buildings or to adjacent structures and areas. This restriction of heat transmission would have been highly valued in a region of hot summer temperatures in excess of 40°C, aiding the coolness and habitability of building interiors as well as external areas. Strategic use of vents from the interior rectilinear fire installation 'rooms' in the winter may have enabled this heat to be directed into other interior spaces to warm interiors. This would have increased the habitability of buildings and the comfort and health of occupants in the colder months, when temperatures drop below freezing and drying and heating is otherwise difficult.

In modern experiments in use of large earthen fire installations, temperatures sufficient to prepare and cook food over a 24-hour period were rapidly reached using dry grasses, as demonstrated during an Earth Building UK and Ireland Clay Fest experiment in 2018. The availability of heat for cooking, for example, would have ranged through time from rapid grilling, when flames abated and temperatures were at their highest, to roasting and stewing for up to 24 hours after firing. Drying of foodstuffs, for example, is also possible (Hastorf 2016).

Other installations at Bestansur include: sets of small hearths as in Trench 9; small plaster lined features in Trench 7; clusters of fire-heated stones; and open area fire-spots (Chapters 9 and 16). Similar sources of fuel were used. Combustion efficiency, however, was reduced and more charred residues are associated with some of these features (Chapter 9). Fire rake-out in areas adjacent to fire installations in thin-section includes a diverse range of materials and coprolites from low–moderate temperature burning including: burnt bone fragments, dark brown silty clay aggregates, clay shapes and sparse omnivore coprolites, suggesting a range of domestic, sanitation and perhaps ritual residues were burnt in the embers of fires to reduce their bulk and noxiousness, perhaps after their primary use for food or craft, as in T10 Sp44 (Figs 12.32 and 12.35). Some of these smaller installations are likely to have been used for cooking specialist dishes such as molluscs, as suggested by their presence within and around a small clay-lined fire installation in Trench 7 (Chapter 9). Fire-spots with fire-cracked stones may have been used for grilling fish and meat, suggested by burnt bones, or roasting nuts as attested by charred nut residues in archaeobotanical and thin-section samples (Fig. 12.11c). Others may have been used for craft activities, such as preparing and heating mastics, where associated with lithic residues as in T10 Sp27 (Fig. 12.27; Chapter 9 and T7).

Food security and diet

One of the major aims in integrated micromorphological and phytolith analyses was to examine to what extent the sparsity of charred food remains recovered by water-flotation at Bestansur was due to bioturbation and shrink–swell action, as argued in Chapter 18, and to local ecology and plant use strategies, as argued by Arranz-Otaegui and colleagues (2016a; 2016b; 2018b) for the Neolithic more widely. A range of taphonomic factors has been identified by thin-section micromorphology, including bioturbation, *in situ* fragmentation of plant remains and high combustion temperatures that burn off carbon leaving few carbonised remains. Additional factors include the impact of climate, environment and habitat stress on cereal propagation in the Zagros, as discussed by Riehl (2016) and above.

Some charred legumes including lentils and non-lentil pulses were identified in occupation deposits in thin-section in line with observations of the greater prevalence of legumes at Bestansur and more widely in the Zagros (Chapter 18; Arranz-Otaegui *et al.* 2016a). Both cereals and legumes, however, are rare in thin-section, as at many sites including Çatalhöyük (W. Matthews 2005). No clear examples of cereal grain have been identified in thin-section to date. Few domesticated cereal- or cereal-like husks have been identified to date in phytolith assemblages in thin-section or spot samples, suggesting that, like grains, cereal by-products were not a widely used resource at Bestansur although present in some animal dung (Chapters 13, 16, 18).

Evidence of plant processing that may have broken down grain, pulses and seeds as well as other plant remains, has speculatively been identified in thin-section. This includes impressions of fine linear/curvilinear plant impressions from husks/leaves/stems in association with grindstone flakes that may represent residues from grinding in external area occupation deposits Sp27 T10 (Fig. 12.27). A range of ground-stone artefacts, including pestles and mortars for pounding and grinding, has been identified across the settlement at Bestansur (Chapter 22). If used in food preparation, for which there is some evidence (Chapter 22), grinding would have significantly enhanced the nutritional value of foods by breaking down food plants and increasing the accessibility of nutrients, and would have increased the range of foodstuffs that could be provided (Hastorf 2016).

We are currently investigating whether potential charred foodstuffs are present in plant assemblages from both water-flotation, and in thin-section in areas of more amorphous charred remains which include plant remains. Stereo-binocular and ESEM analyses are being applied to establish whether these may be the remains porridge- or bread-like meals or fermentation residues such as those identified at other sites (Arranz-Otaegui *et al*. 2018a).

A range of wild plant foods has been identified at Bestansur through micromorphological and phytolith analysis, as argued by a range of researchers for the early Neolithic more widely (Colledge and Conolly 2014; Arranz-Otaegui *et al*. 2016b; Whitlam *et al.* 2018; Wallace *et al.* 2019). New evidence that thistle-like roots, dicotyledonous leaves, grasses- including cereals and occasionally reed shoots, were consumed has been provided by identification of phytoliths from these plant types and parts *in situ* in human coprolites, by integrated micromorphological, phytolith and GC-MS analyses (Chapters 13 and 16).

Evidence of other wild food sources observed in thin-section includes identification of charred nuts or fruits, and charred and phytolith remains of dicotyledonous leaves. Whilst some dicotyledonous leaves are preserved within animal dung and may have been eaten by browsing animals or selected as fodder (Chapters 13, 16), some leaves in occupation deposits and discard may have been consumed by humans (Hastorf 2016). This use of renewable nut/fruit and leaf resources from trees and shrubs, at the same time as the sparse use of wood fuel, may suggest that trees were conserved for the habitat that they provided for hunted and managed animals, as well as wild food resources and fodder. Evidence of similar conservation of trees is suggested for Level E at Ganj Dareh, *c.* 8000 BC, where nuts rather than cereals were a mainstay of the diet, and *pistacia* wood was not burnt as fuel (van Zeist 1984; W. Matthews 2016).

This identification of consumption of a range of wild food sources is especially important given the scarcity of cereals and provides new insights into the biodiversity of early settled community ecological strategies and diet, and the value of local wild resources.

Other plant and dung uses

A range of other plant uses has been identified by analysis of charred and non-charred plant remains in the field and in thin-section. This evidence includes extensive use of woven and sometimes pigmented mats, baskets and burial wrappings made from reeds and grasses (Fig. 12.24; Chapter 9). This use of floor coverings, in itself, would have been an additional factor in the sparsity of accumulated charred and other plant and micro-archaeological remains on floors, as well as and health in the built environment. Plants were also used to temper building materials, including mortar, mudbricks, packing, wall and floor plasters and create lighter roofing.

Other plant uses include fodder for animals, which comprised both reeds and grasses as well as dicotyledonous leaves as seasonally available and storable. Plant and other refuse could have been used as compost to enhance soil and plant productivity, as few middens or very plant-rich deposits have been found on site to date, suggesting removal off-site. Compost is a highly valued resource and may have been used in local garden agriculture or to enhance productivity and sustainability of wild or cultivated stands, trees and plants (Bogaard 2005; Jones 2012). This integrated archaeobotanical analysis has revealed that the local environs at Bestansur included a biodiverse range of woodlands, wetlands and grasslands that provided a wide range of plant resources.

Animal management and resources

As dung is present in many deposits across the site of Bestansur, including the 49 thin-sections examined in this research, animal management and resources are briefly considered in this chapter, as well as more fully in Chapters 15 and 16. No definite animal pens were identified within the settlement at Bestansur, in contrast to research at other contemporary and earlier sites, including Sheikh-e Abad, in the highland Zagros at *c.* 7590 BC, and more widely at Aşıklı Höyük *c.* 8200 BC (Stiner *et al.* 2014) and Çatalhöyük *c.* 7000–6500 BC. One possible candidate is a temporary pen at the end-life/post Building 9 Sp53 in a multi-purpose area (Fig. 12.15d). The use of dung fuel throughout the history of the areas of the site excavated suggests that herbivores were proximate to the site (see also Chapter 16). The dung is likely to have been obtained from domesticated goat based on zooarchaeological evidence of their kill-off patterns and that the sheep appear to have been wild and hunted at Bestansur (Chapter 16). Whilst close to the site, these managed herbivores would have provided a comparatively reliable source of: food; hide, leather and sinews for clothing, containers, artefacts and furnishings; horns as symbols of power/ritual; as well as dung fuel and a potential manure source, thus contributing significantly to food security, material culture and a sustainable second-generation fuel supply. The extent of dung-fuel use is likely to be under-represented as many fires exceeded 650–750°C, the point at which characteristic dung spherulites calcine and lose their diagnostic form and extinction cross and are no longer readily detectable (Canti 1999; Canti and Nicosia 2018). Greater proximity to animals and handling of animal dung, however, are likely also to have been potential sources, vectors and pathways for disease (Fournier *et al.* 2017), as discussed above.

Animal diet included reeds, grasses and dicotyledonous leaves, as attested in micromorphological and spot phytolith records from this and other sites, including Sheikh-e Abad (W. Matthews 1999; 2005;

Shahack-Gross 2011; Shillito *et al.* 2013a; Garcia-Suarez *et al.* 2018; Portillo *et al.* 2019; Chapter 16). Domesticated goats, as well as wild sheep and deer, are likely to have had an impact on the environs and to have competed with human communities for landscape resources, and browsers in particular may also have had an impact on the delayed spread of woodland (Vera 2000; Jones *et al.* 2019). It is also notable that the extent of grassland in the Zagros in the region of Lake Zeribar, 45km to the east-northeast at *c.* 1290m asl, started to decline during the occupation of the site (Wasylikowa *et al.* 2008).

Sustainable resource use and risk management strategies

One of the major aims and outcomes of this research has been to investigate sustainability of ecological and social practices and lifeways of the early settled community at Bestansur. A range of the risk management strategies has been identified, whether or not these were consciously deployed. These strategies included: conservation of woodland habitats and resources; use of renewable and second-generation grass, reed and dung fuel to provide a sustainable energy supply for cooking, heating and the diverse crafts at the site which provided a basis for the community's wealth, social significance and networks; biodiverse human and animal diets; food processing to enhance nutritional value; use of plants in construction and furnishing; and management of refuse by burning, discard and frequent resurfacing all of which would have contributed to the sustainability and health of this settled community.

Conclusions and future directions

Sedentism, society and ritual: Built environment design, use, sustainability and health

Built environment innovation, design, socialisation and ritual

Analyses of the materiality of building construction and design has revealed remarkable knowledge and innovation in the utilisation of a wide range of sedimentary materials and their application. This knowledge included experimentation in diverse wall construction materials and technologies including in use in walls of pisé, strip-chineh and rectilinear and boat-shaped mudbricks; foundational packing, plastering of floors, walls and features and pyrotechnology in production of fired lime. Many of these traditions indicate shared technological knowledge across Southwest Asia from the highland Zagros to central Anatolia, as well as local knowledge and access to materials at both a household and cross-sectoral level, with increasing evidence of selection of more shared colluvial rather than alluvial/plain sediments, perhaps due to shifting land-use practices and ownership.

The similarities in the orientation of buildings and abutting walls indicate considerable cross-community collaboration and shared concepts in building traditions and settlement organisation. The absence of party walls and construction of individual fire installations within each building unit, however, attest to growing independence and productivity of individual co-residential groups, although the burials in particular, suggest that the sustainability – social, economic and cultural – may have been dependent on wider non-genetically related networks (Pilloud and Larsen 2007; 2011).

The large size and elaboration of Buildings 8 and 5, and the aggrandisement of the latter, as well as their associations with high numbers of primary and secondary burials, indicate that these places were particularly important arenas for the local and wider community. These buildings, and the individuals who sustained them, clearly operated as major nodes in early sedentary community social networks. The creation of large reception rooms within these buildings provided a well-maintained space capable of hosting the public-scale social interactions that these networks attest. The rendering, high-maintenance and furnishings of these spaces with fine-plastered and white-washed walls and pigmented mats would have afforded marked status.

Built environment health and sustainability

There is substantial evidence from analysis of the materials and designs of buildings and the built environment that, consciously or not, these created hygrothermally optimal living conditions, energy efficient buildings and fire installations, and waste-management strategies that would have added significantly to the sustainability, health and comfort of this community by restricting disease reservoirs, vectors and pathways.

A range of strategies contributed to the sustainability of the community at Bestansur and its local and supra-regional networks. These practices include use of renewable and second-generation sources of reeds, grasses and animal dung for fuel, which is a major challenge to settled communities (Asouti and Austin 2005; Henry *et al.* 2018), and efficient combustion and retention of radiant heat in well-designed ovens and fire installations. Human and animal diet was very biodiverse, with a range of wild resources that spanned different ecozones and seasons and would have helped to buffer risk (Marston 2011).

Resource management and sustainability: A micro-contextual approach

Plant taphonomy, diversity, ecology, resource use and diet

The integrated archaeobotanical approach developed here has added considerably to our knowledge of plant resource availability, management and use in the Zagros by developing integrated micro-contextual archaeobotanical approaches that consider not only charred plant remains, but the diverse plant impressions, phytoliths, desiccated and humic remains and calcitic ashes that are preserved in the archaeological record, as discussed in this chapter and Chapters 13, 16 and 18. This approach has been especially important at Bestansur where charred plant remains are particularly scarce and poorly preserved (Chapter 18), as at a number of other Neolithic sites in Southwest Asia, North Africa and Europe (Stevens and Fuller 2012; Morales *et al.* 2015; Pelling *et al.* 2015; Arranz-Otaegui *et al.* 2016b). The results and implications, therefore, are of much wider significance. The factors for the scarcity of charred plant remains are considered in detail above. At Bestansur these include not only post-depositional bioturbation (Chapter 18), defined and excluded from thin-section analyses, and *in situ* fragmentation but also and most significantly: widespread evidence of high temperature oxic combustion conditions that leave little residual carbonised remains; extensive use of non-woody non-seed plant materials including fragile monocotyledon and dicotyledon leafy material and animal dung as fuel, as well as use of nuts/fruit and tubers that may be lost or disarticulated during water-flotation (Van der Veen 2007; Colledge and Conolly 2014); and the absence of middens and scarcity of thick occupation deposits to date due to management of waste and the built environment in this early sedentary settlement, and perhaps composting to improve fertility (Bogaard 2005).

Although charred wood is scarce in both macro-botanical and micromorphological samples, wood from deciduous trees and shrubs as well as nuts/fruits are attested in thin-section. This evidence of trees interestingly, is supported by the identification of phytoliths from deciduous bark and leaves in both micromorphological thin-sections, here, and spot phytolith samples (Chapters 13 and 16), suggesting they may have grown within the vicinity of the site. Many of the charred remains in thin-section are also represented by epidermal leaf fragments. Dicotyledonous bark and leaf phytoliths have been identified in herbivore dung, suggesting use as leaf and twigs as fodder as observed in ethno-archaeological research in the Zagros and elsewhere (see also Chapter 13; Halstead 1998).

The most abundant plant remains are phytoliths from reeds and grasses, both in thin-section and in phytolith spot samples (Chapters 13 and 16). Their ubiquity and abundance suggest significant presence of wetlands, riparian environments and grasslands. Their contextual representation and association indicate their use for matting, baskets, burial wrappings in Trenches 10, 12 and 13, and as fuel and fodder more widely across the site.

The scarcity of cereal grains and chaff in the macro-botanical, thin-section and phytolith assemblages suggest that cereals were not a major component of the diet. The most commonly occurring charred seeds in thin-section are pulses from diverse legumes, corresponding with a wider regional preference for legumes in the Zagros (Arranz-Otaegui *et al.* 2016a). This preference/prevalence may relate to the greater tolerance of legumes to wildfire and the value of legumes in fixing nitrogen in soils vital for plant and crop growth (Asouti 2017).

The identification of both wild root trachea and dicotyledonous leaves in a range of human coprolites in an open area in Trench 13 Sp25 provide the first direct evidence that wild foods were a significant component of the diet at Bestansur, as argued for the Neolithic more widely particularly in its earliest stages (Savard *et al.* 2006; Arranz-Otaegui *et al.* 2016a; Whitlam *et al.* 2018). This evidence, coupled with the extensive presence of mollusc shell from *Helix salomonica* in external deposits across all sectors of the site, and wild fauna in the zooarchaeological assemblage indicate that the sparsity of cereals may be due to greater reliance on locally available wild food resources and that a biodiverse broad spectrum diet was not only a characteristic of the Epipalaeolithic and Early Neolithic but extended well into the eighth millennium BC in the Zagros. This diverse diet is perhaps all the more significant when the complexity of the architecture, material culture and social networks at Bestansur are considered, as these are often considered a hallmark of more fully-fledged agricultural communities. The geographic location of Bestansur next to a major spring, with wetlands, riverine resources and adjacent plain and foothills provided an exceptionally biodiverse range of biomes and resources to sustain this community and its networks.

Animal diversity, ecology and resource use

Animal dung was widely used as fuel and is probably under-represented due to the high-temperature combustion and resultant loss of dung spherulites (Canti 2003; Canti and Nicosia 2018; Chapter 13, 16). No pens have been identified to date, although aggregates of laminated dung from penning occur in a range of contexts probably from importation of dung as fuel and suggest penning close to the site at least periodically. Dung content indicates a biodiverse diet that included perhaps seasonal variation in grazing/

browsing and or fodder from reeds, grasses and dicotyledon leaves and twiggy material from wetland/riparian habitats, grassland and perhaps parkland or riverine trees/shrubs. Dung may also have been used as manure, although there is no direct evidence of this to date at Bestansur (Styring *et al.* 2014).

Future directions

Future micro-contextual research at Bestansur in the next phase of research at the site will include further development of integrated archaeobotany with ESEM EDX analyses to study plant remains *in situ* in small block samples and in foodstuffs and difficult to identify remains such as tubers, wood fragments and seed fragments. We are also conducting more integrated spot phytolith analyses, high-precision analysis of samples drilled and extracted from resin-blocks for phytoliths, and ZooMS, to study traces of plants and animals in a wide range of contexts including coprolite lenses and fragments to study diet. A further aim is to develop microbiome research to examine gut health through study of the coprolites identified by GC-MS analyses as human and from different animal groups.

Current and future research includes 3-D and quantitative modelling of built environment construction materials and accumulated residues as well as disease reservoirs, vectors and pathways to develop studies of hygro-thermal properties and health of the built environment in collaboration with colleagues in the University of Reading, School of Built Environment, notably Dr Zhiwen Luo. Research by Alessandro Guaggenti is developing new 3-D multi-scalar micromorphology, modelling and GIS analyses to investigate the diversity of construction material resources and technologies and use and health of the built environment at scales of individual buildings, neighbourhood, site and environs.

13. INTEGRATED MICRO-ANALYSIS OF THE BUILT ENVIRONMENT AND RESOURCE USE: HIGH-RESOLUTION MICROSCOPY AND GEOCHEMICAL, MINERALOGICAL, PHYTOLITH AND BIOMOLECULAR APPROACHES

Wendy Matthews, Aroa García-Suárez, Marta Portillo, Chris Speed, Georgia Allistone, Ian Bull, Jessica Godleman and Matthew Almond

Interdisciplinary approaches to the built environment, resource management and sustainability

A major aim in the Central Zagros Archaeological Project is to develop integrated analyses of construction materials, archaeobotanical remains and faecal matter to study new high-resolution micro-contextual data on early sedentary built environments, resource management, fuel, diet and health at Bestansur, 7700–7000 BC, and Shimshara, from 7330–7180 BC to early seventh millennium BC, in Sulaimaniyah province.

A range of analytical techniques has been applied and piloted to identify specific organic and inorganic components and materials. This chapter begins with the analyses of high-precision spot sample analyses of construction materials, archaeobotanical remains and human and animal coprolites, that are closely correlated with microstratigraphic units in thin-section. These diverse remains have been variously characterised by pH, particle size and X-ray diffraction (XRD) and Fourier transform infra-red spectroscopy (FTIR) to study preservation conditions and mineralogy; and by phytolith, dung spherulite and gas chromatography-mass spectrometry (GC-MS) analyses to identify plant micro-fossils and detect human and animal coprolitic material to provide new data on plant and animal management, diet and health.

This chapter then reviews the application of integrated *in situ* micro-analyses of materials within their microstratigraphic context in large resin-impregnated micromorphological thin-sections. The analytical techniques applied include environmental scanning electron microscopy with energy dispersive X-ray analysis (ESEM-EDX) and infra-red microscopy (μ-IR) to study the materials and technology of multiple fine layers of wall plaster and paint from an elaborate Early Neolithic building. Confocal laser scanning microscopy was applied in a new pilot study in archaeology to study plant remains and coprolite contents in 3-D within their depositional context to enhance identification and the security of their micro-contextual associations, as well as autofluorescence which can be an indicator of preservation and combustion, and provide important new data on human and animal diet and health. Portable X-ray fluorescence (pXRF) was applied in a new pilot analysis of slices or surfaces of resin-impregnated blocks of deposits from which micromorphological thin-sections were cut to enable cross-comparison of elemental and microscopic characterisations, and to investigate the value of the archived blocks and slices. The focus of this research was on analyses of construction materials and detection of raised levels of phosphorus indicative of a range of human activities from across the settlement and compared to standards and blanks analysed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES).

The rationale and methodology for each analytical technique are reviewed and the results from each analysis presented and discussed in turn. The integration and wider implications of these results are examined in the concluding section, highlighting the value of interdisciplinary organic and inorganic micro-contextual analyses and their contribution to the study of early architectural construction, art, plant and animal resource use, and the sustainability and health of built environments. These analyses were conducted throughout the second phase of the Central Zagros Archaeological Project from 2012–2017, and complement the focused study of human and animal coprolites and early animal management conducted in research by Sarah Elliott with colleagues (Chapter 16)

Integrated high-precision spot sample analyses of construction materials, archaeobotanical remains and coprolites

A range of analyses was conducted on high-precision spot samples that are closely correlated to the microstratigraphic units in thin-sections, to identify and quantify specific components and materials that require extraction from their depositional matrix. In the laboratory at the University of Reading, high precision spot samples were collected from the back of each block prior to impregnation from each macroscopically discernible layer, with typically 6–15 samples collected per block, each weighing in the order of 10–50g, and their locations recorded and mapped by high-resolution photography.

We begin with analyses and results of the preservation conditions and characteristics of deposits and burial environment by: pH and particle size determination and x-ray diffraction (XRD) analysis of the clay mineralogy. We then highlight the analyses and results from biomolecular analysis by gas chromatography-mass spectrometry (GC-MS) which have enabled identification of herbivore, omnivore and human faecal material, and from high-precision spot sampling for integrated phytolith and dung spherulite analyses that are linked to the GC-MS and micromorphological analyses and discuss the importance of this for transformations in animal management and the built environment and health in the concluding section of this chapter.

Analyses of pH, particle size, and mineralogy by XRD and FTIR

Geoarchaeological analyses were conducted to characterise the sediments and preservation conditions in natural deposits below the mound and construction materials and occupation deposits on the mound, in a pilot study prior to the coring programme (Chapter 6). These pilot studies included analysis of pH, particle size, and clay mineralogy by X-ray diffraction (XRD) on ten samples from natural, wall and floor materials, and ashy occupation deposits after the first season of excavations. These analyses were conducted by Quaternary Scientific (QUEST), School of Human and Environmental Sciences, University of Reading. Fourier transform infra-red (FTIR) analyses were conducted to analyse the mineralogy of the multiple layers of plasters applied to the walls of Building 8, T10 (Godleman *et al.* 2016).

Methodology

pH DETERMINATION

The pH value of the soil sample was determined in water (Ministry of Agriculture, Fisheries and Food 1973) and adding calcium chloride (Avery and Bascombe 1974) according to the following procedure:

Ten grams of air dried 2mm sieved soil were weighed in to a 50ml centrifuge tube. 25ml ultrapure water were added using an automatic dispenser. Then the sample was placed on the shaker for 15 minutes. The pH meter was calibrated with either pH 4.00 and 7.00 buffers (if the soil suspension might be acidic) or pH 7.00 and 9.22 buffers (if the soil is alkaline). pH electrodes were placed in the soil suspension, the pH was recorded after 30 seconds. 2ml of 0.135M $CaCl_2$ solution were added to the sample. The solution was then mixed and the pH in $CaCl_2$ measured soon after. The electrode was rinsed with ultrapure water and blotted dry with soft tissues between each sample. The calibration of the pH meter was checked frequently.

PARTICLE SIZE DETERMINATION

The particle size of loose material in bulk sediment sample bags was analysed by laser granulometry and evaluated using the statistical programme GRADISTAT (Blott 2008) by Quaternary Scientific (QUEST). The results were then calibrated to correspond with the Soil Survey particle size classification (Hodgson 1974) and thereby CZAP field descriptions.

FOURIER TRANSFORM INFRA-RED (FTIR)

Spot samples of deposits and materials were analysed in powder form by ATR-IR utilising a Perkin-Elmer spectrum 100 FT-IR spectrometer that was set to record between 4000 and 510cm^{-1} at a resolution of 4cm^{-1} and scanned 16 times (Godleman *et al.* 2016: 196).

Results of pH, particle size, and mineralogy by XRD and FTIR

Ten samples from natural, wall and floor materials, and ashy occupation deposits were analysed to

Table 13.1. Sample contexts and results from pH and particle size determinations.

Sample	*Context*	*Trench*	*Description*	*Particle size*	*pH water*	*pH $CaCl_2$*
193	1087	4	Natural	silty clay loam	8.15	7.5
453	1202	7	wall material (sediment)	silty clay	8.37	7.45
454	1183	8	wall material (greenish sediment)	silty clay loam	8.29	7.53
455	1186	8	wall material (sediment)	silty clay loam	8.37	7.52
456	1099	1	wall material (sediment)	silty clay loam	8.58	7.52
457	1088	4	Natural	silty clay loam	8.32	7.57
69	1073	5	Ashy deposit	silty clay loam	8.18	7.37
377	1176	7	Around quern stones	silty clay loam	8.22	7.46
289	1156	9	Bottom of sounding	silty clay loam	8.26	7.53
259	1182	8	Green silty clay mudbrick	silty clay loam	8.16	7.39

investigate the preservation conditions and deposits characteristics and properties by bulk pH and particle size determination and XRD analysis of the clay mineralogy in the eastern, southern and western sectors of the settlement (Table 13.1).

pH DETERMINATION

pH values across all these deposit-types are neutral to slightly alkaline at pH 7.37–7.57 and pH 8.15–8.58, enabling preservation of calcareous materials such as bone, shell, plant ashes, silica phytoliths up to *c.* pH 8.2 (Weiner 2010: 175), but restricting pollen survival (Avery and Bascombe 1974).

PARTICLE SIZE DETERMINATION

Results indicate that all deposits analysed are fine grained with >20–38% clay, >60–75% silt and <0–5.5% sand, including natural, wall and floor materials, and ashy occupation deposits (Table 13.1). Nine out of ten of these can be classified as 'silty clay loam' (Hodgson 1976). One deposit is finer grained and can be classified as silty clay (Hodgson 1976) with >35% clay at 38.2% clay and 0% sand, C1202, used for wall construction in Trench 7.

X-RAY DIFFRACTION (XRD)

XRD analysis has established that expandable clays represent 42–59% of wall construction materials and 47–52% of floor and ashy deposits (Fig. 13.1). These expandable clays include smectite (27–59%). Other clays present include: illite, a non-expandable alumino-silicate (29–61%) and kaolinite, a non-expandable layered silicate. Of the mass percentages of mineral phases, calcite represents 50–65% and quartz 27–39% (Fig. 13.2). The remaining <12% include kaolinite, albite, potassium feldspar, dolomite and haematite.

Discussion of particle size, geochemical and mineralogical results

The pH determinations indicate that the conditions of the depositional environment are currently slightly alkaline and within the preservation tolerance of a wide range of key materials including bone, phytoliths – which dissolve at pH >8.2 (Weiner 2010: 175), and calcareous dung spherulites – which dissolve at pH <6.5 (Canti 1999).

The particle size determinations indicate that many deposits are fine-grained. All earthen walls and occupation deposits were classified as silty clay loam, with the exception of the earthen wall in Trench 7.

Micromorphological analyses of both mudbricks and packed earth walls, as well as many earthen plasters, reveal that these construction materials included traces of linear and curvilinear plant and/or fibre remains (Fig. 13.3). The addition of these fibrous materials would also have provided added tensile strength and flexibility (Houben and Guillaud 1989; Cammas 2018). This addition would in effect have helped to compensate for, firstly, the fine-grained particle size, as the clay content of the walls of Building 3 in T7 at 38% exceeds the 30% ideal limit. An ideal mudbrick mix should comprise: 15–30% clay, 10–30% silt and 40–75% sand (Norton 1986). The fibrous additions would have helped to compensate for the shrink-swell action of the expandable clays.

One of the current conservation challenges is how to preserve the earthen walls at Bestansur, for, as at many sites, these fibrous materials have since decayed and are no longer present to bond the earthen materials (Chapter 8). All deposits at Bestansur have a high percentage of expandable clays at 42–59%, which expand and contract when wet and dry. These properties have been observed in soils across much of the region, including at Jarmo, and can result in cracks and mixing to depths of *c.* 50–60cm (Buringh 1960: 253–273). Shrink-swell action can also impact fragile materials and cause mechanical damage. These properties have impacted the preservation and stratigraphic integrity of a range of charred plant remains as discussed in Chapters 12 and 18.

Integrated phytolith and dung spherulite analyses

Methodology

In the field laboratory, spot smear slides were analysed to identify the presence and type of phytoliths and calcareous dung spherulites present in deposits

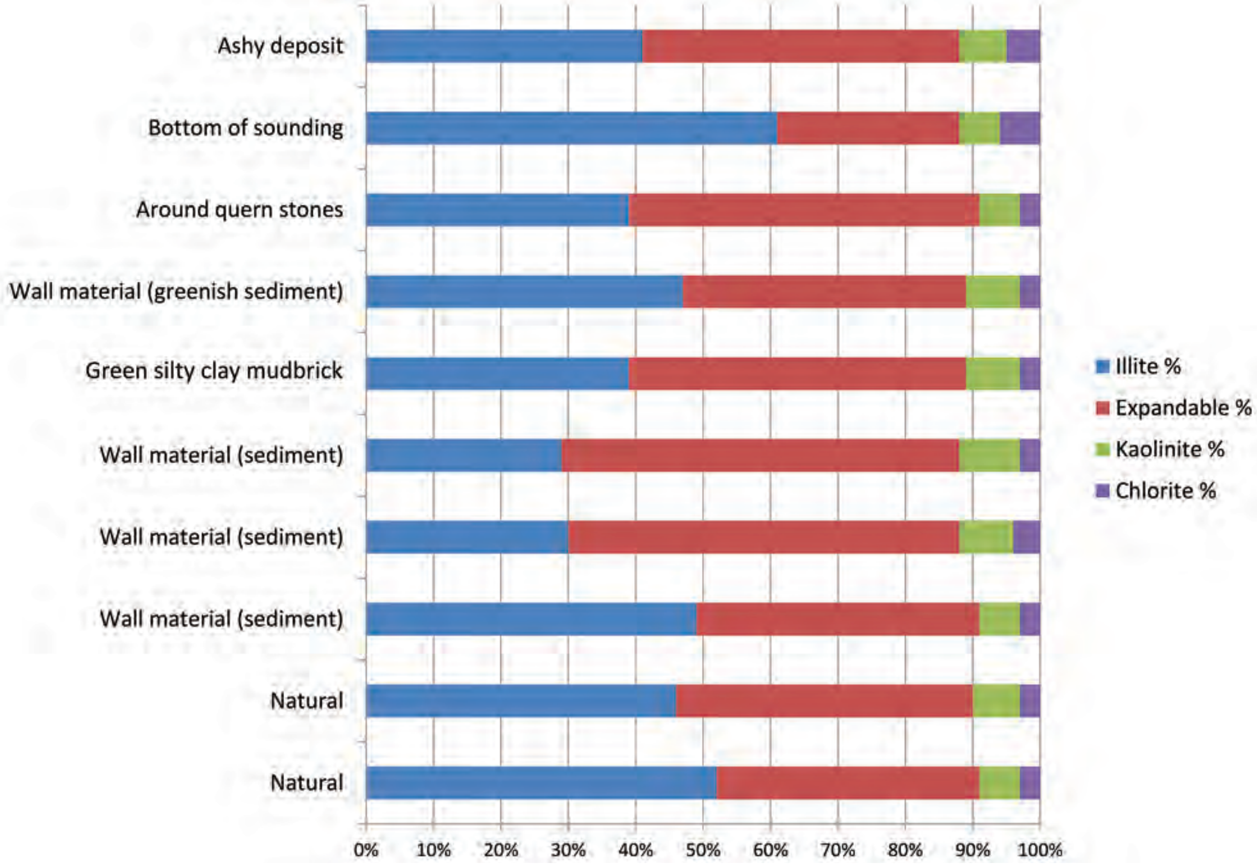


Figure 13.1. XRD clay mineralogy percentages.

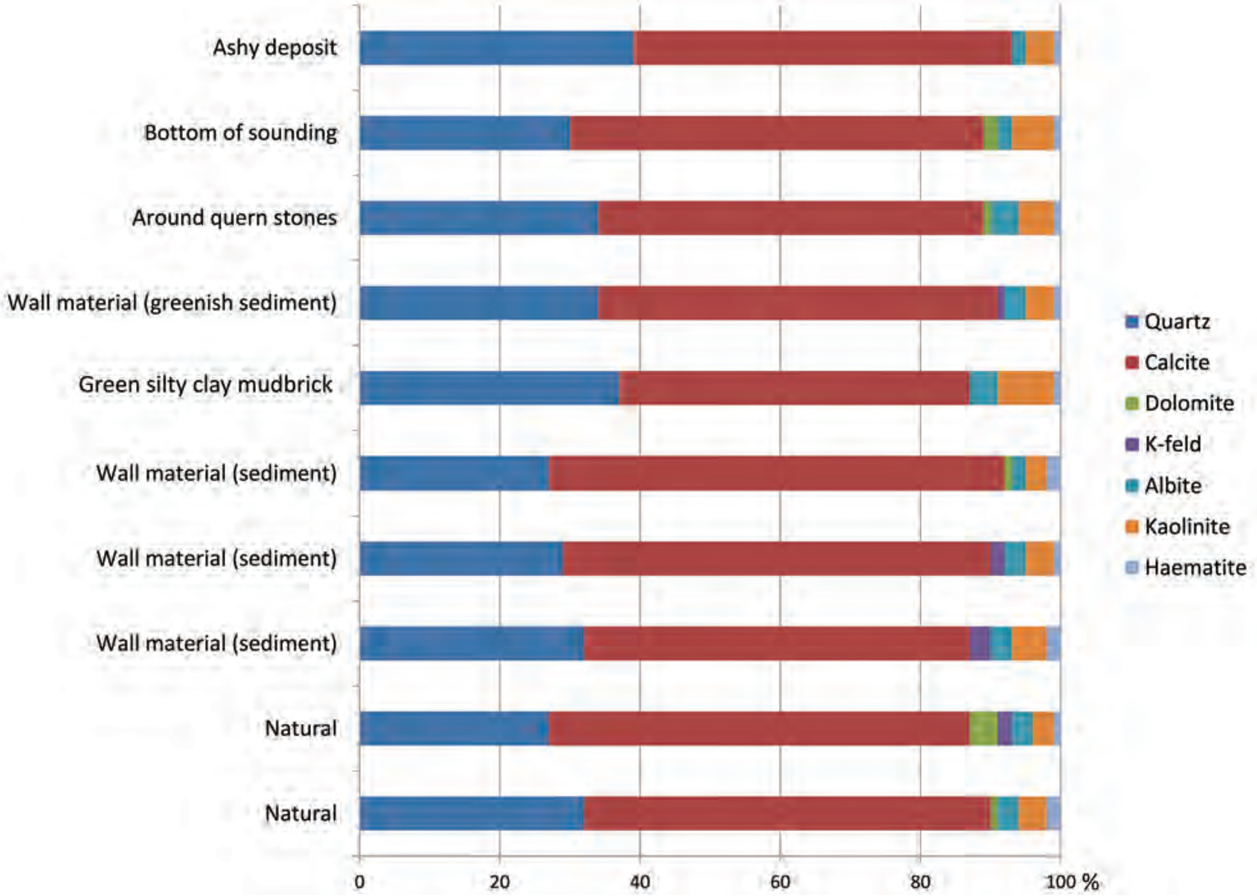


Figure 13.2. XRD clay mineralogy mass percentages of mineral phases.

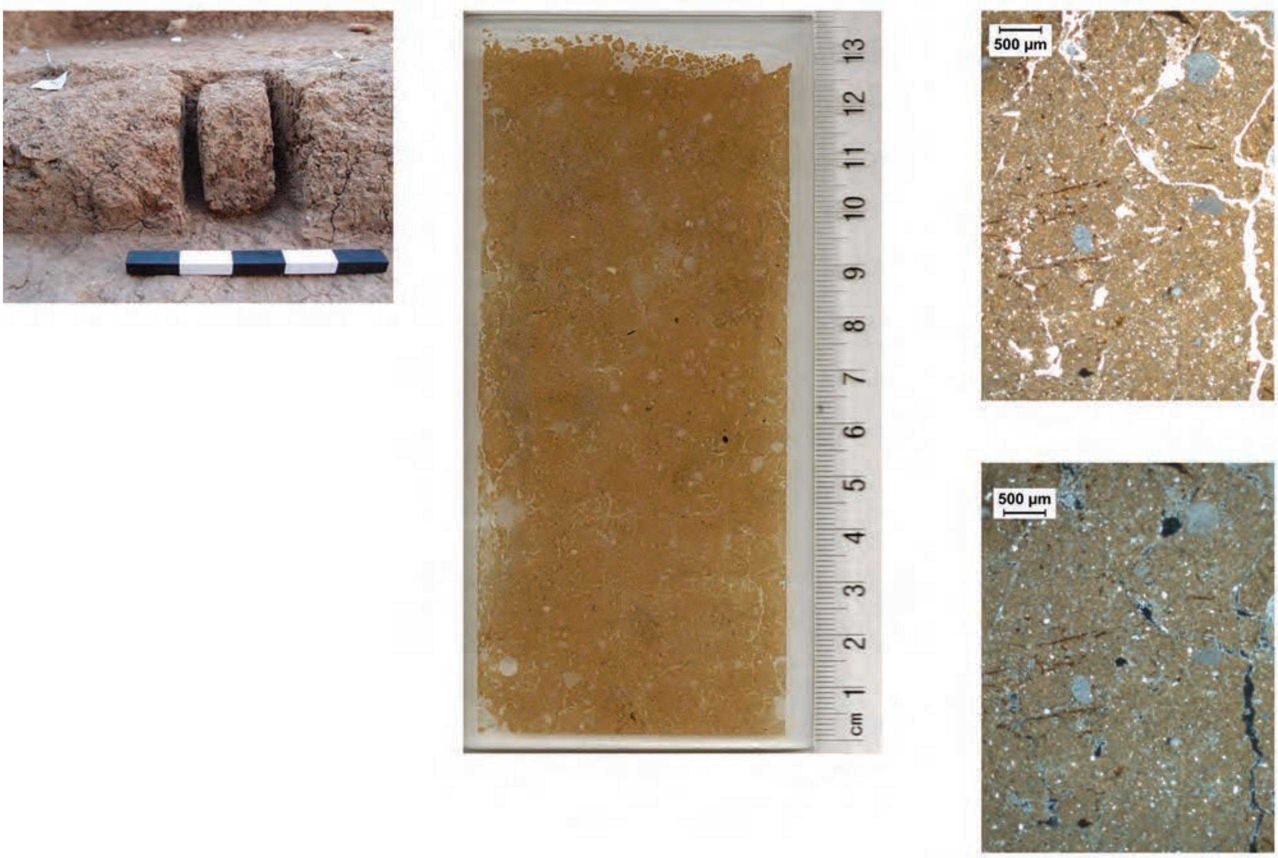


Figure 13.3. Impressions and brown mineralised remains of plant remains/fibres in earthen wall of Building 3, Trench 7, Bestansur, and modern cracks (scale = 50cm; PPL and XPL).

to inform on plant and coprolite preservation and use and excavation and sampling strategies and interpretations during field investigations by Wendy Matthews and Marta Portillo (W. Matthews 2000; 2005; Shillito *et al*. 2013a).

To study fuel sources, accumulated occupation deposits, and contents of coprolites to inform on diet, health and animal management, 22 high-precision subsamples were selected from Trench 10 and Trench 13 for integrated phytolith and dung spherulite analyses from Bestansur (Table 13.2) and 12 from experimental combustion from modern dung by Georgia Allistone and Marta Portillo in the framework of EU Horizon 2020 MICROARCHEODUNG project (H2020-MSCA-IF-2015-702529). This work was also supported by an Undergraduate Research Opportunities Programme fellowship supervised by Marta Portillo and Wendy Matthews at the University of Reading. Analysis of extracted phytoliths enables detailed quantification of individual (single-celled) and articulated multicellular phytoliths by the removal of occluded organic remains and other components that may mask identification and enables rotation of phytoliths within a viscous medium to locate diagnostic features and facilitate their identification. Further, microscopic examination of these spot subsamples enables close correlation with micromorphological analyses of their precise context of deposition, as well as on formation processes and the contextual associations of individual components and other microfossils such as calcitic dung spherulites at high-resolution.

Phytolith extraction followed the methods of Katz *et al.* (2010). A weighed aliquot of 40mg of dried sediment was treated with 50µl of a volume solution of 6N HCl and then with 450µl 2.4g/ml sodium polytungstate solution [$Na_6(H_2W_{12}O_{40})$]. Microscope slides were mounted with 50µl of sample. A minimum of 200 phytoliths were examined at ×200 and ×400 using a Leica DMEP optical microscope. Morphological identification was based on modern plant reference collections and standard literature (Twiss *et al.* 1969; Brown 1984; Mulholland and Rapp 1992; Rosen 1992; Twiss 1992; Albert and Weiner 2001; Piperno 2006; Tsartsidou *et al.* 2007; Albert *et al.* 2008; 2016; Portillo *et al.* 2014). The International Code for Phytolith Nomenclature – ICPN 2.0 was also followed where appropriate (Neumann *et al.* 2019).

The methods used in the spherulite study are similar to those developed by Canti (1999). Microscope slides were mounted with about 1mg of dried sample using Entellan New (Merck). Spherulites were counted at ×400 under the optical microscope with cross-polarized light. Samples were compared to ethnoarchaeological datasets of modern livestock dung (Portillo *et al*. 2012; 2014; 2017; Elliott *et al*. 2015; Portillo and Matthews 2020), as well as to experimental samples obtained from the combustion of ovicaprine and cattle modern dung from the site vicinity. Modern dung pellets were ashed in laboratory-controlled conditions between 400 and 900°C (at intervals of 50 or 100°C for 4h) using a muffle furnace. After ashing, both phytoliths and spherulites were examined following the above-described methods. The initial weight in rich-dung samples was of around 0.5mg in order to avoid microfossil overloading (Portillo *et al*. 2017; 2019).

Results and discussion of integrated phytolith and faecal spherulite analyses

Phytoliths

Phytoliths were abundant in all the samples examined from both Trench 10 (Sp27, Sp44 and Sp48) and Trench 13 (Sp24 and Sp25), ranging from 0.3 to 20.2 million phytoliths per gram of sediment (Table 13.2).

In general, the low proportions of weathered phytoliths, along with the presence of multicellular or anatomically or connected phytoliths (up to 64% in oven sample SA1783.ss3 from Sp48), are indicative of a good state of preservation of most of the assemblages. Overall, the morphological results indicated that monocotyledonous plants and particularly grasses from the Pooideae subfamily dominated the phytolith record (with an average close to 70%, Fig. 13.4). Among monocotyledonous phytoliths, diagnostic morphotypes from the Cyperaceae family (sedges) and reeds (Arundinoideae subfamily), which are also commonly found in wetlands, were observed in most of the samples. Grass phytoliths were divided into the different anatomical plant parts in which they were formed (Fig. 13.5).

Epidermal cells from grass leaves and stems, including flabellate bulliforms, acute bulbosus (trichomes) and stomata, were noted in all the samples in different amounts (between *c*. 40–85%, Fig. 13.6a–b). The results show that multi-celled concentrations of these plant parts and particularly derived from reeds, were high in samples related to ashy remains in open areas and fire installations such as ovens (more than 80% in SA1783.ss2 and SA2299 from Sp48 and Sp44, respectively, Fig. 13.5). The presence of phytoliths showing evidence for partial melting observed in deformations caused by high temperatures in these combustion assemblages

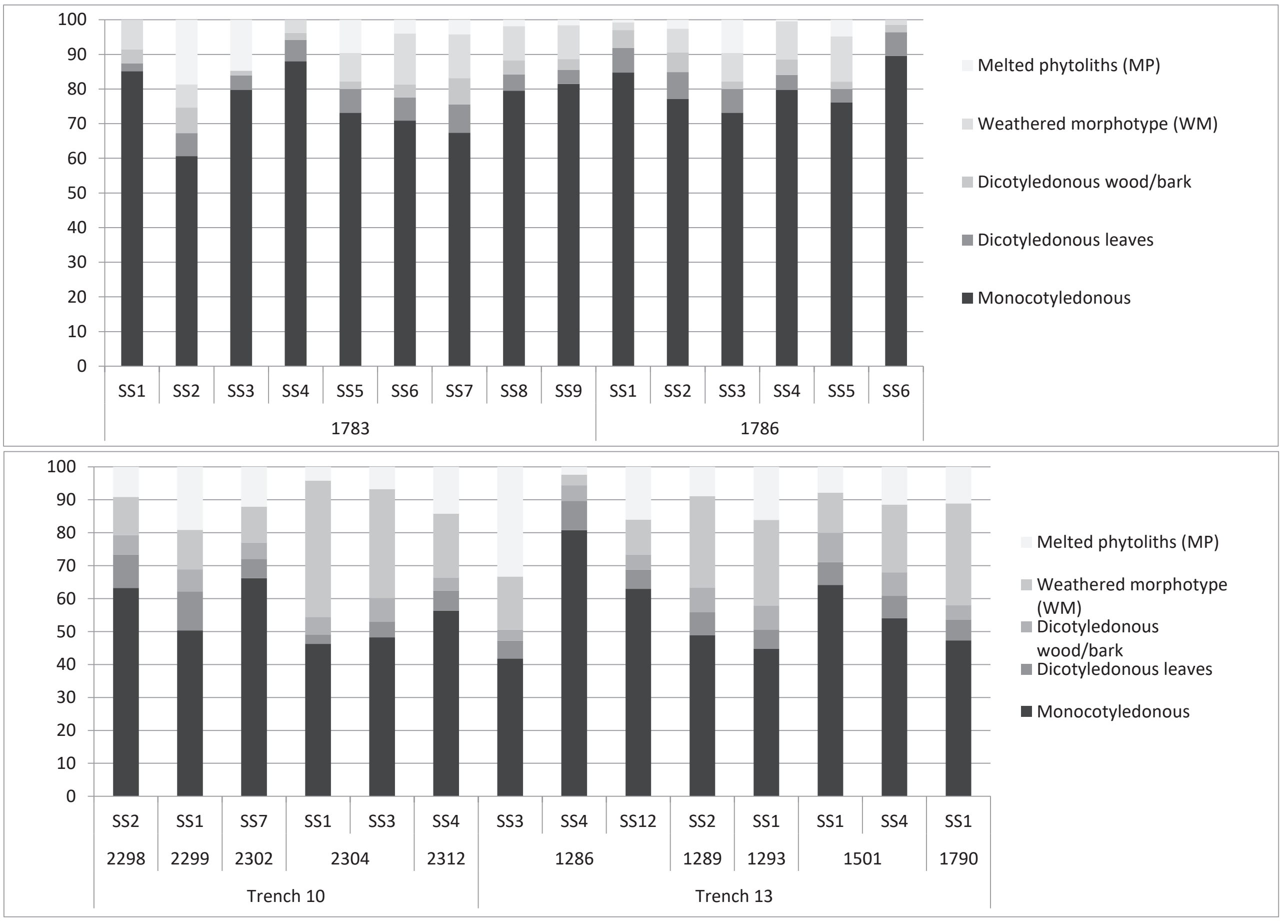


Figure 13.4. Relative abundances of phytoliths obtained from the samples. Uppermost: SA1783 vs SA1786 oven samples, Trench 10; lowermost: Trench 10 vs Trench 13 samples.

Table 13.2. Description of samples and main phytolith and spherulite results obtained from Trench 10 and Trench 13.

Sample ID	*Sub-sample ID*	*Trench*	*Space*	*Building*	*Context*	*No. phytoliths 1g of sediment*	*% Multi-celled phytoliths*	*% Phytoliths weathering*	*% Phytoliths melting*	*No. spherulites 1g of sediment*	*Context*
1783	SS1	10	48	5	1610	300,000	4.9	8.5	0.0	0	Oven plaster
1783	SS2	10	48	5	1610	1,100,000	50.0	6.7	18.7	0	Oven, *in situ* fuel
1783	SS3	10	48	5	1610	4,800,000	64.2	14.7	0.0	0	Oven, *in situ* fuel
1783	SS4	10	48	5	1610	5,600,000	38.0	3.7	0.0	19,000	Oven, *in situ* fuel
1783	SS5	10	48	5	1610	6,600,000	47.6	8.2	9.6	0	Oven, *in situ* fuel
1783	SS6	10	48	5	1610	2,800,000	43.3	14.7	4.0	32,000	Oven, *in situ* fuel
1783	SS7	10	48	5	1610	480,000	35.8	12.6	4.2	0	Oven, *in situ* fuel
1783	SS8	10	48	5	1610	2,100,000	22.5	9.9	1.9	30,000	Oven, *in situ* fuel
1783	SS9	10	48	5	1610	3,500,000	32.8	9.8	1.6	0	Oven, *in situ* fuel
1786	SS1	10	48	5	1562	20,200,000	31.6	2.3	0.8	26,000	Oven, *in situ* fuel
1786	SS2	10	48	5	1562	1,800,000	36.8	2.6	2.6	36,000	Oven, *in situ* fuel
1786	SS3	10	48	5	1562	2,000,000	25.6	3.4	3.4	110,000	Oven, *in situ* fuel
1786	SS4	10	48	5	1562	1,500,000	21.1	11.0	0.4	0	Oven, *in situ* fuel
1786	SS5	10	48	5	1562	2,100,000	23.0	13.1	4.8	18,000	Oven, *in situ* fuel
1786	SS6	10	48	5	1562	7,300,000	30.4	1.5	0.0	0	Oven, *in situ* fuel
2298	SS2	10	44	5	1767	970,000	15.9	3.4	9.1	14,000	Oven, *in situ* fuel
2299	SS1	10	44	5	1767	1,500,000	26.4	11.9	19.2	30,000	Oven, *in situ* fuel
2302	SS7	10	27	n/a	1772	1,500,000	28.9	12.1	12.1	57,000	Open area, ashy deposits
2304	SS1	10	27	n/a	1749	2,600,000	13.5	41.4	4.2	120,000	Open area, ashy deposits
2304	SS3	10	27	n/a	1749	2,000,000	19.9	33.0	6.8	58,000	Open area, ashy deposits
2312	SS4	10	44	n/a	1755	1,100,000	27.4	19.3	14.2	36,000	Open area, domestic debris charred lens
1286	SS3	13	25	n/a	1494	770,000	30.6	16.1	33.3	19,000	Open area
1286	SS4	13	25	n/a	1494	13,400,000	33.2	3.3	2.4	32,000	Open area, coprolites
1286	SS12	13	25	n/a	1494	1,300,000	20.1	10.6	16.1	21,000	Open area, coprolites
1289	SS2	13	24	n/a	1479	2,000,000	17.4	27.7	8.9	120,000	Open area, domestic debris charred lens
1293	SS2	13	24	n/a	1470	2,200,000	22.4	26.0	16.1	57,000	Open area, domestic debris charred lens
1501	SS3	13	25	n/a	1665	22,000,000	23.8	12.2	7.8	120,000	Open area, coprolites
1501	SS4	13	25	n/a	1665	1,700,000	24.9	20.6	11.5	36,000	Open area, coprolites
1790	SS1	13	25	n/a	1494	3,500,000	22.2	11.1	11.1	18,000	Open area, coprolites

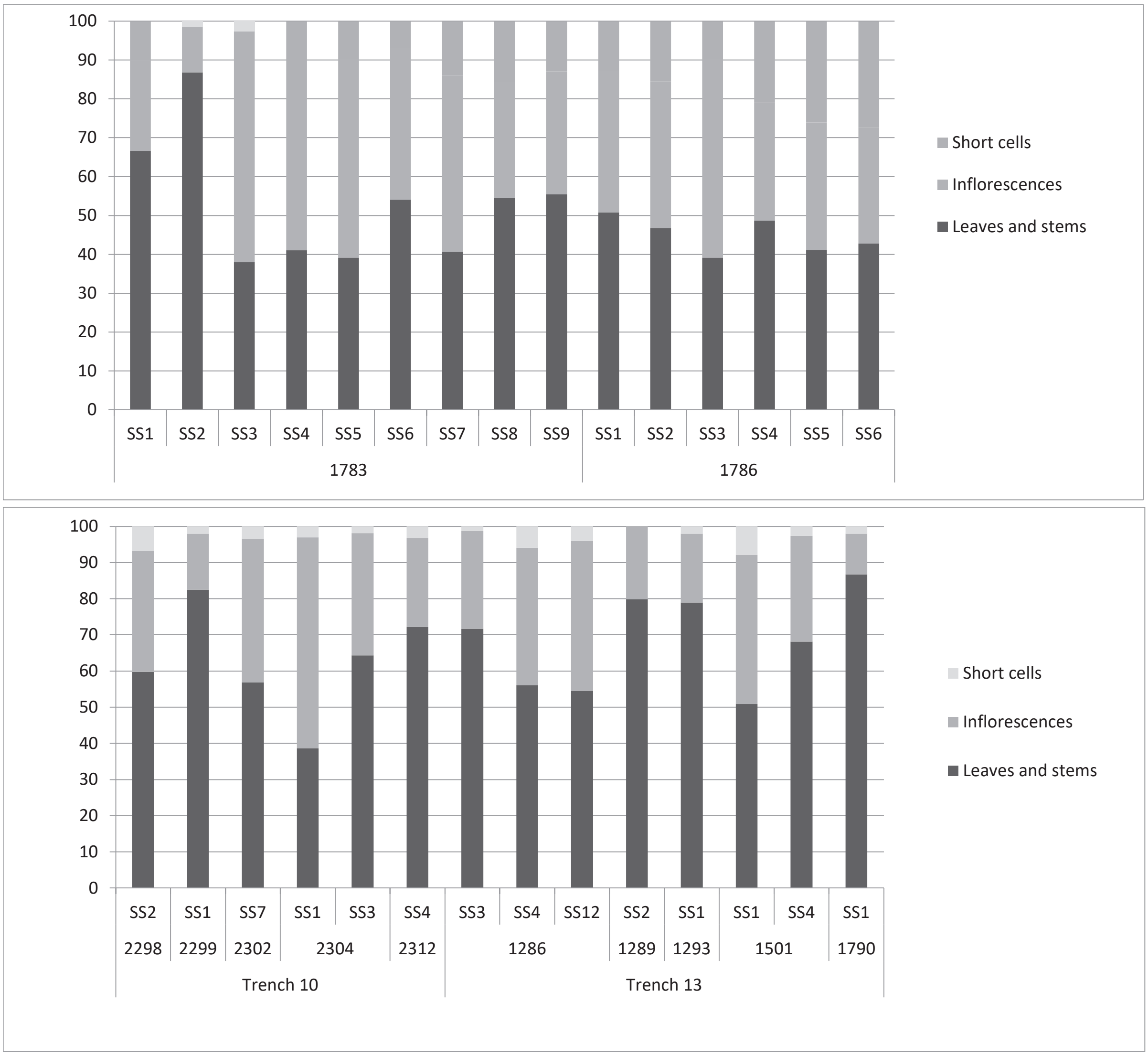


Figure 13.5. Anatomical origin of grass phytoliths. Uppermost: SA1783 vs SA1786 oven samples, Trench 10; lowermost: Trench 10 vs Trench 13 samples.

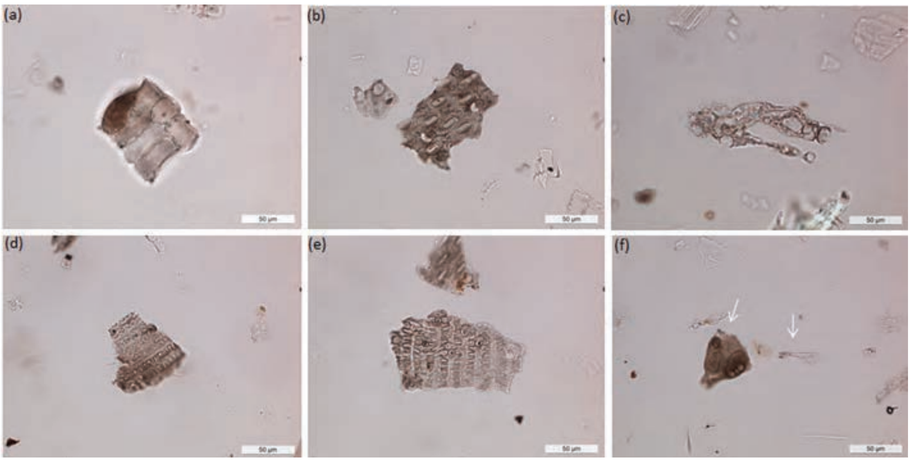


Figure 13.6. Photomicrographs of phytoliths identified in oven sample SA1783.ss4 from Building 5 Space 48 (×400): a) multicellular (articulated) bulliforms flabellate from monocotyledonous leaves; b) multicellular elongate phytoliths with stomata from reed leaves/stem; c) melted phytoliths; d–e) multicellular dendritic phytoliths with short cells rondel from Pooideae grasses; f) epidermal base with attached appendage hair from dicotyledonous leaves.

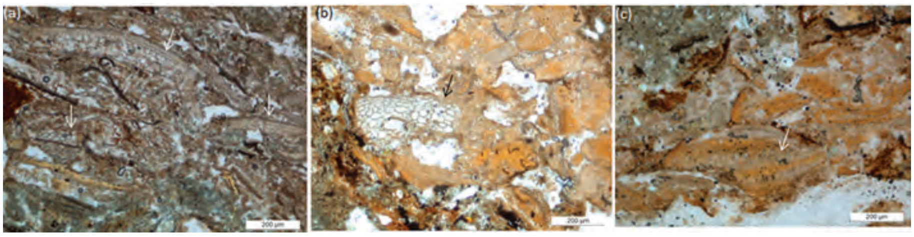


Figure 13.7. Photomicrographs from micromorphology thin-section displaying multi-celled or anatomically connected phytoliths of dicotyledonous leaf tissues in a–b) ashy deposits with omnivore and human coprolites (SA1286.ss3 and ss2); c) and of tracheary in an omnivore coprolite (SA1286.ss12), T13 Space 25.

is also of significance, particularly in oven deposits (Fig. 13.6c). Additionally, grass morphotypes derived from the floral parts of these plants were also abundantly noted in most of the samples. Grass inflorescences were defined mainly by decorated dendritic and dentate (echinate) elongate phytoliths in addition to epidermal morphotypes such as papillate. Multi-celled dendritic phytoliths from the husks and culms of Pooids, were also observed in many samples (Fig. 13.6d–e). The presence of these morphologies, which are considered as delicate or fragile cells, points also towards a general good preservation conditions in most of the assemblages. The richest sample by far was SA2304.ss1 from T10 Sp27, belonging to ashy deposits from an open area, where grass inflorescences represent *c.* 60% of all grass morphotypes (Fig. 13.5). Further, certain samples from coprolitic materials from open areas in T13 Sp25 also displayed large proportions of multicelled phytoliths from the husk of Pooideae grasses (SA1286.ss4, SA1286.ss12 and SA1501.ss3, *c*. 40%).

These samples yielded also epidermal appendages and multi-celled phytoliths produced by the dicotyledonous plants such as tracheids, acute bulbosus (hairs) and their epidermal bases (Figs 13.6f and 13.7a–c). This is especially noteworthy given that dicotyledonous plants are minor phytolith producers. This vegetal microfossil composition in association with coprolitic materials is suggested to derive from a defector diet that includes a leafy component or roots.

SPHERULITES

In contrast, dung spherulites were scarce, or even absent in certain oven samples from B5 Sp. 48. Their concentrations range between 14,000 and 120,000 spherulites/g sediment. The largest numbers were obtained from open area ashy deposits and domestic debris (SA2304.ss1 and SA1289.ss2), and the coprolite sample SA1501.ss3 from Sp25 (Table 13.2). This high variability possibly relates to variable production by different defecators (certain species produce low amounts or none such as omnivores, but it also may depend on a range of factors such as seasonality and sex/age based differences in dietary calcium intake), to dissolution as they degrade rapidly in acidic burial environments, or from decomposition at temperatures above 650–700ºC, as observed in ethnographic and experimentally-produced combustion datasets (Canti 1999; W. Matthews 2010; Shahack-Gross 2011; Portillo *et al.* 2017; 2020). The latter is likely the case of the oven samples, as in closed firing installations burning temperatures of dung fuel rapidly reaches temperatures as high as 850ºC (Gur-Arieh *et al.* 2013; Portillo *et al*. 2014; 2017). The partial melting of phytoliths indicative of high temperatures, above 700ºC, is also significant in the oven samples as well as in certain open areas composed of dung ashy remains (up to 33% in SA1286.ss3 from Sp25; Table 13.2).

Overall, this integrated microscopic approach to plant and dung resource use, firing and the sustainability and health of built environments of this study illustrates the nature of fuel resources, the variability of faecal matter and coprolite inclusions found in these contexts and the complexity of human–animal relationships during this period of transformations. Integrated quantitative phytolith and spherulite data in association with qualitative micro-contextual observations of key deposits have resulted in the characterisation of mixed and *in situ* burned deposits, as well as the composition of faecal matter and a range of coprolitic materials found in different settlement open areas. The implications of these results for early Neolithic life-ways and the sustainability and health of built environments are discussed below.

The variable amounts of both phytoliths and dung spherulites in mixed and *in situ* burned deposits and particularly in ovens from spaces Sp44 and Sp48 suggested the occurrence of accumulations of animal faecal matter in these contexts. These assemblages were composed of variable amounts of monocotyledonous phytoliths, including Pooideae grasses, reeds and sedges, and such microfossil associations indicated that these plants might have had a significant input as fuel and possibly as derivatives of livestock fodder as well. Furthermore, the presence of partially melted phytoliths (indicative of high temperatures, above 700ºC) in association to the scarcity or even absence of spherulites which are also damaged by high temperatures rapidly reached in closed firing installations such as ovens (around 850ºC), have provided some insights into firing activity at the site. The extent of melting of phytoliths has been also observed in modern experimental and ethnoarchaeological materials of dung-dominated fuels (Portillo *et al.* 2017; 2020). As recorded ethnographically, dung fuels can sustain temperatures for longer than wood sources and can be re-used for secondary uses such as manuring and building material, all of which points to the value of dung fuels and their potential sustainability in the present day (e.g. Portillo *et al.* 2017). The role of livestock as providers of a range of dung-products and their sustainable applications, such as a fuel resource has proven to represent important archaeological materials for investigating the sustainability and health of built environments and the developments of early farming communities of the early Holocene (for a review for Central Anatolia see Portillo *et al*. 2020).

Coprolitic materials

Another point to emerge from the present study is the characterization of coprolitic materials found in different open areas at the settlement (Sp24, Sp25 and Sp44). All these coprolitic materials have provided a low spherulite content in association with a highly variable proportion of phytoliths and other components such as bone remains, possibly reflecting differences in diet or feeding habits between individuals, that in thin-section micromorphology have been described as omnivore and have been further investigated through biomolecular analyses to discriminate between animal and human coprolites through sterol and bile acid biomarkers (see section below on Biomolecular analyses by GC-MS). Phytolith results point towards variable vegetal diet regimes, by identifying highly variable plant components, including both grass and dicotyledonous leafy remains. Analyses of lipid biomarkers from these materials are enabling distinction between human and animal coprolites, discussed below, an aspect that is critical to enable further investigations of health, diet, and animal foddering/grazing and livestock management at the site. In any case, the presence of refuse materials in open areas within the settlement cointaining animal dung and other coprolitic materials in close proximity to living spaces has critical implications regarding health and hygiene in the community. Further, it implies an exposure to pathogenic micro-orgnanisms such as bacteria, parasites, and viruses and the potential spread of diseases within the settlement as noticed in other early farming communities in the early Holocene (Anastasiou and Mitchell 2018; Larsen *et al.* 2019).

Biomolecular analyses by GC-MS

Methodology

Biomolecular analyses by gas chromatography – mass spectrometry (GC-MS) were conducted to confirm whether the yellowish organic matter observed in the field and in micromorphological thin-sections was coprolitic, as proven in previous research in the Zagros and other regions of the Middle East (Bull *et al.* 2005; Shillito *et al.* 2011; 2013a; 2013b; Ledger *et al.* 2019). A key objective was to determine which species may have produced faecal matter targeting both sterols and bile acids. In this study nine subsamples of suspected coprolites from Bestansur, collected from the sediment blocks prior to resin impregnation for thin-section manufacture (Table 13.3), and four samples from faecal-rich areas at Sheikh-e Abad were analysed by GC-MS by Marta Portillo, Aroa García-Suárez and Ian Bull, and a further 16 by Sarah Elliott and Ian Bull (Chapter 16) supported by NERC Scientific Support and Facilities at the University of Bristol in collaboration with Wendy Matthews.

Samples were crushed with a pestle and mortar and then sieved using 2mm and 75µm meshes; 10µl of hyocholic acid (0.1mg ml^{-1}) and 10µl of preg-5-en-3β-ol (0.1mg ml^{-1}) were added to 1g of sediment from each sample as internal standards. All samples were extracted by microwave-assisted solvent extraction (Ethos EX closed Vessel Microwave-Assisted Extraction System, PRO-24, Milestone Productivity Tools) using 10ml DCM:methanol (2:1 *v/v*). Samples were heated to 70°C for 10 minutes, this temperature was maintained for a further 10 minutes, and finished by sample cooling for 20 minutes. Cooled samples were then centrifuged at 1700rpm for three minutes and the supernatant decanted. The extraction tubes containing the solvent extracted residue were refilled with 6ml of DCM/methanol (2:1 *v/v*) and centrifugation was repeated. This process was repeated a third time. The supernatants were combined and solvent was evaporated under a gentle stream of nitrogen to obtain the total lipid extract (TLE).

Saponification was performed by adding 2ml of sodium hydroxide in methanol (5 M) to the TLE in a glass vial. The solution was heated at 120°C for 1 hour and then cooled to room temperature before 5ml of ultrapure water was added. This solution was acidified to a pH 3-4 using hydrochloric acid (6 M). The saponified TLE was extracted into chloroform (3 × 5ml). The chloroform extracts were combined and dried over anhydrous sodium sulphate before being filtered. The chloroform was then evaporated under a gentle stream of nitrogen.

The saponified TLE was dissolved in 1ml of DCM/2-propanol (2:1 *v/v*) before being applied to an aminopropyl column (Discovery® DSC-NH2 SPE Tube bed wt. 500mg, 3ml, Agilent) preconditioned with 6ml of dichloromethane/2-propanol (2:1 *v/v*).

Table 13.3. Description of samples analysed by GC-MS.

Sample no.	*Sub-sample no.*	*Trench*	*Space/ area*	*Context*
447.1		4		Natural sediment below the mound
1501	SS3	13	25	Open area rich in coprolites
1501	SS4	13	25	Open area, coprolites
1790	SS1	13	25	Open area, coprolites
1286	SS3	13	25	Open area, coprolites
1286	SS12	13	25	Open area, coprolites
2302	SS7	10	44	Open area, dung fuel
2312	SS4	10	24	Open area, domestic debris charred lens

6ml of dichloromethane/2-propanol (2:1 *v*/*v*) was used to elute a neutral fraction. Subsequently, acidic compounds (including bile acids) were eluted with 9ml of 3% acetic acid in MeOH (*v*/*v*). Solvent was evaporated from both the 'neutral' and 'acid' fractions under a gentle stream of nitrogen.

The neutral fraction was further separated using a sintered glass column (150×5mm i.d.) packed with silica gel 60 (Sigma-Aldrich) and pre-eluted with 6ml DCM. The 'neutral' fraction was dissolved in 1ml of DCM, briefly ultrasonicated, then applied to the top of the silica column. Less polar compounds including hydrocarbons and wax esters were eluted with 6ml DCM, a second fraction containing sterols (and other hydroxy group bearing compounds) was eluted with 4ml DCM/methanol (1:1 *v*/*v*). Solvent was evaporated from this latter 'sterol' fraction under a gentle stream of nitrogen. Sterol fractions were trimethylsilylated by the addition of 30µl *N*,*O*-bis(trimethylsilyl)trifluoroacetamide (BSTFA)/trimethylchlorosilane (TMCS) (99:1 *v*/*v*) and heating at 70°C overnight. Excess derivatisation agent was evaporated under a gentle stream of nitrogen and the sample redissolved in 50–100µl of ethyl acetate prior to analysis by GC-MS.

Biomolecular analyses were performed using a ThermoScientific ISQ GC-MS. The ion source and the transfer line were maintained at 300°C. The emission current was set to 50µA and the electron energy to 70 eV. The analyser was set to scan *m*/*z* 50–650 with a duty cycle time of 0.2 s. GC-MS peak assignments were made by comparison with known mass spectra (NIST08 and a laboratory reference library) and, where possible, authentic standards.

Two types of organic compounds can be used to identify and analyse faecal matter in the archaeological record: 5ß-stanols and bile acids. 5ß-stanols are the products of the metabolic reduction of cholesterol and phytosterols in the intestinal tract of mammals (Bull *et al.* 2002). Bile acids are a group of C_{24}, C_{27}, and C_{28} steroidal acids produced in the digestive system of animals whose main functions are to assist in the enzyme-mediated digestion of fats and to contribute to the maintenance of cholesterol levels through the removal of excess sterols from the body (Bull *et al.* 2005). Both groups of organic compounds are hydrophobic and highly stable for prolonged periods, properties that enable their use as faecal biomarkers since they are rarely leached from their original deposition (Evershed 2008). Analysis of sterols allows distinction between omnivore and herbivore faeces, with 5ß-cholestan-3ß-ol (coprostanol) representing approximately 60% of the total sterol content in humans (Shillito *et al.* 2013b; Gea *et al.* 2017). Additional data from bile acids can corroborate the omnivore origin of coprolitic materials, and allow further distinction between human, dog and pig faeces (Bull *et al.* 2005).

Results from biomolecular analyses by GC-MS

Of the eight samples analysed from Bestansur (Table 13.3), four have yielded a faecal signal. Three are spot samples from SA1501 and SA1286, collected from Trench 13, Space 25 (Figs 13.8–13.10). The high coprostanol and cholesterol concentrations, diagnostic sterols and absence of hyodeoxycholic bile acid indicate a human origin for all three of these coprolite samples (SA1501 ss3 and ss4; SA1286 ss3 (Figs 13.8–13.10; Bull *et al.* 2005). A fourth spot sample collected from block SA1790 ss1, also from Space 25, exhibits a weak cholesterol signal, with no other sterols identified.

By contrast, the samples analysed from the site of Sheikh-e Abad in Iran, collected from a pen context in Trench 3 B1 Sp8, suggest a herbivore defecating species. Two out of the four samples from Sheikh-e Abad analysed by GC-MS are confirmed as faecal matter through this technique, displaying high concentrations of 5ß-stigmastanol, a biomarker predominant in herbivore dung. Plant lipids in the form of *n*-alkanols are also abundantly present in these samples, likely derived from digested and deposited plant materials.

These preliminary biomolecular results have confirmed the presence of coprolitic materials in approximately half of the sampled contexts at Bestansur, previously analysed and detected through micromorphology (Chapter 12). The absence of faecal

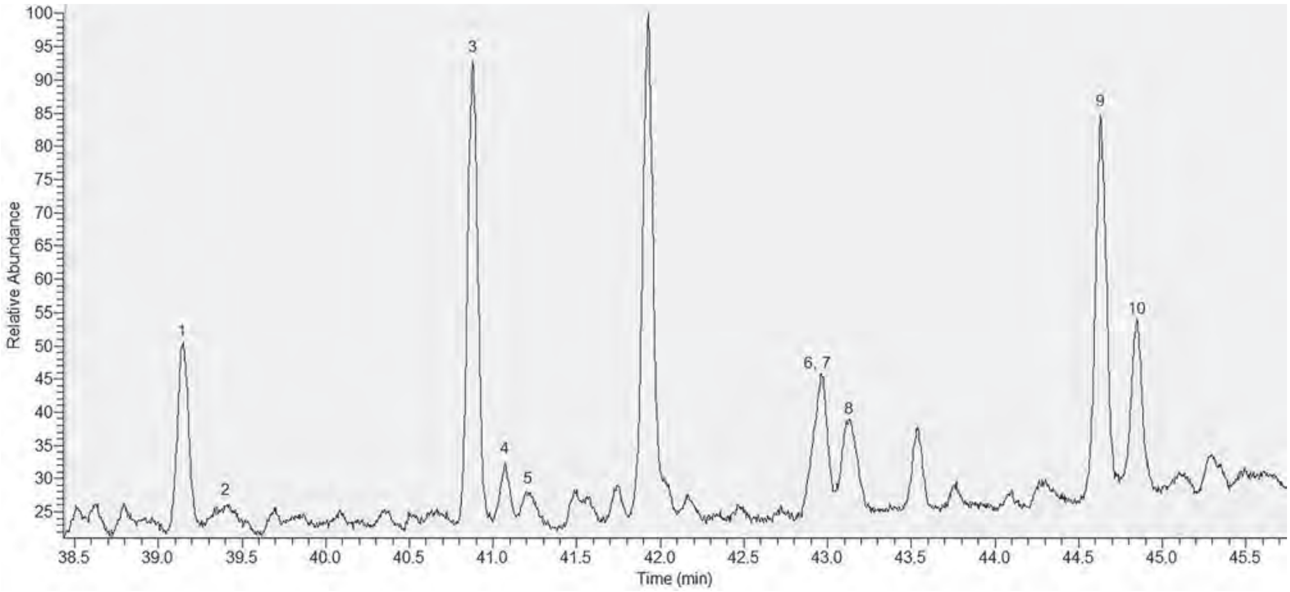


Figure 13.8. Chromatogram of sterols in Bestansur SA1501, Trench 13, Space 25, displaying high concentrations of: (1) coprostanol; (2) epicoprostanol; (3) cholesterol; (4) 5α-cholestanol; (5) 5β-campestanol; (6) 5β-stigmastanol; (7) 5α-campestanol; (8) 5β-epistigmastanol; (9) sitosterol and (10) 5α-stigmastanol.The presence of these sterols and the absence of hyodeoxycholic bile acid indicate that this coprolite is of human origin.

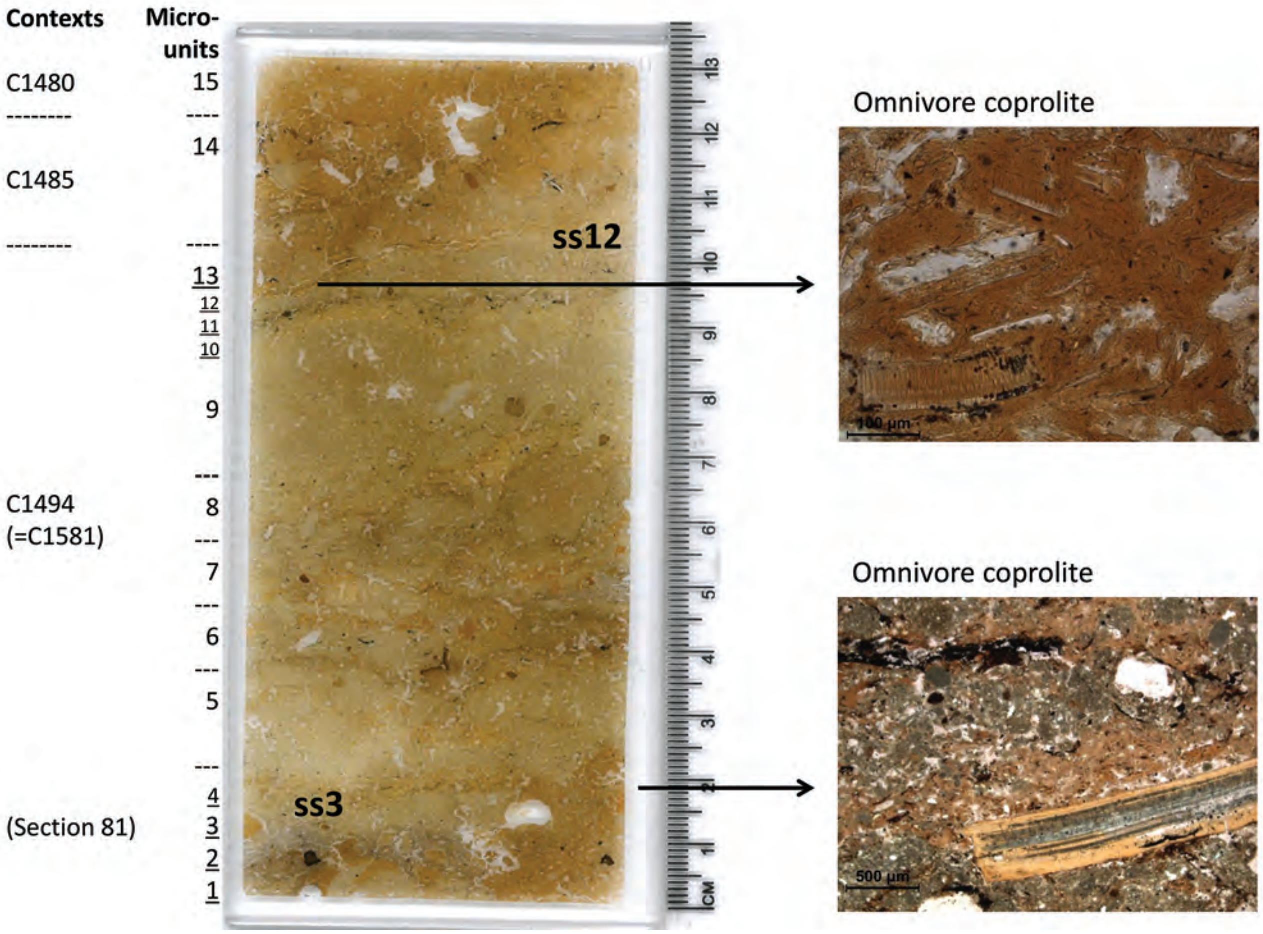


Figure 13.9. Micromorphology of thin-section SA1286, T13 Sp25 and location of spot sample ss3 which GC-MS results indicate is a coprolite of human origin.

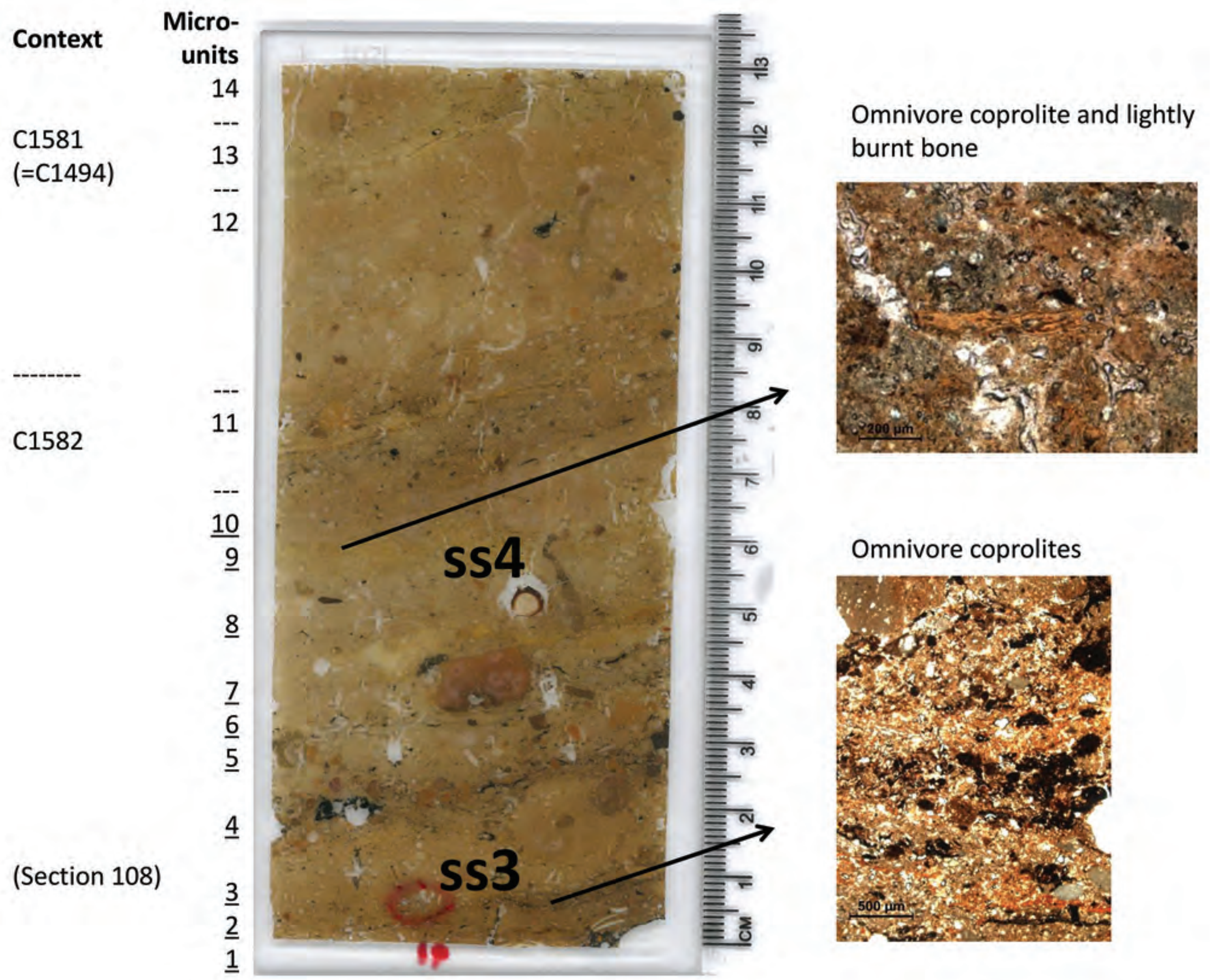


Figure 13.10. Micromorphology of thin-section SA1501, T13 Sp25 and locations of spot samples ss3 and ss4 which GC-MS results indicate is a coprolite of human origin.

sterols in some of the samples, such as in SA2302 and SA2312 could be due to the fact that these correspond to discarded dung previously used as fuel, as determined through micromorphology, and there is a possibility that the heating of these materials at high temperatures could have caused the degradation of the faecal sterols. These examples illustrate the difficulty in correctly identifying coprolitic materials in the archaeological record, a goal that is best reached through an interdisciplinary methodological approach. The results from this project highlight the importance of integrating biomolecular and micro-contexual techniques to analyse organic components of suspected faecal origin.

Integrated *in situ* analyses of construction materials, archaeobotanical remains and coprolites

A range of techniques was piloted and applied in high-precision analysis of materials *in situ* in the resin-impregnated thin-sections. The strength of this integrated high-resolution *in situ* approach is that it enables analysis of materials and components within individual lenses or aggregates, for example. By contrast, spot and bulk sampling irreversibly disaggregate and destroy evidence of micro-contextual associations and depositional context, and may lead to inadvertent mixing with surrounding sediments.

We begin with high-precision ESEM-EDX, IR and μ-IR analyses of construction materials and pigments. We then consider one of the first applications in archaeology of confocal Laser scanning microscopy and 3-D autofluorescence imaging of plant and microbiological remains in order to complement and advance phytolith and GC-MS analyses by enabling high-resolution *in situ* analysis of the micro-context and associations of these materials, as well as the content of faecal matter identified to producer type by GC-MS analyses.

We conclude with discussion of innovative pXRF analysis of construction materials and activity areas in resin-impregnated slices

Environmental scanning electron microscopy with energy dispersive X-ray analysis (ESEM-EDX), Infra-Red (IR) and µ-IR analyses of construction materials and pigments

Aims and methodology

The source materials and technology of wall plasters, pigments and fired lime plaster were analysed by integrated: 1) micromorphology to study their composition, microstructure and application sequence; 2) environmental scanning electron microscopy with energy dispersive X-ray analysis (ESEM EDX) to study their elemental composition; and 3) infra-red (IR) microscopy to study their mineralogy (Godleman *et al.* 2016). This research builds on the high-resolution high-precision micro-analyses of plasters and pigments studies at the highland Zagros site of Sheikh-e Abad and Çatalhöyük, where synchrotron radiation source (SRS) IR microscopy was also applied in the first archaeological application at the UKs CCLRC diamond light source (Anderson *et al.* 2014). Six samples and 14 depositional layers were analysed for IR, u-IR and ESEM-EDX analyses from walls, plasters and pigments in Trench 1 Building 2, Trench 10 Buildings 5 and 8 (Godleman *et al*. 2016).

Results and interpretations of ESEM-EDX, IR and µ-IR analyses

Integrated analyses using µ-IR and ESEM-EDX enabled identification of the composition and pigmentation of a range of materials at Bestansur (Godleman *et al.* 2016). The multiple fine wall plasters on wall W56 in the entrance room Sp56 in Building 8 T10 at Bestansur were made from a range of different sediment sources (Fig. 13.11). The green clay plaster was determined to be from local celadonite-bearing marine clays. The fine bright white plasters were

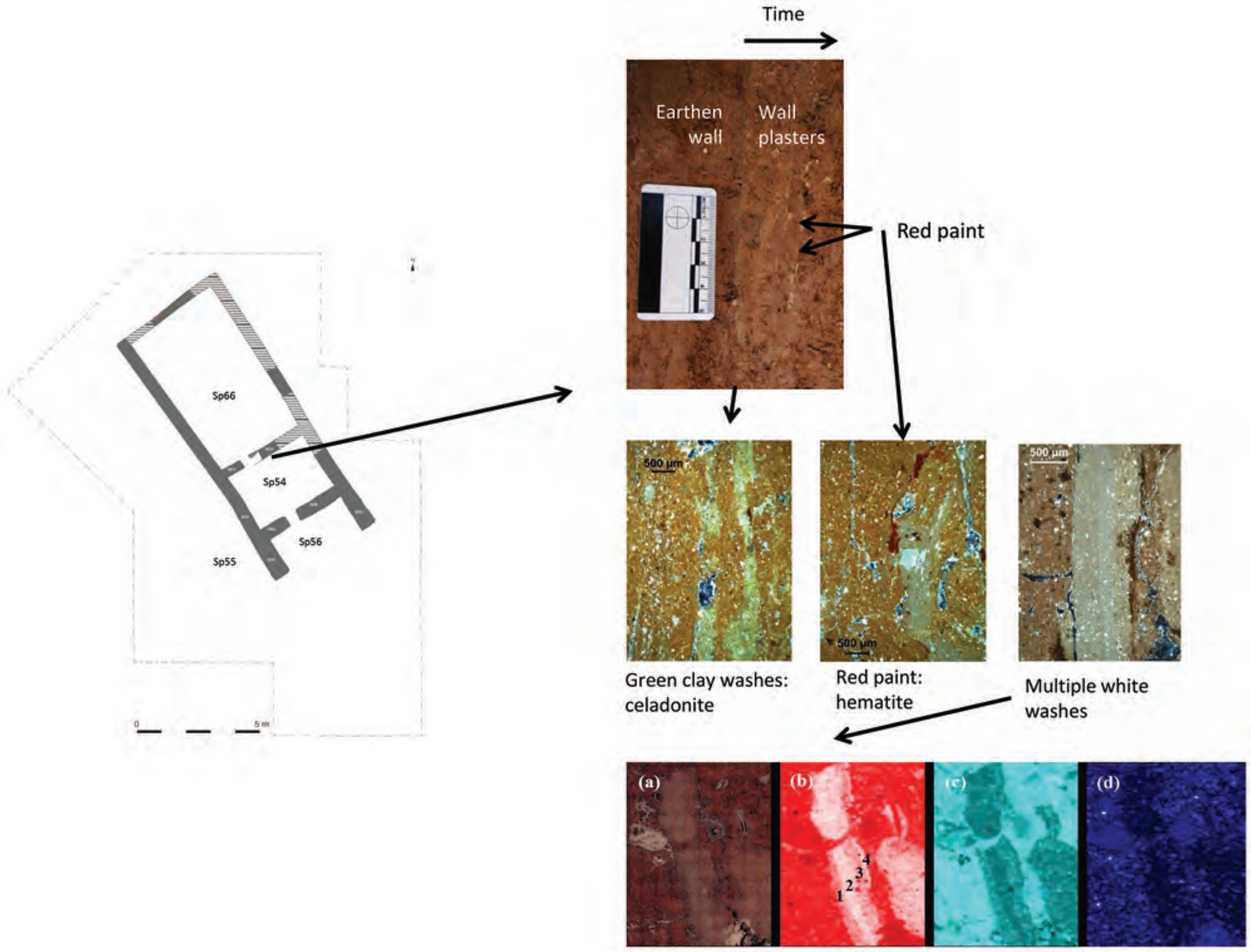


Figure 13.11. Multiple layers of green, grey, reddish–brown and white wall plasters and red paint on Building 8 Sp56 wall W56. a) visible light microscopy (PPL); µ-IR chemimaps of: b) calcite rich white finishing coat layers; c) clay plasters; d) quartz (after Godleman et al. 2016: fig. 10).

calcite rich and from a non-local source and resemble the finishing coats of plasters on walls from the later site of Çatalhöyük, which were analysed using Synchrotron Radiation Source (SRS) μ-IR (Anderson *et al.* 2014). The red pigment that had been applied as discontinuous strokes contained iron and was most likely derived from hematite (Fig. 13.11).

Aggregates of red pigment on the floor of the entrance room to the large overlying building, in Sp47 B5 T10 proved also to be of hematite, the closest source of which is 40km away at Penjwin/Mishaw, in the Shalair Group deposits (Jassim and Goff 2006: 337; Sissakian 2018: 27).

Combined IR and ESEM-EDX analysis of the hard pinkish–white exterior surface in Sp27 established that this surface was manufactured from fired-lime based on a ratio of 5.2 for heights of the ν2 and ν4 bands, which is higher than that of naturally occurring calcite which is 3, and indicative of firing (Chu *et al.* 2008; Godleman *et al.* 2016: 199). The production of fired-lime was a major early technological development in the Fertile Crescent (Toffolo *et al.* 2017).

The black deposits on a human skull from Sp50 Building 5 proved to contain manganese and iron, likely to be present as manganese dioxide and magnetite, and derived from post-depositional bacterial action (Goldeman *et al.* 2016: 202).

Confocal laser scanning microscopy and 3-D autofluorescence imaging of plant and microbiological remains

Aims and methodology

To advance the study of diet and to evaluate the potential for microbiome studies of gut health and disease, selected plant remains and microbiological traces were analysed *in situ* within coprolites in micromorphological thin-sections using confocal laser scanning microscopy (CLSM). The aims and objectives in this study are: first, to aid identification of materials and components through study of their 3-D morphology and secondly, to conduct robust high-precision *in situ* analysis of the contents of coprolites, which can be difficult to isolate and subsample precisely, without contamination, when they are represented as thin lenses within deposits, <5mm thick. This technique has allowed *in situ* examination of the 3-D morphology and autofluorescence of materials and components, reported here for the first time in archaeological applications of micromorphology by Aroa García-Suárez with Wendy Matthews. Confocal fluorescence microscopy offers exciting new opportunities for *in situ* detection and identification in 3D of a diverse range of dietary and health indicators including phytoliths, bone fragments, and microbiological traces including parasites and spores. Previous archaeological applications have demonstrated the efficacy of CLSM in the study of isolated extracted microfossils such as parasite eggs (Morrow and Elowsky 2019) and pollen (Gavrilova *et al.* 2018); none are known to date by the authors on *in situ* materials in micromorphological thin-sections. One thin-section was analysed from Bestansur, from Trench 13 Sp25 external area deposits in thin-section SA1286 in order to investigate the morphology and contents of omnivore and human faecal material and thereby human diet and health, as GC-MS analyses of adjacent spot samples indicate that one of these is of human origin (SA2186 ss3; see Fig. 13.9 below). One thin-section was also analysed from Shimshara, SA763 to investigate the 3-D morphology of phytoliths to enhance identification of plant use, reported on here, and other samples from Çatalhöyük. Analyses were conducted using a Nikon A1R confocal microscope (ICMR Alfie) at Institute of Cardiovascular and Metabolic Research (School of Biological Sciences, University of Reading) with the assistance of Graham Luke. These high-resolution analyses were performed directly on the coverslipped thin-sections, at magnifications between ×40 and ×400. The images obtained were processed with the software NIS Elements, version 4.51.

Results and interpretations of confocal laser scanning microscopy and 3-D autofluorescence imaging of plant and microbiological remains

High-resolution images of omnivore faecal aggregates from SA1286 in Trench 13, Bestansur, were obtained through CLSM. Figure 13.12a displays a 2D photomicrograph in plain light of the dense phosphatic mass of the omnivore coprolite containing embedded inclusions of tracheid phytoliths. These microfossils appear more conspicuous in Figure 13.12b, which represents two 3D models of the same area of the coprolite obtained through the application of reflected laser light and vertical scanning coupled with confocal imaging. These images visually surpass in both depth of field and resolution those produced using optical microscopy, showing also higher contrast imaging than that resulting from scanning electron microscopy.

Articulated microlaminations of plants with bulliform phytoliths were observed in SA763 from burnt plant remains on a floor in the E–W section Shimshara, eighth millennium BC and were also analysed with CLSM, as shown in Figure 13.13. These microfossils overlie a phosphatic mass formed by amorphous organic matter and charred plant remains, the latter displaying darker colours and lower fluorescence levels. The articulated siliceous plant remains situated in the middle of the images show a particularly high fluorescent response. This observation is significant since recent observations of plant remains in hearths and other combustion features from a range of sites have revealed that phytoliths typically appear to be epi-fluorescent,

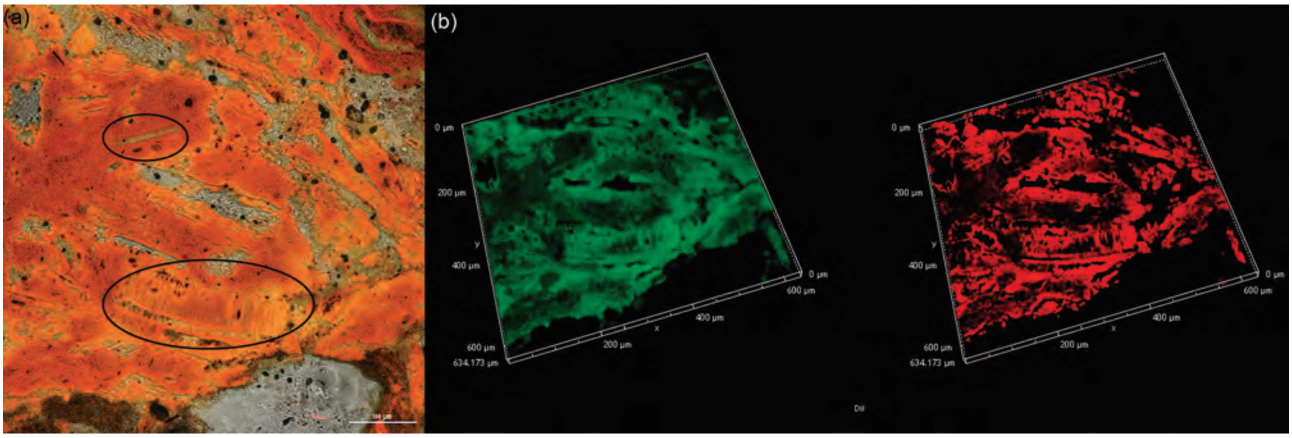


Figure 13.12. Photomicrographs of omnivore coprolite from Bestansur with embedded tracheid phytoliths from dicotyledonous plants: a) omnivore faecal material under plane polarised light, scale = 100µm; b) same as a) displaying 3-D morphologies under fluorescent light (SA1286.15, T13 Sp25), square sides = 600µm; section thickness = 24.50µm.

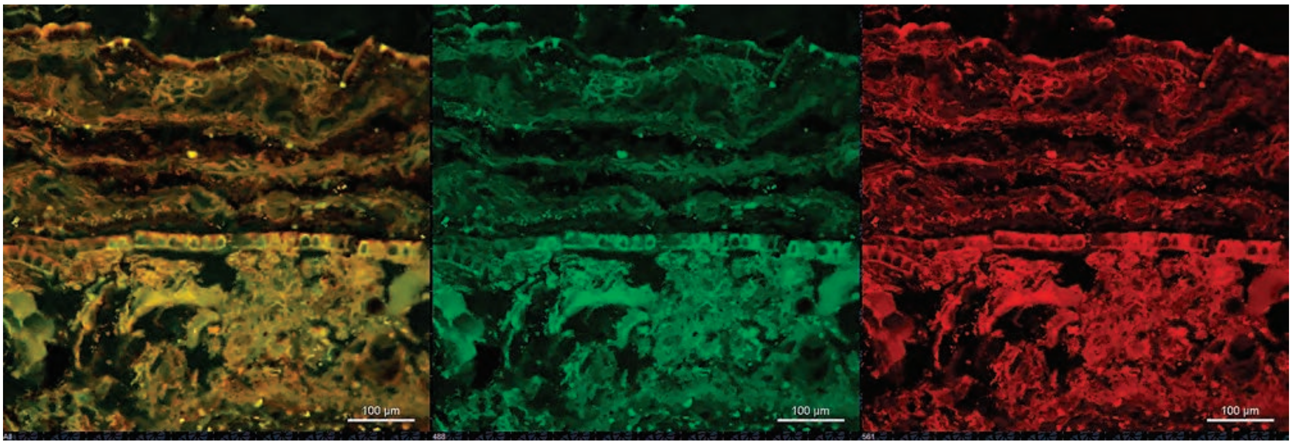


Figure 13.13. Fluorescent photomicrographs of articulated phytoliths and amorphous organic matter in archaeological deposits from Shimshara (SA763), scale = 100µm.

perhaps indicating that one of the effects of particular combustion conditions is fluorescence and may relate to alterations to the organic compounds within and on the surface of phytoliths (Hodson *et al*. 2020; Devos *et al*. accepted).

In spot sampling, conducted both in the field and in the laboratory, it is often difficult to ensure the accurate collection of a single coprolitic lens, which may be <1–3mm in size. Thin-section micromorphology has overcome this by enabling the high-precision analysis of individual coprolites and the identification of specific associations of microfossil and trace contents within these. As demonstrated in this research, subsequent confocal laser scanning microscopy of organic micro-lenses identified in micromorphological thin-sections contributes further to extracting 3-D morphological and contextual information from microfossils that is commonly masked by the phosphatic material in which they are embedded. This technique, therefore, has great potential for the archaeological investigation of microbiological remains, especially those whose identification and analysis through traditional optical microscopy has often been restricted by the presence of occlusive materials and groundmass noise.

Portable X-ray fluorescence (pXRF) analysis of construction materials and activity areas in resin-impregnated slices and methodological testing of pXRF

pXRF aims and methodology

To investigate the technology and composition of constructional materials and geochemical traces of activities, portable X-ray fluorescence (pXRF) was applied by Chris Speed to characterise depositional layers in resin-impregnated slices cut directly adjacent to the thin-sections from the same block, also for the first reported time here in archaeology. As many such slices are routinely archived in micromorphology laboratories, they provide an important resource for the development of analytical techniques and close correlation of results with high-resolution micromorphological analyses. Twenty-eight resin-impregnated slices and 3–9 depositional layers within each sequence were analysed by pXRF from across the settlement and compared to standards and blanks analysed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). As part of this research was to evaluate and develop an analytical methodology, this is discussed together with the results.

pXRF analyses of the resin-slices cut from the same block as the thin-sections were conducted to investigate whether any elemental differences in packing, plaster and occupation layers could be detected and to identify elevated levels of phosphorus (P) that may indicate areas of intensive human activity, animal dung or penning and waste-materials such as coprolites. A range of informative trials were conducted in testing the method of pXRF, which are also reported here.

The pXRF equipment used was a Thermo-Scientific Niton XL3t GOLDD+, used in Mining (Cu/Zn) mode for 1 minute X-ray duration per sample (10 seconds for each of the main range, low range and high range, 30 seconds for the light range). Three replicates were taken for each identified subsample layer (usually identified on micromorphological criteria, but also using visible colour and sedimentary differences). The practical lower limit to subsample layer thickness analysed was approximately 1cm, due to accurate placing of the instrument, and the X-ray aperture on the pXRF (8mm); smaller layers were, therefore, in some cases grouped. This aspect is an important limitation in the method; micromorphology often identifies significant individual layers of 1mm or less in thickness and these cannot be individually chemically characterised by this method. A more appropriate method for the thinner layers would be to use electron probe micro-analysis via scanning electron microscopy (SEM), although only a much smaller sampling area could be analysed, as reported above and in Godleman *et al.* 2016.

Data within each subsample layer were averaged to give element concentrations and standard deviations in ppm and also expressed as a percentage enhancement over background values (defined as a mean of six scans of block SA447, the natural deposits). This approach was taken as human effects on natural sediments often consist of enhancement or depletion of natural chemical concentrations, while the absolute magnitude of element concentration is inherent in the sediment type itself and is not necessarily diagnostic of anthropogenic changes (Matschullat *et al*. 2000). Element concentrations within individual micromorphology blocks were investigated using Principal Components Analysis, and Cluster Analysis using Minitab 17. These methods identify the groups of similar elements which have the highest discrimination content in each block, but do not predict element levels within subsamples of a block.

In order to assess the correlation between pXRF and ICP-OES values, pellets made from the bulk ICP internal standards were cast using Transmit resin. These were sampled using pXRF in the same way as the micromorphology blocks in the study, and the element concentration values compared to the same standards analysed using pseudo-total aqua regia digest/ ICP analysis. Three internal standards were used; an uncontaminated loam soil, a sewage sludge amended loam soil, and a ground-up plant standard (geranium, spiked with Ni, Cu, Zn and Pb). To a certain extent, the results should be comparable to sediment, organic rich midden with coprolitic waste, and plant rich micromorphology subsamples, respectively.

pXRF methodology test results

The range of elements tabulated is different to the others presented in this report due to the different element ranges analysed by pXRF and ICP-OES (Table 13.4; Fig. 13.14). In all but one case, the pXRF values were much lower than the ICP pseudo-total values. The exception is for lead in the spiked geranium sample; this is possibly because the high light element content (H, C, O) of the plant sample was transparent to the X-rays, which allowed the lead shielding from the instrument set-up to be detected. This standard was spiked at 200ppm for each of the heavy metals added, and which was virtually undetected using pXRF, with the exception of lead. The comparison in this case indicates that highly organic layers within micromorphology blocks may have their element content very under-represented compared to more mineral layers. Slight excesses of potassium were evident in pXRF measurements compared to ICP.

It is evident from these results that it is not meaningful to attempt to define 'absolute' chemical element concentrations using pXRF; results

Table 13.4. pXRF element values as a proportion of ICP-OES pseudo-total extraction.

Element	*Zn*	*P*	*Cu*	*Ba*	*Sr*	*Fe*	*Cr*	*Ca*	*K*	*Al*	*Pb*	*S*
Soil	0.38	0.32	0	0.86	0.61	0.71	1.26	0.64	1.27	0.37	0.74	0
Sewage	0.4	0.44	0.43	0.25	0.56	0.49	0.56	0.52	1.4	0.49	0.49	0.49
Geranium	0.04	0.24	0	0	0.06	0	0	0.05	0.13	0	3.19	0.03

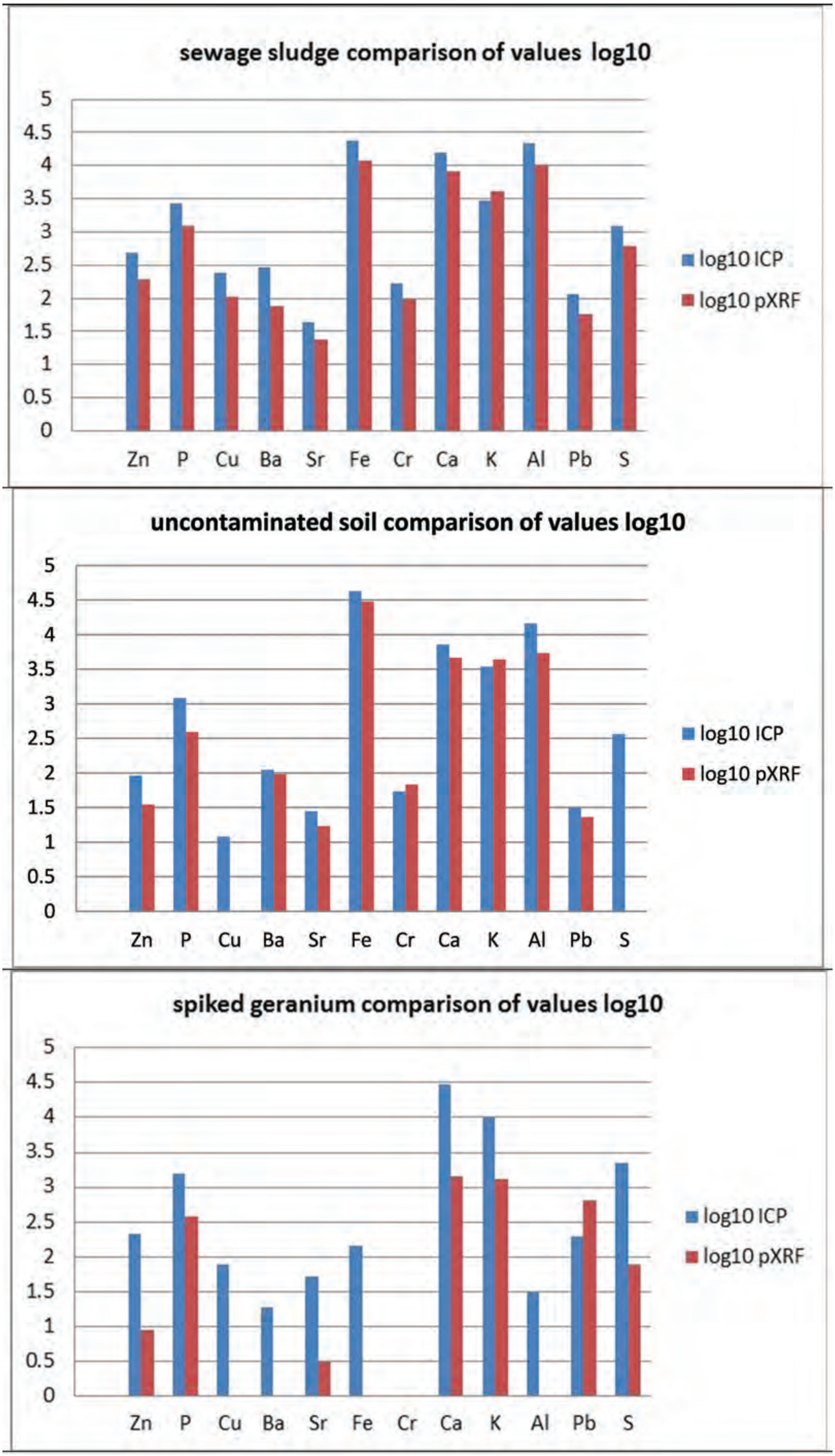


Figure 13.14. Comparison of pXRF and ICP-OES log element concentration.

should only be used comparatively within one micromorphology block, and even then with caution, as the organic content of individual subsample layers varies, and will have a major bias on the element concentrations detected by pXRF. Although the absolute values varied, the pattern of elements using both pXRF and ICP was generally much more similar in the case of the mineral soil standards (Fig. 13.14). By plotting the results on a logarithmic scale, the large differences in absolute value are minimised, and this also allows main and trace elements to be plotted on the same diagram.

pXRF analytical results and interpretations of Bestansur samples

The chemical composition of the micromorphology blocks varied considerably, but not in a consistent manner across differing blocks, even those within the same excavation area. This means, essentially, that similar macroscopic layers in these sediments do not have diagnostic chemical signatures.

Aluminium, silicon, iron and calcium are generally assumed to be derived from the mineral structure of the sediments. Phosphorus was generally the element most enhanced over background in subsample layers that were identified as occupation layers on the basis of other criteria (Oonk *et al*. 2009; Chapter 16). Few other consistent correlations were apparent. Many element enhancements do not have well understood archaeological causes, often having ambiguous or multiple explanations (Oonk *et al*. 2009), and many are only general anthropogenic indicators.

Phosphorus enhancement varied between background (SA447) and nine times the background level within the blocks examined and was generally over twice the background level in most subsamples examined. This was also the case even in construction materials such as mudbrick. The phosphorous in this case may be from the addition or incorporation of organic materials during manufacture, such as the addition of vegetal or other fibrous material as stabilisers to provide tensile strength and flexibility, which have been identified in thin-section (Fig. 12.12c). Confirmation of this would also require comparison with off-site background samples from possible source sediments. In subsamples with very high phosphorus (over 5× background), many were dark coloured 'organic' layers as might be expected. Sample SA1283 shows this pattern well, with phosphorus of 1.5–2.5 background levels in dark organic layers alternating with more mineral sediments with phosphorus at background concentrations (Fig. 13.15). In these cases, it is likely that the high phosphorus derives from the diverse burnt and non-burnt bone, plant remains and omnivore coprolite fragments in these deposits, identified in the corresponding micromorphological thin-section (Chapter 12). However, in a number of cases, light coloured subsamples had very high phosphorus enhancement. In the case of block SA2315, micromorphological analysis showed that these occupation deposits included burnt and non-burnt bone fragments as well as omnivore coprolite and herbivore dung fragments (Fig. 12.15c), all of which are major sources of phosphorus (Villagran *et al*. 2017; Brönnimann *et al*. 2017a; 2017b). Unfortunately, the generally high calcium levels in all these sediments meant that there were not often great calcium enhancements over background, generally preventing this component of bone being detected in the pXRF results, which limits the predictive power of the chemical data. In thin-section, it is evident that these high-levels of calcium derive not only from the calcitic sediments and rock fragments of the region, which were used as floor and construction materials, but also from calcitic plant ash from high temperature burning (Chapters 12 and 16).

Some of the highest phosphorus elevations were from the external open area Sp25 in T13 (Fig. 13.16). These phosphorus elevations correspond to deposits with the highest concentrations of omnivore coprolites in thin-section at 30-50%, which biomolecular analyses by GC-MS have shown in some instances are human in origin (Figs 13.8 and 13.10; Chapter 16, Table 16.1).

Strontium has been associated with middens and organic waste dumps (Jones *et al*. 2010). Several of the analysed blocks have subsample layers which show enhanced strontium; SA1501.ss3 shows strontium enhanced to 2.5 times the background in a layer sequence otherwise near background. Phosphorus is also four times background in this layer, and a midden deposit would be a possible explanation for this, testable by micromorphology. In block SA1778, high strontium, phosphorus and calcium are all present in SA1778.ss6, which is combined with depleted aluminium and iron; and in block SA1782, strontium is enhanced in layers 1 and 2 of this block, suggesting a possible explanation of middens for these layers also. No other elements show systematic changes within the micromorphology blocks examined, although sulphur and chlorine were often enhanced, and arsenic showed some high enhancements relative to background (although the absolute values were low).

pXRF conclusions

The use of pXRF relies on detecting chemical changes within anthropogenic sediments. As sediments differ in their geological make up, it is necessary to define anthropogenic changes by chemical additions or transformations to background values. A primary task is therefore to identify 'natural' to define background. If Neolithic societies did not bring anything onto site but relied on *physical* changes to on-site materials (such as mudbrick) not many *chemical* changes will be shown. Exceptions are phosphate enhancement from organic material and fires with high magnesium and calcium. pXRF analysis is not highly resolved enough to define thin activity layers such as wall plaster and paint, when these are thinner than the analytical window. The use of other methods such as micromorphology is more accurate at detecting these physical changes. It is only with later archaeological periods, where

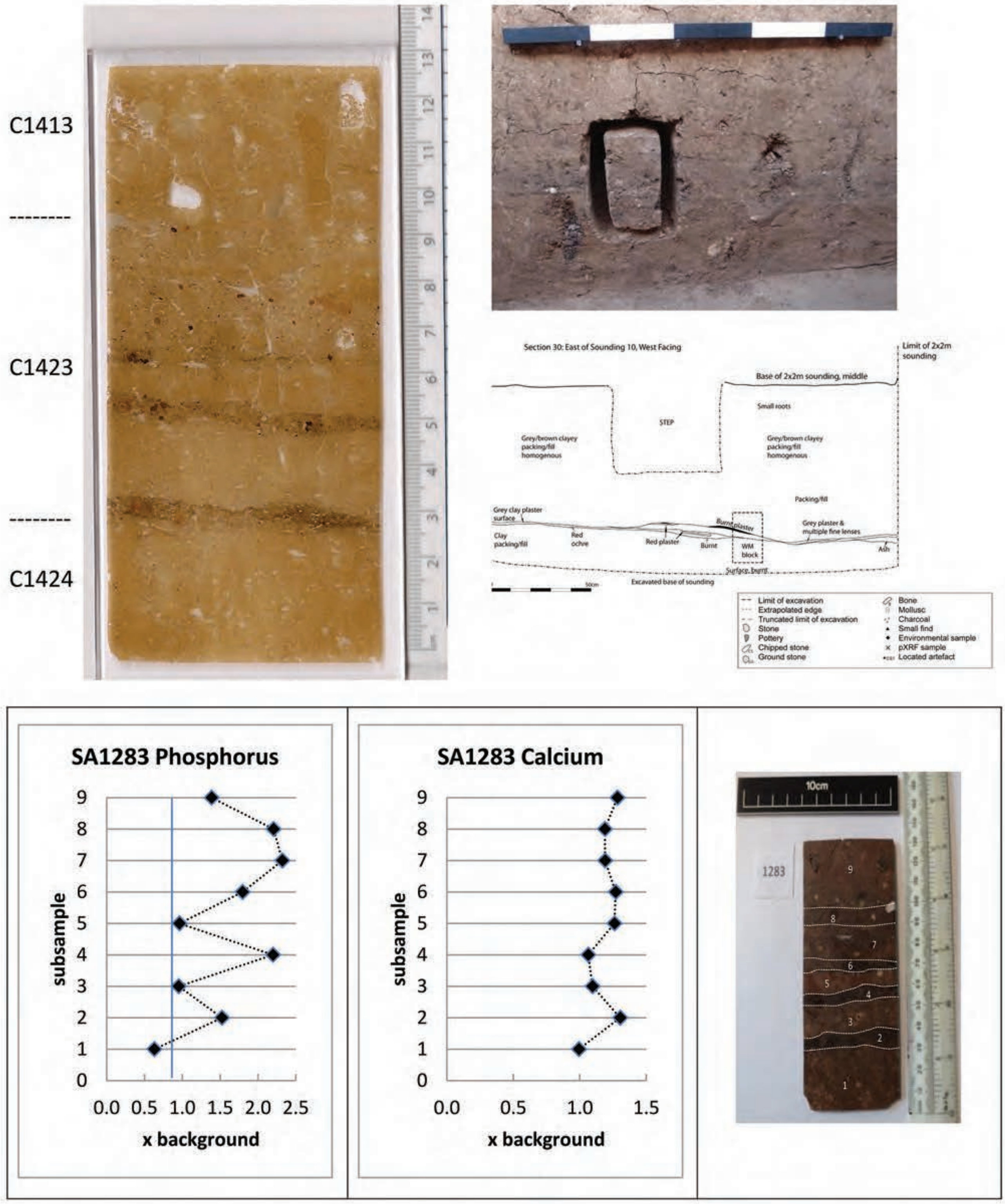


Figure 13.15. pXRF analyses of resin-impregnated slice cut from the same block as the corresponding thin-section SA1283 from and external area Sp27 in T10, Bestansur, C1413, C1423 and C1424. Phosphorus and calcium elevations above background samples from natural (T4 SA447 C1087 and C1088).

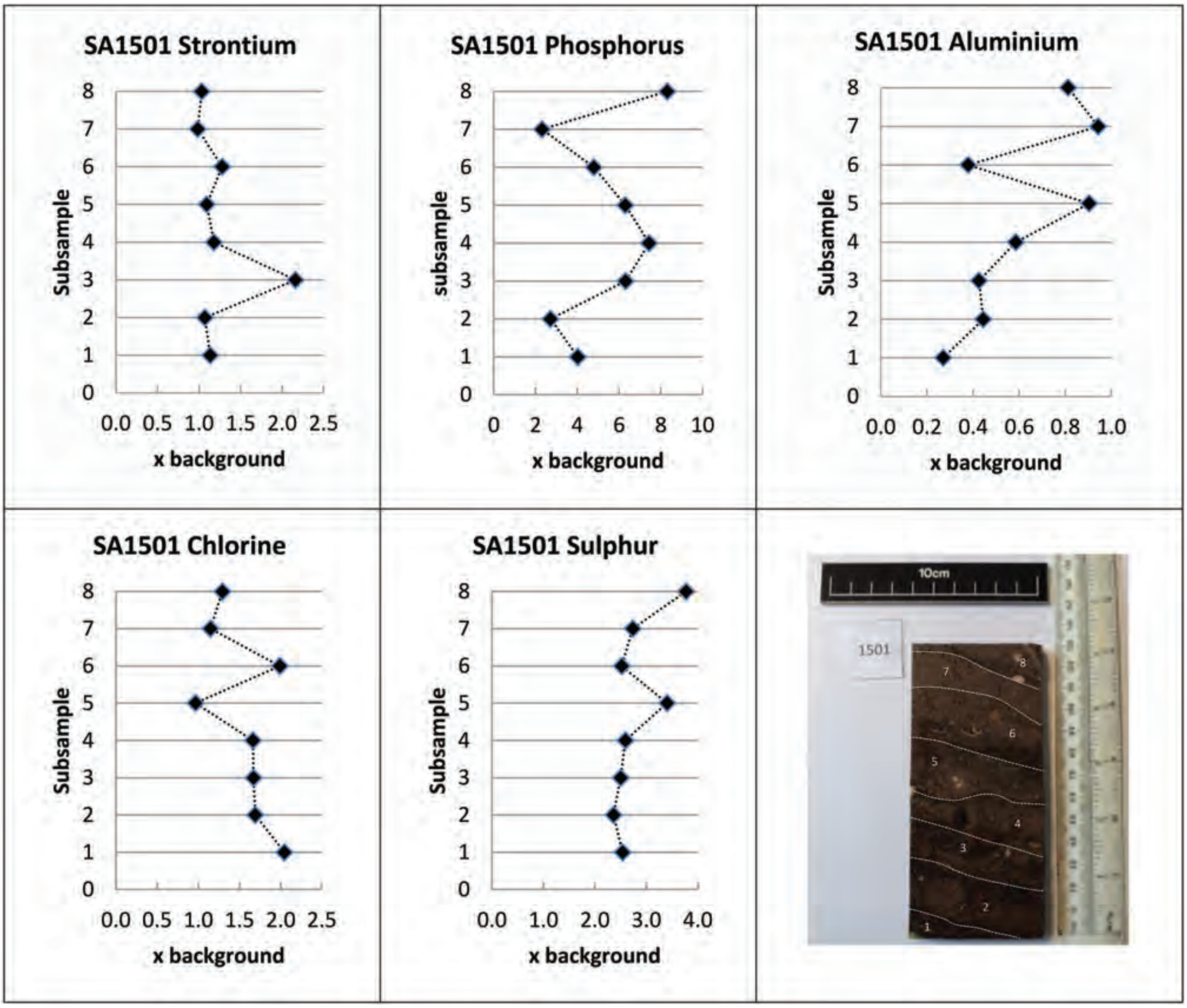


Figure 13.16. pXRF analyses of resin-impregnated slice cut from the same block as the corresponding thin-section SA1501 from and external area Sp25 in T13, Bestansur. Elemental elevations above background samples (natural sediment in T4 SA447 C1087 and C1088). See Fig, 13.10 for thin-section micromorphology and corresponding GC-MS results.

sediments with different chemical signatures, such as metal ores and exotic building materials, are brought onto site that chemical differences can be used to define activities, and pXRF analysis may be useful in these circumstances. These changes may be more obvious in micromorphology by colour changes, mineralogy, dung spherulites and other attributes. Portable XRF chemical survey therefore may not be a very useful diagnostic analytical technique for prehistoric sediments, where there are few sedimentary chemical additions to identify specific activities when used without the integrated micromorphological and GC-MS analyses applied in this research. Elevated phosphorus levels, up to five to nine times higher the background, however, were consistently characteristic of organic rich occupation deposits.

Interdisciplinary approaches to the built environment, resource management and sustainability

The integration and wider implications of these results are examined in this concluding section, highlighting the value of interdisciplinary organic, and inorganic micro-contextual analyses and their contribution to the study of early architectural construction, art, plant and animal resource use, and the sustainability and health of built environments.

These integrated analyses are providing important high resolution insight into, firstly, the importance of wetlands and grasses to early sedentary communities (Jones *et al.* 2019). Phytoliths from these biomes are very well-preserved and indicate that plants were used as a renewable source of fuel as well for matting, roofing and basketry for example. Secondly, analyses of deposits with omnivore coprolites at least some of which biomolecular analyses by GC-MS analyses have shown are human, are providing exciting new insights into the biodiversity of early sedentary diet, which included consumption of some wetland leaves, cereal-like plants, as well as dicotyledonous plants and tracheary from roots (see also Chapters 12 and 16). This type of biodiverse plant diet has been suggested for a range of Epipalaeolithic to Neolithic sites across the Fertile Crescent (Chapter 24; Wollstonecroft 2011; Ramsay *et al.* 2015; 2018). *In situ* analyses by CLSM enable 3D analysis of the contents of coprolites in cover-slipped thin-section, and are providing robust new ways of examining materials within thin lenses of coprolites and deposits that may be difficult to subsample separately to inform on these dietary choices and sanitation and health and the built environment, as well as potentially microbiomes through study of microbiological inclusions and parasites as identified at other sites such as Çatalhöyük (Chapter 12; see Ledger *et al.* 2019; Larsen *et al.* 2019). Analysis of the autofluorescence of coprolites and plant remains is aiding detection and identification of these materials in thin-section and study of their taphonomy and the potential effects of burning (Ismail-Meyer 2017; Brönnimann *et al*. 2017a; 2017b; Stoops 2017; Devos *et al*. accepted).

pXRF analyses of resin blocks have provided rapid elemental data to complement micromorphological analyses, by enhancing characterisation of construction materials and highlighting the concentration of phosphorus in occupation deposits as an indicator of presence of organic remains and/or bone. This data has shown that pXRF analyses have the potential also to be used to assess the potential for future more time-consuming analyses either on spot samples collected from the backs of blocks prior to resin-impregnation, or new *in situ* analyses of thin-sections piloted here included ESEM EDX, μ-IR, and CLSM. Deposits with high phosphorus levels have been shown to correspond to deposits that include for example herbivore or omnivore coprolites, which have been examined for the presence of faecal spherulites in rapid spot samples, and then analysed for phytolith and GC-MS analyses, as conducted here and in Chapter 16.

Lastly, integrated ESEM EDX, μ-IR have provided new information on developments in architectural technology and the built environment. A diverse range of sources were used in manufacture of well-prepared thin green, reddish brown and grey wall and floor plasters as well as white washes to create particular settings within elaborate buildings, some of which were large and used to host more than 80 burials, such as Buildings 8 and the overlying Building 5 (Godleman *et al.* 2016). Fired-lime technology was also used thousands of years prior to later uses by the Romans, in a suite of construction technologies that were shared across the Fertile Crescent and locally adapted (Chapter 24; Weiner 2010).

14. MICROARCHAEOLOGY: THE SMALL TRACES OF NEOLITHIC ACTIVITIES

Ingrid Iversen

Introduction: context and aims

Interest in, and the application of, microarchaeological techniques originate in concerns that quantities of the material recovered in the process of excavation are found in secondary contexts, divorced from their primary context of use and first discard. The argument is that microartefacts are more likely to be found where they were used as their small size makes it less likely that they were cleared up and then dumped elsewhere (Rainville 2005a: 26–31). In analysis of the microartefacts recovered in heavy residue, a prime aim is to investigate the spatial organisation of activities in order to augment and modify interpretations based on features and macroartefacts. Some excavated areas of the site at Bestansur have few features and no architecture, and a key source of information is the recovered artefacts, both macro and micro, which can be used to understand how these spaces might have been used. The density of microartefacts can also provide an indication of the intensity and/or duration of the use of certain spaces and thus help in addressing the question of whether the site was occupied on a permanent, occasional or seasonal basis.

In this chapter, a case is made for the analysis of microartefacts recovered in heavy residue, and the added value in terms of additional contextual information is outlined. Potential problems with the data collected using this technique are reviewed and evaluated. The methodology adopted in sampling and processing heavy residue is then outlined. The recording and analytical procedures applied to the microartefacts are described and the resulting data are used in discussion of the spatial organisation of activities.

Defining the technique: heavy residue analysis

Use of the term ‘microarchaeology’ can result in confusion, since it has also been used to describe material “[beyond] the visible archaeological record”, as in Weiner (2010). In contrast, the artefacts recovered from heavy residue as the product of flotation and/or wet-sieving are visible to the naked eye, although at times aided by some magnification to confirm the identification of material. Microartefacts, which are defined here as artefacts smaller than 1cm and larger than 1mm, are typically overlooked in conventional excavation methods and only collected systematically when excavated sediment is wet-sieved or floated. A further difference is the scale at which the evidence is collected, with heavy residue often covering a much larger area than is feasible with microscopic techniques. Micromorphology (Chapter 12) can provide very detailed and precise evidence for a selected portion of a larger archaeological context, while the analysis of microartefacts is more wide-ranging and can provide data for the context as a whole, or a much larger proportion of the whole. During excavation and collection of samples for wet-sieving/flotation different thin layers are often aggregated and it is these that can be identified and analysed using micromorphological techniques. The analysis of heavy residue is better at addressing questions at a larger horizontal scale (W. Matthews *et al.* 1997a; Cessford 2003; W. Matthews 2005).

Primary and secondary contexts: processes of deposition

Artefacts recovered during archaeological excavations may be found where they were last used, that is, in their 'primary' contexts but are also found in 'secondary' contexts, deposited as rubbish or having been moved as a result of scavenging or curating (Schiffer 1976; 1983). Many areas, especially within buildings, will have been subject to cleaning which is likely to remove all but the smallest artefacts (Hayden and Cannon 1983; Rainville 2005a: 31).

There is likely to be a 'size-sorting' effect of refuse disposal with larger items cleared away and only the smallest being overlooked (Hayden and Cannon 1983; Metcalfe and Heath 1990: 782; Schiffer 1996: 267–269). Natural processes such as water, wind or animals (gnawing and burrowing) also have size-sorting effects on artefacts (Schiffer 1996: 267–269). The small size of recovered artefacts may reflect their original size but can also be the result of larger artefacts being reduced in size, for example by trampling and fragmentation. Different types of material are subject to differing formation processes following different actions and activities as summarised in Table 14.1. and discussed below.

Sources of animal bone

Animal bones can enter the archaeological record in a number of ways and identifying depositional and taphonomic pathways can aid in understanding spatial patterns of the associated activities. Whole animal bones, or at least large pieces of animal bone, may be deliberately discarded after butchery, preparation or eating (Chapter 15). Fragments of animal bone which get dropped during processing may remain on surfaces and become embedded. Animal bones may also have been subject to non-human actions; for example, they may be scavenged by dogs or be intrusive, in the form of burrowing animals such as reptiles or small rodents (Halstead *et al.* 1978; Kroll and Isaac 1984: 14; Wilson 1996: 72; Bendrey 2014: 71).

Sources of chipped stone artefacts and debitage

Chipped stone is found in contexts originating from different stages of the object's life, that is, manufacture, use, curation or discard (Chapter 20). Tools were manufactured and then used in other activities and so could be recovered from the place of manufacture, but more likely the place of use or repair, all of which can be defined as primary contexts, but of different activities. Tools may be modified during their life and this too could produce debitage (Andrefsky 2008). Rainville (2005a) suggests that lithic micro-debris larger than 5mm represents secondary deposits while items smaller than this have become embedded in surface deposits and so are defined as being found in primary deposits. The range of activities involved underlines the limitation of simply using concepts of 'primary' or 'secondary' contexts and stresses the need to consider the actions which result in chipped stone artefacts entering the archaeological record.

Table 14.1. Actions and activities: contexts of deposition for ubiquitous material.

	Primary contexts			*Secondary contexts*
Chipped stone	Manufacture	Tool use	Repair or modification	Dropped Lost Cleaning
Animal bone	Butchery & processing	Cooking	Eating	Rake-out
Molluscs	Gathering	Cooking	Eating	Dumping

Sources of mollusc debris

Shell debris may indicate areas where the molluscs were sorted, cooked, eaten, discarded and/or trampled (Chapter 17). Molluscs can also occur naturally and, even at sites where there is no evidence that they provided a food source, shell fragments can be ubiquitous in heavy residue as the result of burrowing. At Shimshara where the average density of molluscs in heavy residue is 0.3g per litre compared with 2g per litre at Bestansur, shell is present in all samples. In Chapter 17, different types of mollusc deposits are identified and associated with possible mollusc-related activities.

The added value of microarchaeology

Microartefacts should not be treated purely as complementary to other material collected as they can provide new sources of information. While correlations between macroartefacts or architectural features and microartefact distributions are of value – and many sampling protocols are explicitly designed to look for such relationships by taking samples from hearths, ovens, etc. as well as 'random' samples (Rainville 2000; 2005a; Özbal *et al.* 2004; Foster 2009) – it is arguably the new and different information which makes microarchaeology particularly valuable. With some notable exceptions, the technique has been little used in excavations at sites in Southwest Asia, especially at Neolithic sites, resulting in significant information not being recovered. Where the method has been adopted it is frequently at sites with evidence for architecture, in defining spaces and the results from microarchaeology used to show the patterning of activities within those spaces (Özbal 2000; Rainville 2005a; 2005b). While microarchaeology has its most obvious use in situations where there are few other material remains, for example, campsites or areas of sites without architecture, its use in a range of more complex contexts has also proved its worth (Rosen

1993: 141; W. Matthews *et al*. 1994). The systematic approach adopted in the excavations at Bestansur has suggested activities taking place in open areas as well as confirming the use of spaces within buildings, conclusions which would not have been possible without the analysis of heavy residue.

The relationship between the types and size of artefacts is in itself information which can be used, as the presence of both macroartefacts and microartefacts, the absence of any or the presence of only one size category can be interpreted to indicate different uses of space, discard and cleaning practices (Stein and Teltser 1989; W. Matthews *et al*. 1994; Sherwood *et al.* 1995: 432; Rainville 2001; 2003).

The collection of samples for heavy residue analysis is typically undertaken in a systematic way with accurate recording of the volume of sediment. The density of material in heavy residue allows for comparisons which may not otherwise be possible (Rainville 2005a: 29–30).

Abundance, scale and variability

Not only are microartefacts more likely to be found in their primary contexts, but their greater abundance lends itself to different, and potentially more robust, statistical analyses of densities and distributions. The numbers of items collected through microarchaeological techniques are typically much greater than those recovered of other sizes of artefacts, and microartefacts are likely to show variability which is not evident from macroartefacts, even when they are found in secure primary contexts. The small size of the items allows us to reduce the scale of the analysis, for example, from identifying the find spot in a room to specific areas within rooms. The analysis of microartefacts alongside macroartefacts allows us to examine activities at multiple scales.

Microarchaeology also enhances the potential for identifying repetitive practices, often of primary interest in the analyses of household or industrial activities, in contrast to larger artefacts which at best indicate only the most recent use of a space or its point of abandonment. Microartefact analysis can identify activity areas within rooms and additional functions of rooms or buildings, which are not apparent from the collection of macroartefacts. Microdebris often indicates activities which involved larger items such as pottery vessels or grinding emplacements of which only the microartefactual traces remain (Rainville 2005a). The pattern of use of a space diachronically can be detected by sampling sediment at different occupation surfaces and floor levels (Dunnell and Stein 1989; Rainville 2000; 2003:70; Aslıhan Yener *et al.* 2000: 50; Parker *et al.* 2009: 98). The absence of microartefacts can also convey information such as a lack of activity or intensive cleaning. At Bestansur, the low density of materials inside buildings appears to point to areas with few activities which leave a trace, and/or to intensive and effective episodes of cleaning of interior surfaces following the conduct of activities in interior spaces.

Unique material

Specific types of artefacts such as beads, small mammal and fish bones are rarely picked up by traditional excavation methods. In looking at assemblages of animal bones, Payne (1992) noted that wet-sieving has value both in producing less biased data, as it involves a more consistent method of recovery, as well as recovering bones of animals which would otherwise be missed, especially microfauna. Microfauna bones are often missed during dry-sieving, in some cases because they are smaller than the mesh size being used, as well as the visibility of the small artefacts being poor (Meadow 1980; Payne 1992; James 1997). At Bestansur, the vast majority of fish bones and beads were recovered from the sorted heavy residue. In sum, microartefacts "contain different information about the archaeological record than do macroartefacts" (Dunnell and Stein 1989: 39) both in terms of types of items and in their number and distribution, and have a "predictive value" (Foster 2009: 110).

Practical issues and potential problems: background noise

An awareness of formation processes is key to being able to use and interpret microartefact results, because a simplistic equating of microartefacts with activities is problematic (Cessford 2003). Microartefacts incorporated into construction materials could mistakenly be taken as evidence for activities (Parker *et al.* 2009: 94) and an awareness of the construction methods, especially of floors which are often the key areas for analysis, is essential. Extensive sampling and analysis of microartefacts at Çatalhöyük raised some important points and cautioned against simplistic equating of the spatial patterning of microartefacts and activities. For example, by examining wall plaster alongside floor plaster in the same area it was found that densities of some microartefacts (animal bone and chipped stone) were very similar and so could not be used to suggest activities (Hodder and Cessford 2004: 24–28; Cessford and Mitrovic 2005b). Cessford (2003) argues that the lessons from Çatalhöyük are not necessarily applicable to other sites, but that as wide a set of contexts as possible should be studied and that the integration of microartefact analysis with other specialist studies is important. The analysis of the heavy residue from Bestansur includes a number of control samples taken from walls.

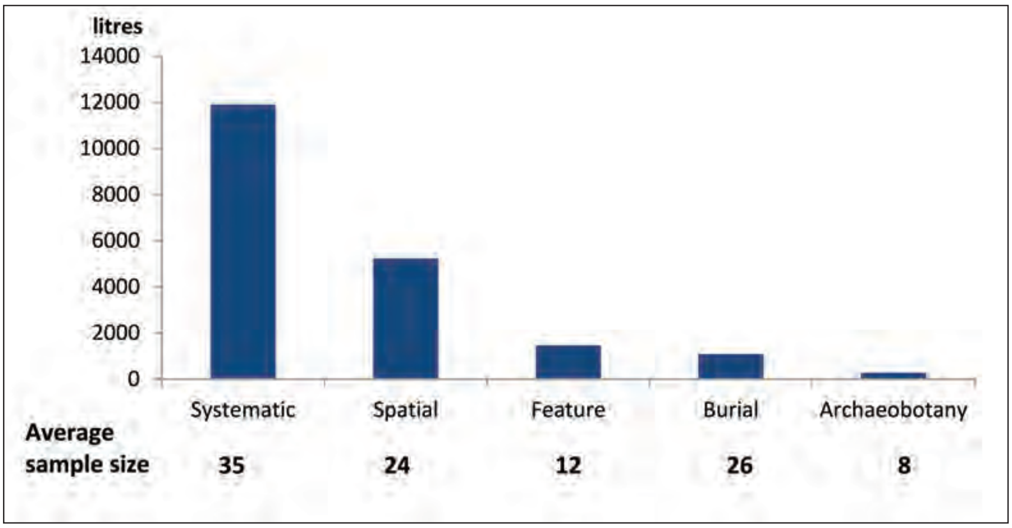


Figure 14.1. Volume of samples processed, by reason for sampling, showing average size of sample.

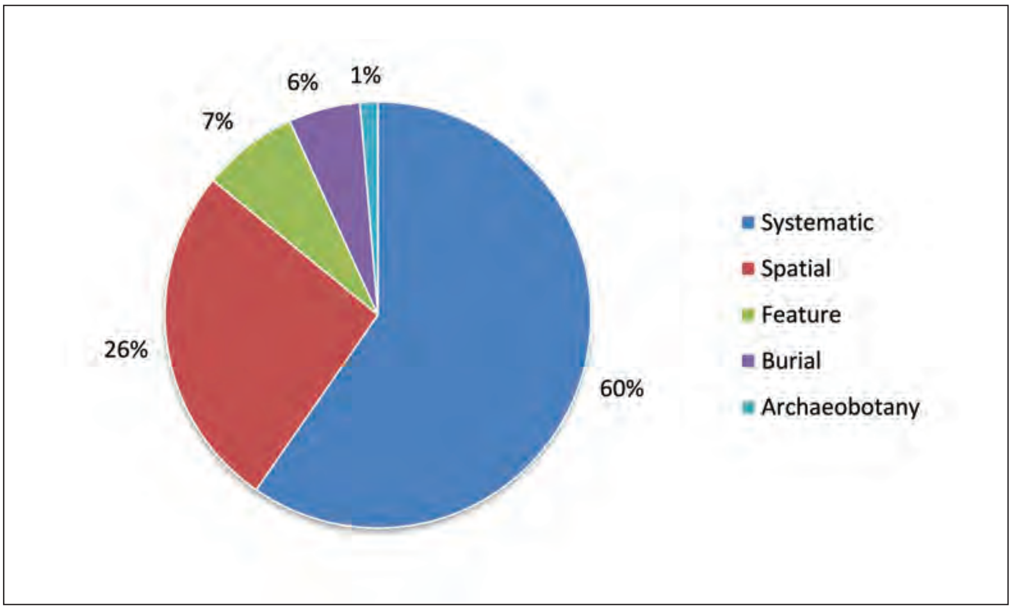


Figure 14.2. Percentage of samples processed by reason for sampling (volume).

Methodology

Sampling protocol

At least one **systematic** sample was collected from all contexts accounting for 60% of the total volume processed. These bulk samples, defined as a sample taken from a single location within the context and processed as one unit, were originally targeted at 50 litres but adjusted to 25–30 litres in later seasons (see sample size, below). In addition, strategic samples were collected, usually selected by the excavator and/or other involved persons, based on archaeological criteria and with a specific objective. These samples were not representative of a wider scale or population. The strategic sampling can be categorised as: sampling to distinguish **spatial** variation in microdebris (around 25% of the total volume), sampling of **features** such as walls and fire installations and samples processed from **burial** contexts (Fig. 14.1).

In all cases, the samples were whole earth, that is, no artefacts were picked out before the sample was sent for processing. Any macroartefacts (>1cm) were recorded as associated with the sample, reflecting the excavation protocols for the project. The exceptions were small finds and human bones which were recovered and recorded during the excavation.

Spatial sampling was used at Bestansur for selected spaces, where often multiple samples were collected over the area and the results compared to look for variation. The purpose of sampling of features was both for archaeobotanical reasons and also to examine the use to which the feature may have been put; for example, small samples were collected around and under ground stones. The microartefactual results of samples taken from features such as walls and fire installations are important in understanding background noise as well as building practices and use of fire and energy at the sites. The main objective for the samples collected and processed from burials was to ensure the recovery of all related artefacts, such as tiny beads deposited with human remains as well as small bones and teeth which may have been missed in excavation (Chapter 21). The volume of samples collected from burials accounted for only 6% of the total but in the last two seasons of excavation accounted for around half of all the samples processed (Fig. 14.2).

Sample size

The results from large samples, 50 litres or more, were evaluated and it was found that they did not provide significantly more information than smaller samples, in the range of 20–30 litres, and yet used twice the flotation time, one of the key capacity constraints. At Bestansur, this encouraged the decision to reduce the size of standard samples from the original target of 50 litres to a new target of 25 litres. The change was made after in depth discussion with the project directors and other members of the team. The key issue was whether the reduction in the size of the samples compromised the quality of the data collected and the conclusion was reached that this was not a significant risk. In fact, smaller samples take less time to sort and check, which potentially improved accuracy overall. There was a benefit in being able to process more samples, as a larger number of smaller samples can provide more information than a smaller number of large samples. In the cases where there was a concern that artefacts might be missed, samples were collected and a proportion was floated (25 litres per sample) and the remaining was either dry-sieved on site or, in a few cases, the remaining amount was also floated, if the artefacts in the initial fraction suggested that this was worthwhile. For example, the discovery of beads in the first 25 litres of some samples resulted in the flotation and sorting of the rest of the sample, to achieve the objective of ensuring that all the material was recovered, rather than the need to process more to produce representative density results.

Processing: sorting and recording

The heavy residue was first sorted by size by sieving through a nest of Endecotts sieves selected to recover artefacts in size fractions of >10mm, 4–10mm (4mm), 2–4mm (2mm) and 1–2mm (1mm), with the microartefacts recovered from the 4mm and 2mm size fractions forming the basis of this analysis. The artefacts larger than 10mm were also recorded. Once the heavy residue had been sieved by size a decision was made on what proportion should be sorted because of resource constraints; in almost all cases all the 4mm size was sorted and the aim was to sort 50% of the 2mm size. After the first season, the 1mm size was left unsorted as the information produced was not statistically significant, in agreement with findings from other sites (e.g. Cessford and Mitrovic 2005a; Saeedi 2010; Williams 2013). In all cases, unsorted heavy residue has been archived and can be revisited if the results of the sorted portion merit it; for example, the discovery of beads in the 2mm size fraction of some samples resulted in the sorting of the rest of the sample.

Figure 14.3. Sorting of heavy residue.

The heavy residue was sorted by type of material, including animal bone, mollusc, chipped stone, fired clay and human bone. Other microartefacts were also recovered, such as beads, worked bone and clay shapes but rarely and so the patterns of densities are not meaningful. These types of artefacts were recorded as small finds. The microartefacts were weighed and counted and the results recorded, alongside other key data such as the volume and context of the sample. Local female labour was employed to conduct the sorting, and they proved to be highly effective at this task (Fig. 14.3).

Identification and recording of material

In the process of sorting heavy residue, artefacts may be missed or incorrectly identified. Efforts were made to limit the errors by checking the remaining residue before it was thrown away. Where possible, artefacts were passed on to specialists who confirmed or adjusted preliminary identifications (Chapters 2, 15, 17, 20 and 21). By using the same process and the same people as sorters every season, the level of errors should be similar across all the samples and so data are comparable. There were some concerns with the identification of certain types of material:

charcoal, for example, is very difficult to identify with certainty with the naked eye, and there was only the very occasional piece of charcoal found, in less than 0.5% of samples, although four times this amount was initially identified before being checked microscopically, but proved to be black burnt clay or bone fragments for example. There is the added concern that some types of material are easier to pick out than others, which may lead to some skewing in the data. For example, pieces of obsidian are easier to see than other chipped stones, because of their colour and lustre. Awareness of these issues aided in the recovery of all microartefacts and avoiding errors in recording.

Measurement

The data recorded form the basis of calculations of a number of measures, which are used to analyse and interpret the results.

Density

The density of material is the key variable and is measured as grams per litre and count per litre. These measures allow the comparison of density across all samples regardless of sample size. The proportion of the sample which was sorted is included in this calculation as the density is calculated according to the volume sorted rather than the total sample volume, where appropriate. The results are used here to discern the distribution of microdebris across the site at different spatial scales. In addition, they are used to compare different types of contexts, deposits and features, and to investigate chronological change within spaces.

Presence and ubiquity

Two related measures of the occurrence of different material are used here: ubiquity and presence, as measured by the proportion of samples from which the material has been recovered. The *ubiquity* measure is used for both the 2mm and the 4mm size fractions separately while *presence* indicates whether the material is present, regardless of size, in the sample as a whole. In the development of the analysis of the heavy residue over many seasons at Çatalhöyük an "intuitive hierarchy of material" frequencies has been adopted as shown in Table 14.2 (Cessford and Mitrovic 2005b: 47). The ubiquity of material is categorised as a hierarchy from 'ubiquitous' to 'rare' and can indicate the microdebris types which should be analysed further (Table 14.2).

The data set

The data on which the analysis is based come from samples collected over seven seasons of excavation. Samples were collected from each context and the heavy residue was sorted and recorded. Samples are included in the analysis if they meet the following criteria:

- The sample came from a Neolithic context;
- The volume of the sample was greater than 5 litres, as the results from small samples run the risk that the absence or presence of material has a disproportionate impact on the measure of density.

A total of 754 samples representing 19,930 litres of deposit from Bestansur, and 28 samples and 790 litres from Shimshara have been fully processed and provide the data for this analysis.

Ubiquity and presence of material

Three main types of material were recovered in a majority of samples: animal bone, chipped stone and mollusc, with other material, such as fired clay and human bone, found occasionally, and their density was also calculated. Other artefacts have been recovered from heavy residue, for example, beads, clay shapes, tokens and worked bone, but

Table 14.2. Ubiquity of material: Bestansur and Shimshara.

	Occurrence (by proportion of samples)	*Bestansur*	*Shimshara*
Ubiquitous	>80%	Mollusc in 4mm and 2mm	Bone in 4mm and 2mm Mollusc in 4mm and 2mm
Very frequent	50–80%	Bone in 4mm and 2mm Chipped stone in 4mm	Chipped stone in 4mm and 2mm Fired clay in 2mm
Moderate	10–50%	Fired clay in 4mm and 2mm Chipped stone in 2mm	Fired clay in 4mm
Occasional	3–10%	Human bone in 4mm and 2mm Beads in 2mm	
Rare	<3%	Charcoal Worked bone Clay shapes	

infrequently and they fall into the occasional or rare categories as outlined in Table 14.2. They were recorded separately as small finds with details such as weight and material noted (Chapter 21). Reporting the density of these artefacts would generally not be meaningful in this statistical analysis, although the density of beads is calculated for the gridded squares in Space 50 for the purpose of looking for any spatial patterning (see below).

Density of material

The density of material is calculated for each sample and the results are analysed at varying spatial scales, and by different spatial and deposit types. The density of microartefacts reported here include the 'ubiquitous' material, that is: animal bone, molluscs and chipped stone, and fired clay which is classified as 'moderate'. Human bone is not included in the aggregated numbers, occurring 'occasionally' at the scale of the site (Table 14.2). The fragmentation of the bones and so the extent of recovery during excavation will influence how much is 'left' in the sediment sent for flotation and sorting. In analysing the spatial patterns of activities, the exclusion of human bone from the totals allows valid comparisons to be drawn. The presence of human bone in some samples is of interest, however, and is analysed below.

All material: averages and dispersion

The appropriate benchmark, or baseline, against which the detailed results can be analysed is problematic because of the nature of the data. Measures of central tendency, that is, averages, produce values which are not particularly meaningful. The distribution of the data shows a high degree of positive skew and large standard deviations; the mean values include a few samples with a very high density of material while the median is affected by a large number of zero values for some material in some samples (Fig 14.4; Table

Table 14.3. Density of all microartefacts; averages and measures of dispersion.

(g per litre)	*Mean*	*Median*	*Standard deviation*	*Coefficient of variation*
Trench 7	2.77	1.45	3.37	1.2
Trench 9	5.29	3.69	4.85	0.9
Trench 10	1.24	0.47	2.65	2.1
Trench 12/13	3.71	1.82	5.66	1.5
Bestansur: all trenches	2.51	1.05	4.09	1.6
(excluding mollusc)	0.52	0.16	1.5	2.9
Shimshara: all trenches	1.55	1.42	1.12	0.72

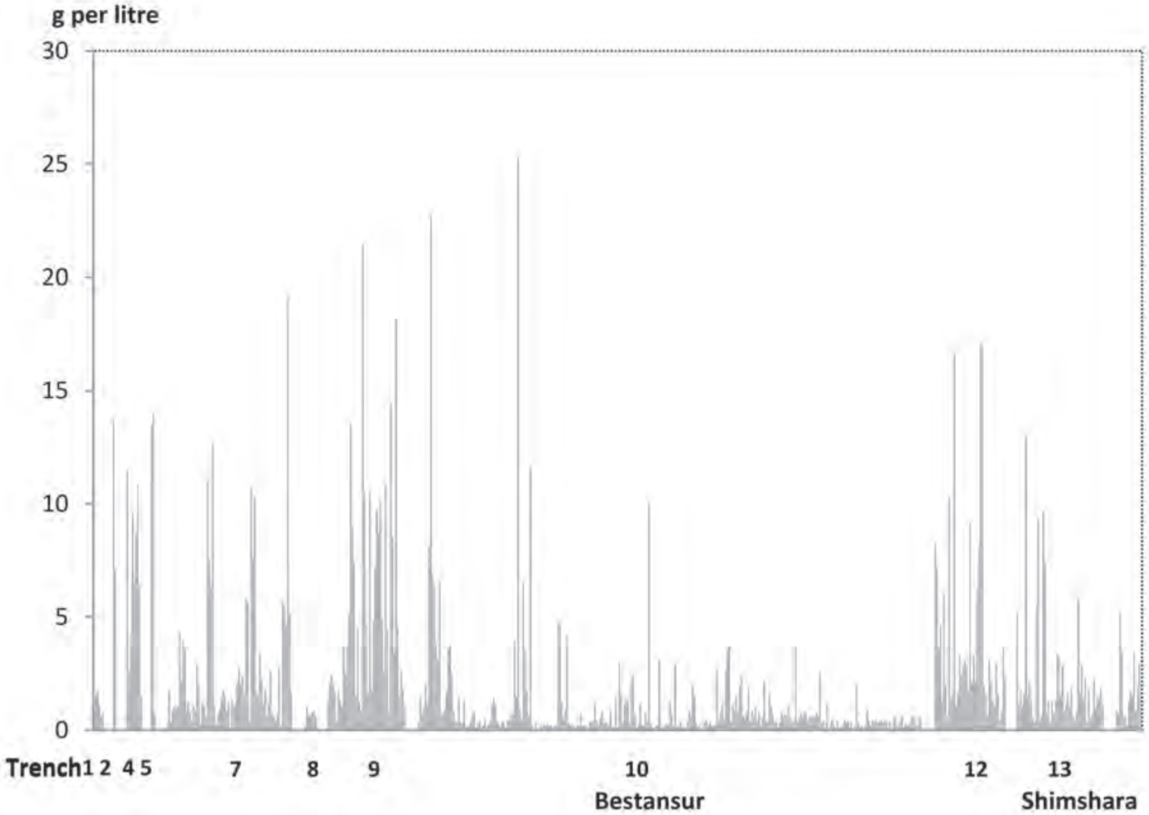


Figure 14.4. Density of microartefacts: by sample.

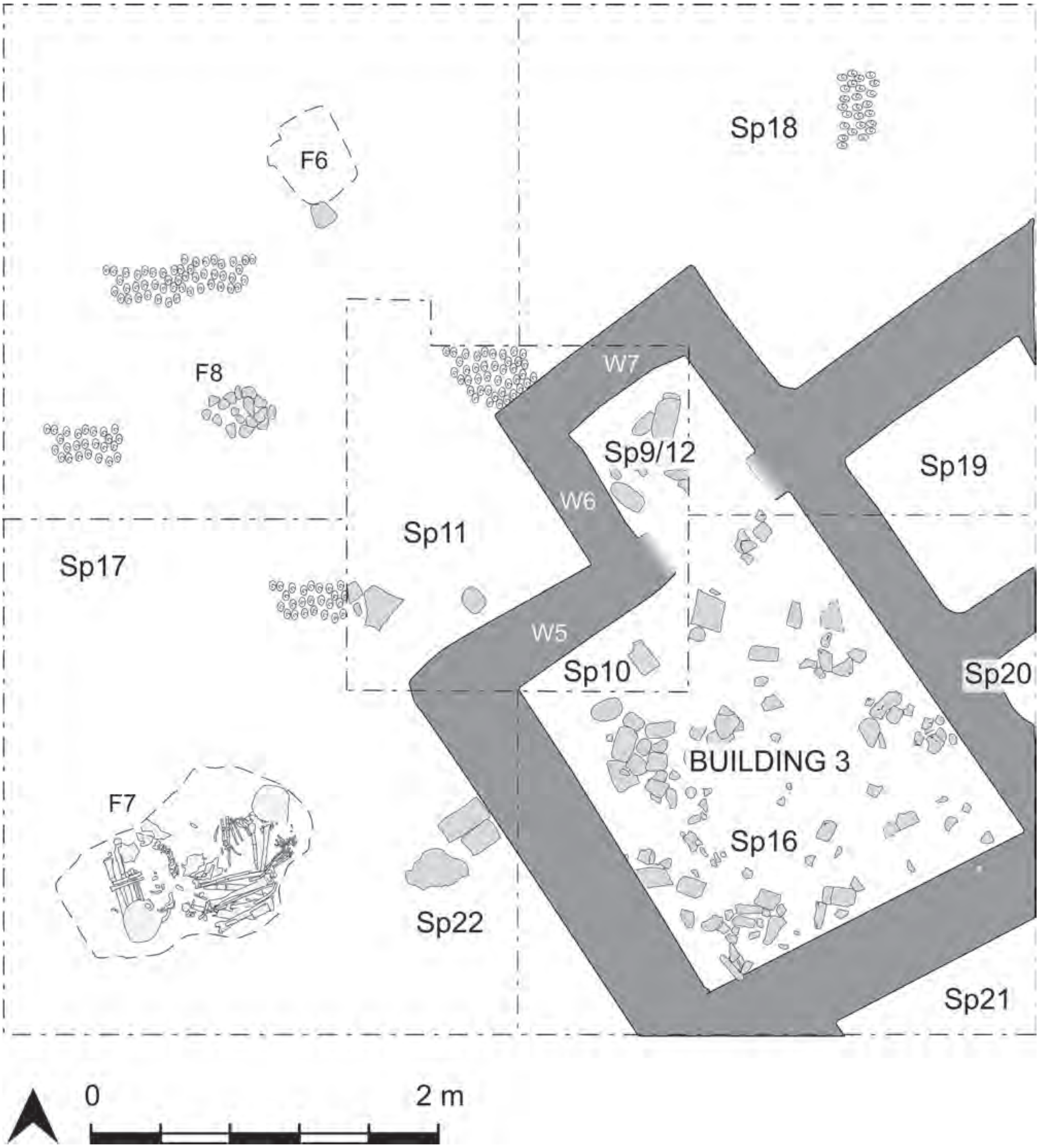


Figure 14.5. Trench 7 plan showing Building 3 and external spaces.

14.3). As the spatial scale of analysis is reduced, from site to trench to context, comparisons become more useful but there is still the need for a site average against which the detailed results can be analysed.

The results

The results from Bestansur are examined by trench and by defined spaces within each trench and then by deposit type.

Bestansur: by trench and space

Trench 7

The samples processed from Trench 7 were predominantly collected from a series of open area deposits, designated as Space 11 in the centre of the trench, Space 17 occupying much of the western half of the trench and the smaller Space 18 in the northeast of the trench. The internal space of Building 3, Space 16, was intensively sampled using a grid (Fig. 14.5).

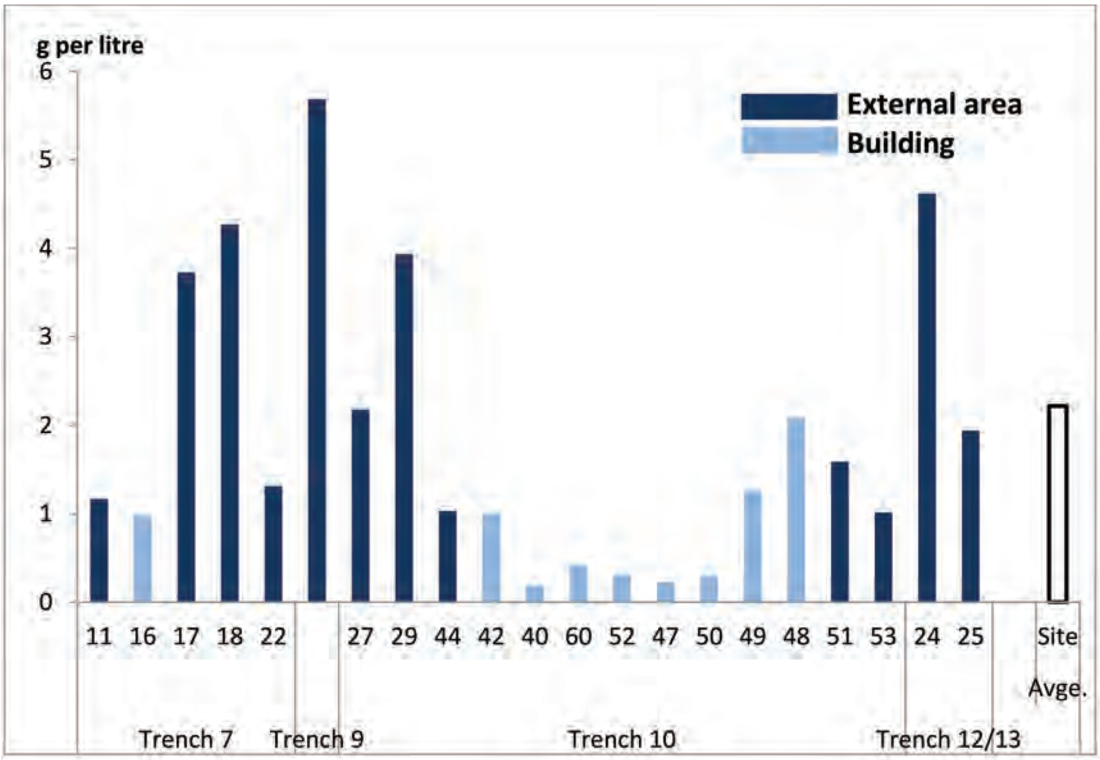


Figure 14.6. Density of microartefacts by trench and space.

Space 11: external area

Seven samples were processed from this space, which corresponded to the original 2 × 2m trench. The density of material is low relative to other external spaces across the site (Figs 14.6–14.9). A closer analysis of the data shows that in the earlier contexts there is a lower density of material compared with the levels above, described as occupation deposits, where the density of material is close to the average for all external areas. Evidence for chert knapping and a deposit of molluscs with an associated burnt surface point to a range of activities taking place and the changing densities stratigraphically suggest individual events and the episodic use of the area for these activities.

In the southern half of the space, evidence of walls was found with a number of ground stones lying on a surface (Chapter 22). This area was intensively sampled using a grid of 0.5 × 0.5m squares, in order to investigate possible variations across the space but also to determine whether there was a difference in the results from the two sides of the wall, suggesting internal and external spaces. However, there was no discernible variation in the density of material across the space. In addition, separate small samples were taken from immediately around and under the stones. There was very little material in these samples, suggesting that the ground stone querns were found *in situ,* as depositing them onto surfaces which had been used for other activities would have resulted in a higher density of material.

Space 16: Building 3

The area was characterised by a number of ground stones, many found lying in small piles which appear to have been placed around the edges of the space (Chapter 22). The space was divided into nine approximate squares of 1 × 1m, and samples were collected from each, averaging around 45 litres. Small samples, averaging around 0.5 litres, were also collected immediately around the stones and from under the stones once they had been removed.

The results show little variation, with a low density of material in all samples suggesting that this space was not used for activities leaving a trace, despite the large number of ground stones. While it is possible that the surface was thoroughly cleaned after the space had been used and then the ground stones were placed on it, the space is small and so is unlikely to have been used by many people at any one time. One interpretation for the use of this space is as a storage area, supported by the large number and range of ground stones and the absence of clear evidence for activities (Chapter 22).

Space 17: external area

Space 17 was extensively sampled with samples collected in three contexts. The results show a pattern of quite different densities of material stratigraphically. The uppermost context (C1248), produced a lower than average density of all types of material while the two contexts underlying produced higher than average results for the density of bone

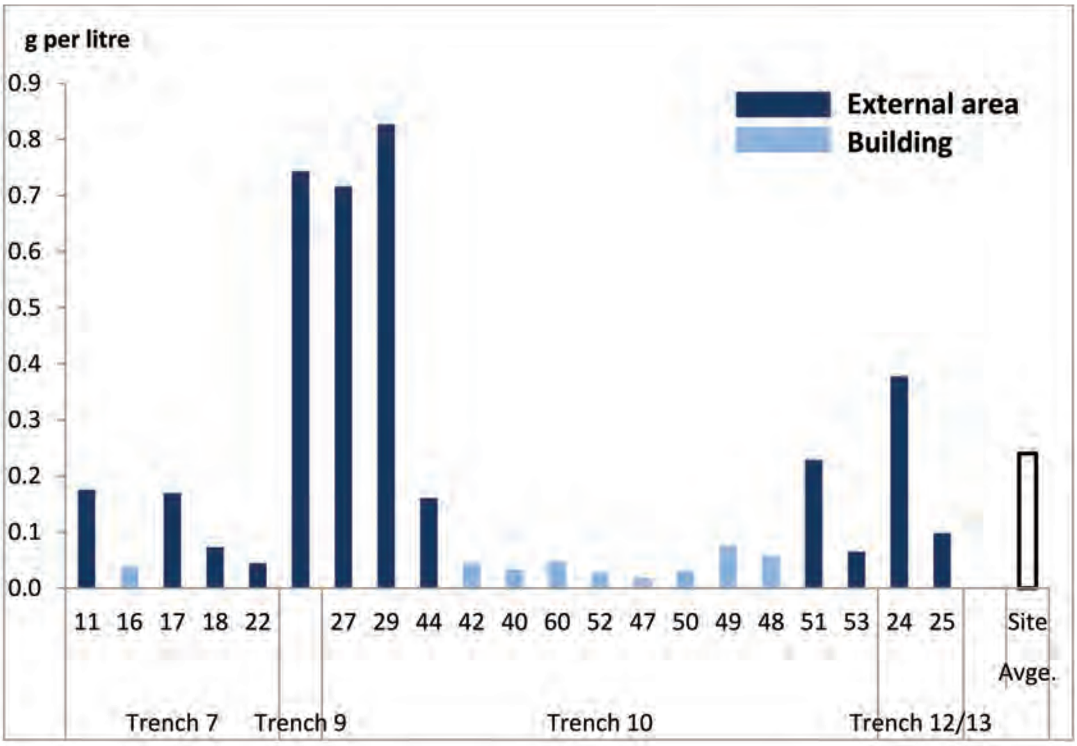


Figure 14.7. Density of animal bone by trench and space.

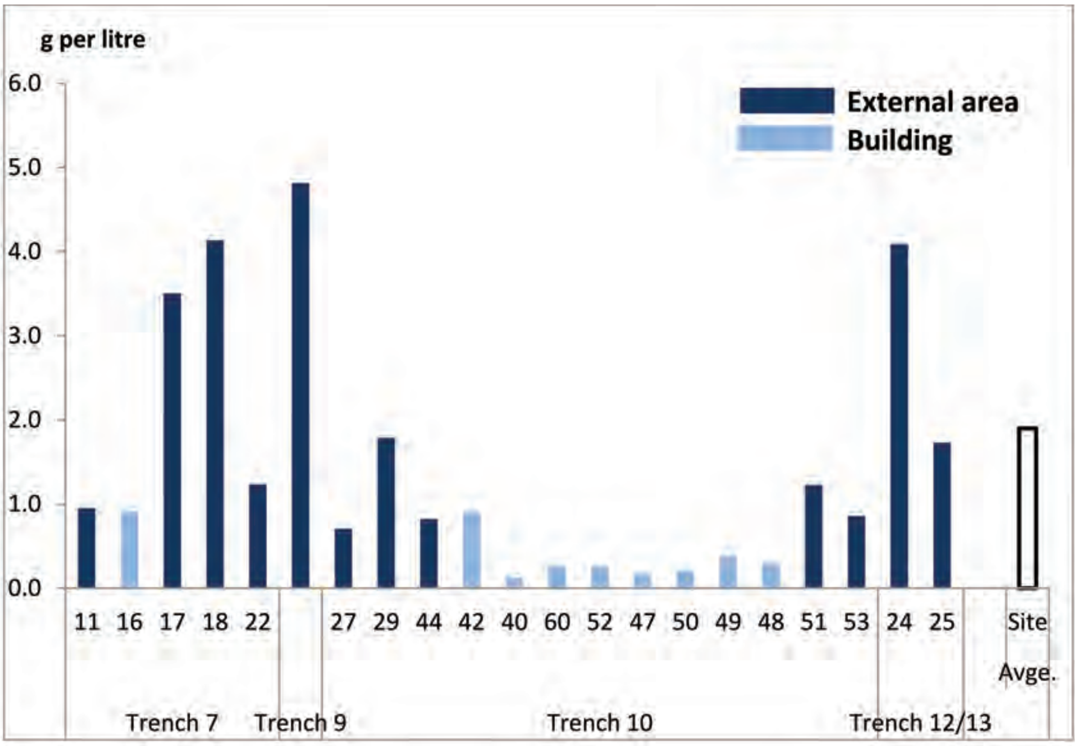


Figure 14.8. Density of mollusc by trench and space.

and molluscs, with chipped stone density around the site average. While both animal bone and molluscs rise in density in the lower levels, chipped stone remains unchanged with low density throughout the sequence.

The locations of the samples were marked on the plan in order to determine whether there was spatial variation and have been analysed by location, albeit determined after excavation by gridding the plan. The decision of where to collect samples was

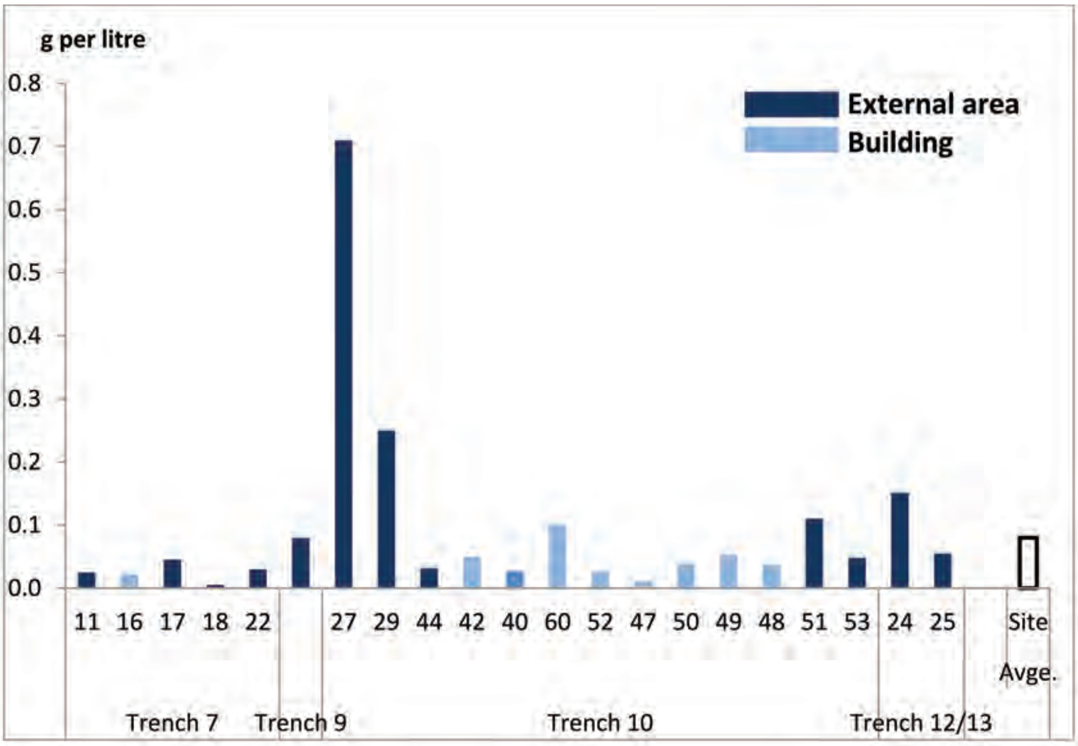


Figure 14.9. Density of chipped stone by trench and space.

based on visible macroartefacts. The samples were collected in the vicinity of clusters of material found lying on occupation surfaces to establish whether these represent foci of specific activities. While some samples show high concentrations of material, when the samples are averaged by grid square the variation is less pronounced. This indicates that there were spots of concentrated microdebris within larger areas.

Overall, this space is markedly different to Space 16 in Building 3 with more material of all types. The variation within the area is somewhat amorphous and does not allow for strong interpretation of the organisation of activities. It is possible to conclude that the space was used for a number of different activities including the use of chipped stone tools, as a number were found lying flat on surfaces, although probably not their manufacture as the density of chipped stone microdebris is low (Chapter 20), the preparation and eating of molluscs and the consumption of meat.

Trench 9

The whole trench is categorised as an external area, with deposits of ash, visible burnt surfaces and the widespread presence of animal bones and molluscs. The density of material in this trench is by far the highest of any excavated area of the site. It has the context with the highest density of animal bone and, with the exception of samples clearly associated with mollusc middens (for example, in Trench 12/13), the highest density of molluscs (Figs. 14.6–14.8). While there is no clear spatial pattern across the trench, there are distinct areas which have a higher density of all material combined. The samples with the highest density of animal bone microdebris are typically the ones also with a high density of mollusc debris. This suggests that there was some clearing away, or pushing to one side, of debris perhaps to allow the space to be re-used.

Chipped stone does not follow this pattern and the overall density for the trench is similar to the site average (Fig. 14.9). The deposition process of chipped stone appears to be different to that of mollusc and animal bone indicating different activities. The debris from the latter two types of material enters the record as a result of food preparation and eating, followed by some form of clear up, whereas the chipped stone artefacts may have been used as tools. It does not appear that chipped stone tools were being manufactured in this space and so the debitage at most represents chips which fell off when they were used, or during repair and maintenance (Chapter 20).

Trench 10

The nature of the excavated deposits varied significantly over the wide horizontal exposure (Fig. 14.10) (Chapter 9). The results of the analysis of the heavy residue from the different areas of the trench highlight this variation with the findings from the external spaces, Space 27 and Space 29, contrasting sharply with those from Building 5 and the surrounding areas. The former show a much

Figure 14.10. Trench 10, Building 5 and surrounding spaces.

higher density of animal bone and chipped stone, with some patches of molluscs, compared with the latter where there is very little material. In the lower levels of Space 50 an exceptional number of human remains were excavated which influenced the approach taken in the collection and processing of samples (Matthews *et al.* 2016a: 3).

Space 27: external area

Of particular note is the amount of chipped stone in the lower levels of this space, in both absolute and relative terms. All samples had a very high density of chipped stone with one context producing over 1800 pieces of chipped stone in three large samples, primarily chert debitage, as well as many pieces of animal bone. The number of pieces of chipped stone from Space 27 account for almost half of the total number of pieces recovered in heavy residue at the site (Fig. 14.9). The samples from C1752 produced 21 pieces of chipped stone per litre compared with a site and trench average of less than one piece per litre. The number of animal bone fragments was also very high at 15 pieces per litre compared with the site average of three pieces per litre.

Space 29: external area

Space 29 is a later large open area that overlies Building 5. It is made up of Late Phase occupation deposits with fugitive surfaces interspersed with layers of packing. Samples from a sequence of contexts show a clear pattern of above average density of material. It is notable that the density of mollusc debris is below average despite the visual evidence during excavation of clusters of whole molluscs. The presence of fired clay in samples collected from some contexts supports observations of areas of burning.

Within the area there is some variation, with spots with markedly higher density of animal bone or chipped stone, and sometimes both. In C1412, for example, in one sample collected in the northwest of the space the density of animal bone is 3g per litre and chipped stone 0.5g litre, well above the average for the context as a whole. Detailed examination of the animal bone suggests that the debris is more characteristic of processing than consumption (Chapter 15). With the density of chipped stone well above the average, it is likely that there was some manufacturing or reworking of tools in this area, supported by the very high proportion of debitage, 95% of which was chert.

Building 5 and the surrounding area

The large pisé building, Building 5, comprises a series of rooms and was constructed on top of an earlier mudbrick building, Building 8. Building 5 is dominated by a large rectangular space, Space 50, which measures 8m by 4.5m and the stratigraphy showed layers of packing, occupation levels and floors, and collapse. Disarticulated and articulated human remains were found in the packing below floors (Chapters 9 and 19).

The density of material for the different spaces shows some variation, although overall it is low at 0.5g per litre compared with around 3g per litre for the external spaces in the trench. The data in Figure 14.6 are shown by space, moving from south to north (Fig. 14.10). Space 44, to the south outside the building, and Space 48, the oven space, have the highest concentrations of material, although in the case of Space 48 it is dominated by fired clay. Space 49 has no obvious source of entry and is probably too small to allow much physical human activity. Its proximity to the oven is likely to have kept it warm and so it may have been used for drying and/or storage. The other spaces within Building 5 are all very clean in terms of microdebris.

Figure 14.11. Space 50 gridded for sampling, original grid, lowermost room fill and then underlying floors. Looking southeast, scales = 50cm.

The large rectangular room, Space 50, was extensively gridded and sampled when it was first exposed during excavation and this grid was maintained over the following seasons (Figs 14.11 and 14.12). It is possible to discern some variation in the material from heavy residue both stratigraphically and spatially in the upper levels, although the densities of microartefacts are very low with the floors largely devoid of debris. The higher density samples were the ones collected next to the walls, at the edges of the room, in areas that may have been less easy to keep clean.

Stratigraphically the context with possible matting lying on a floor produced very fragmented human bone pieces in the heavy residue samples. This is also the context with the highest concentration of chipped stone at 0.1g per litre, around the site average. The other contexts in this space had very low or zero chipped stone in contrast. It is probable that these fragments of material got caught in the matting and therefore survived the high intensity cleaning that kept this room otherwise spotlessly clean.

Figure 14.12. Plan of Space 50 B5 showing sampling grid.

It should be noted that the absolute densities are low across the whole space both horizontally and vertically (other than in human bone), and that the variation is limited, which cautions against strong conclusions. What can be said is that the human remains are in focussed areas suggesting considerable care was taken when placing them in this space. The very low density of all material indicates a space that was kept very clean and was probably not used for daily activities of food preparation and consumption nor for other everyday activities. The samples with human bone have very little other material, although clusters of beads have been recovered in some contexts (Chapters 19 and 21).

Beads

The flotation and sorting of heavy residue of all the

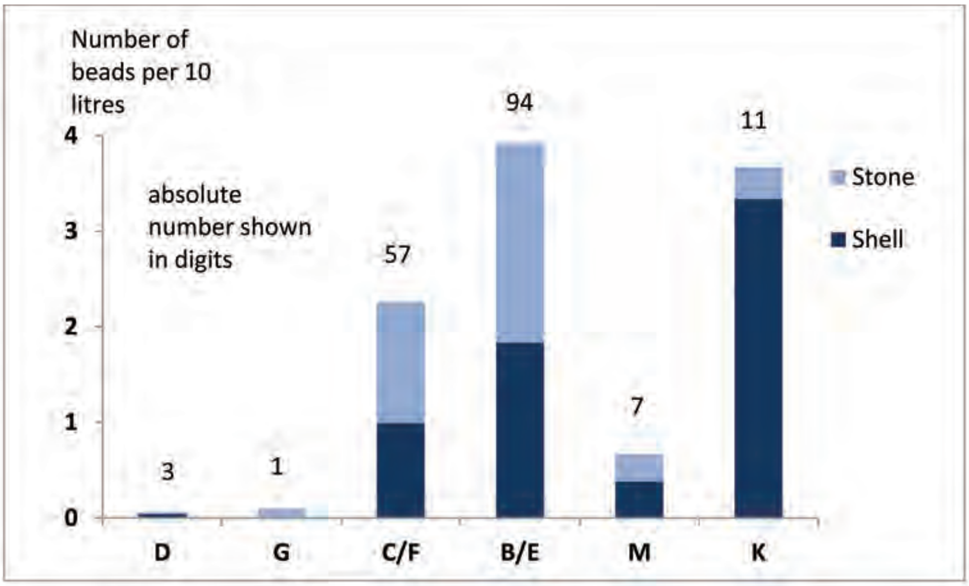


Figure 14.13. Beads recovered: shown by location and type; density and absolute quantity.

Figure 14.14. Excavations in Space 53, Building 9, gridded for sampling.

sediment from Space 50 has ensured not only the complete recovery of all the beads (or very close to complete) but the accurate recording of the volume allows the density to be calculated. The two methods of recovery (hand-picked and recovered in heavy residue) have been combined and the density of beads relative to excavated sediment measured. The grid in Space 50 was maintained and so the densities of beads can be mapped spatially (Fig. 14.13).

Most of the beads, in both absolute and relative terms, were recovered from the central area of Space 50. The highest density of beads at close to four beads

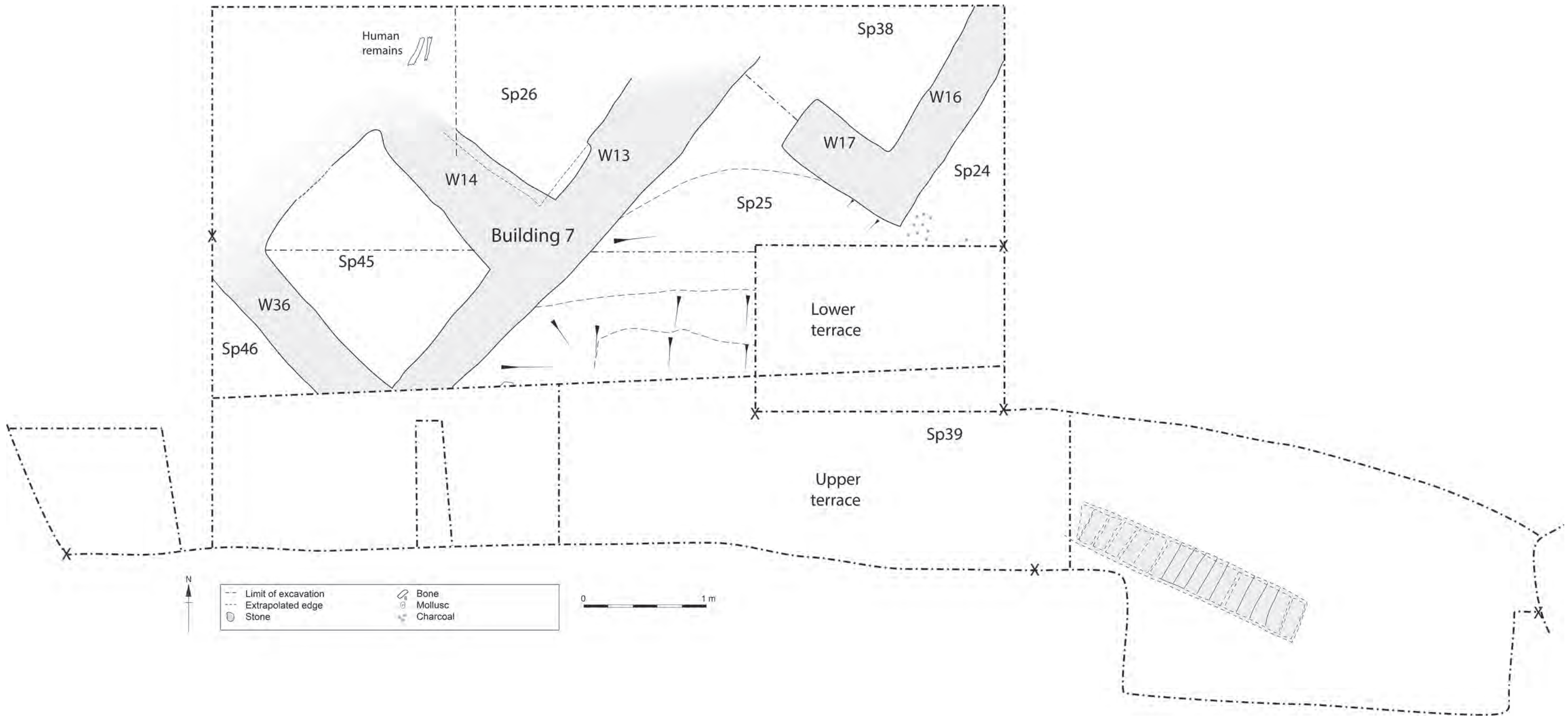


Figure 14.15. Plan of Trenches 12/13.

per 10 litres of sediment was in the adjoining squares B/E. Relating these results to the density of human bone in heavy residue samples is not straightforward as while the presence or not of human bone does indicate the location of burials the variations in the density between samples is not necessarily a good indicator of any concentration of skeletons. Other factors such as the degree of fragmentation of the bones and so the extent of recovery during excavation will influence how much is 'left' in the samples sent for flotation and sorting. Of more interest is to examine if there is any relationship between the number and age/sex of the skeletons and the density of beads.

Building 9, Space 53

Samples were collected and processed from Space 53 within Building 9 which lies at the north end of the trench (Fig. 14.10). During excavation the uppermost deposits in this area were categorised as an external/open area and the lowermost as within a building. The results show a higher density of material than seen in Building 5, at 1g per litre compared with 0.3g per litre, this is still well below the typical values for external areas (averaging 3.6g per litre). The space was gridded and multiple samples collected from the lowermost deposits (Fig. 14.14).

In the north quadrant fired clay was found in the samples which, combined with a number of fire-cracked stones and the ashy nature of the deposit, suggests this material may have been deposited from a fire installation. The burnt stones and fired clay were present in the upper level of the sequence of deposits (C1756), which also showed a higher density of other material, pointing to a change in the use of the space over time. There was also some variation across the space but with the absolute density levels still low.

Trench 12/13

Trench 12/13 covers an area of approximately 10.4m wide running east–west and 5.5m of stepped terraces running northwards from the mound (Fig. 14.15; Chapter 9).

The density of animal bone and mollusc is high across all the samples processed from this trench with very high concentrations of molluscs in some, which are tentatively identified as coming from intensive use of molluscs (Chapter 17). The number of pieces of animal bone per litre (as opposed to grams per litre) is the highest of anywhere on the site, in both the 4mm but especially the 2mm size fraction (Figs 14.7–14.8).

Spaces 24 and 25: external areas

Spaces 24 and 25 lie outside the walls but, although they are both designated as external spaces, the density of material is very different. Space 24 has a high density of all material consistent with an area used for activities or discarded artefacts, with similar values to those found in external areas in Trench 9, while the larger Space 25 has below average density of material although is not as clean as internal areas found associated with other buildings and is rich in ash and human coprolites (Chapters 12, 13).

Bestansur: deposit types and features

The Bestansur data can also be analysed by space type, deposit type and types of feature. Here the different types of microartefacts are aggregated and the analysis is driven by the deposit type. Overall, walls and floors have a very low density of material while the fire installations, the fire spots and occupation residues show a high density of all material (Figs. 14.16–14.17). As the mollusc debris overwhelms the totals, the data are shown without molluscs in Fig. 14.17, allowing the patterns for other material to be seen more clearly. Packing and floor deposits both contain all types of material although all are found in higher densities in the former. Packing deposits show densities of animal bone and chipped stone at around the average for the site but a lower than average density of molluscs.

Fire installations

Examining the fire installations and areas of burning more closely shows that fire spots have much more animal bone than the fire installations, which in turn have more fired clay (Fig. 14.18). The method of heating and cooking varies between the two, as the fire spots found in external areas are generally associated with a higher density of material. There is also a discernible spatial variation across the site, with the areas of burning in Trench 9 producing higher densities of material, especially animal bone, than are found in very small amounts in fire installations in other trenches. Comparing the areas of burning across the site suggests differing cooking and/or cleaning practices as the density of the different material varies significantly.

Shimshara

The more restricted excavations at Shimshara and correspondingly fewer results only allow for some general observations, although some useful comparisons can be drawn with the data from Bestansur. The overall density of microartefacts is lower at 1.6g per litre compared with 2.6g at Bestansur but, as can be seen in Figure 14.19, this is because of the high density of molluscs at Bestansur. Chipped stone and fired clay densities are similar but the density of animal bone is much higher at Shimshara at just over 1g per litre. There is far less variation between samples and there is only a slight increase in the density of microartefacts in areas defined as external compared with buildings (Fig. 14.20).

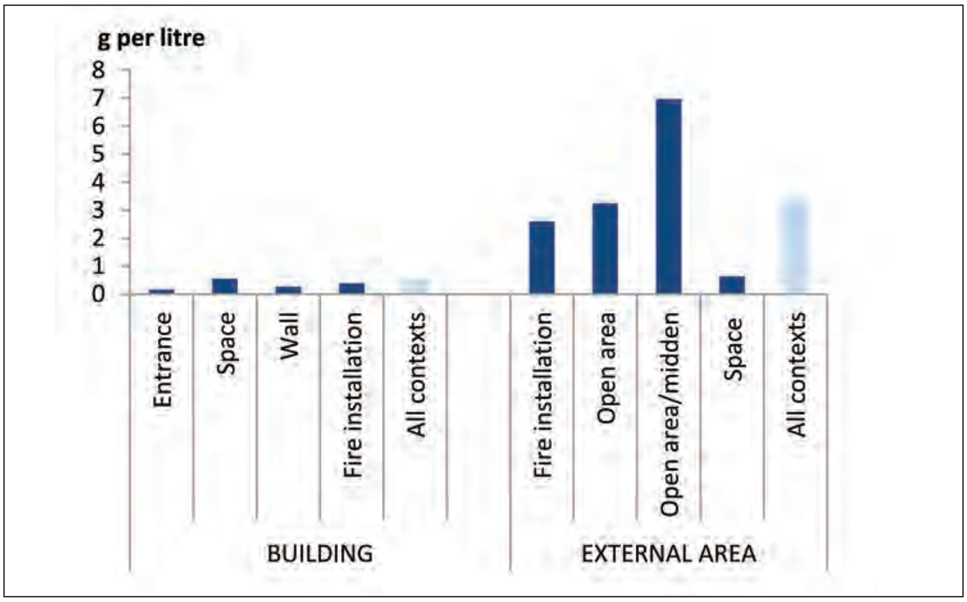


Figure 14.16. Density of microartefacts by space type.

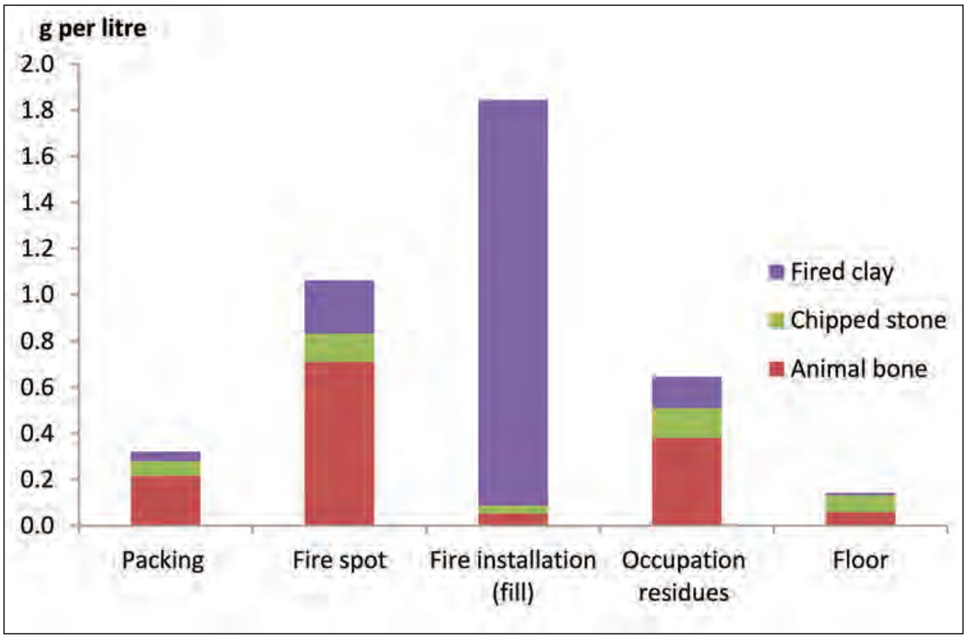


Figure 14.17. Density of microartefacts (excluding molluscs) by deposit type.

Bestansur: activities and actions

The results from heavy residue can be used to investigate the activities evident at the site and their spatial organisation. The comprehensive sampling and processing of sediment allows us to examine whether different spaces were used for specific areas and whether some spaces were 'kept clean'.

Living spaces: areas with defined activities

Across the site there are areas with evidence for a range of activities, as indicated by the higher than average density of all material, but there are also areas characterised by concentrations of one type of material which are discussed in turn below, as summarised in Figure 14.21.

Chipped stone working

Space 27 in Trench 10 produced over 2000 pieces of chipped stone, accounting for around half of the total recovered from heavy residue, showing the highest density recorded at the site. The assemblage was nearly all debitage, at 95% of all the pieces, and over 90% was chert. Among the few tools found in

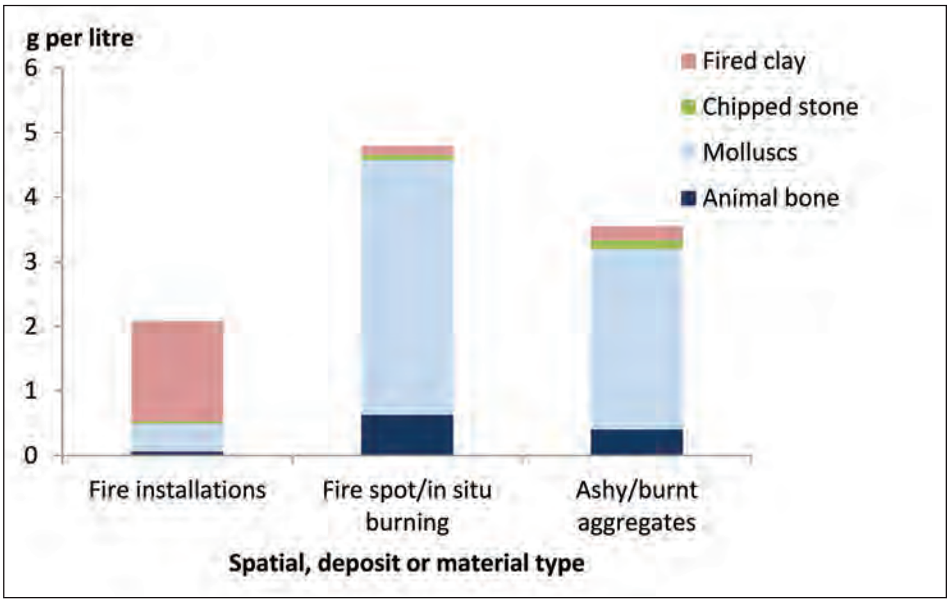


Figure 14.18. Density of microartefacts by different types of burning.

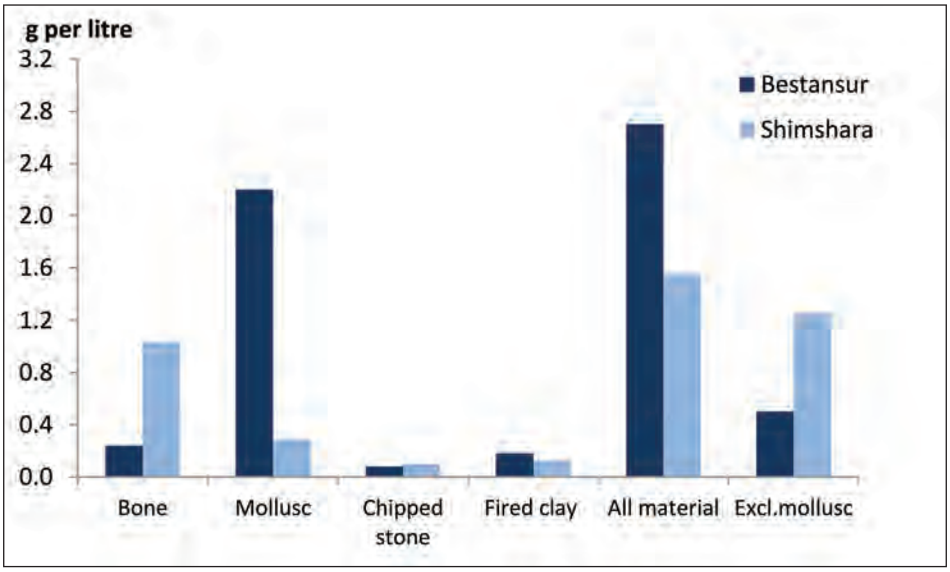


Figure 14.19. Density of microartefacts: Bestansur and Shimshara, by type of material.

this space, 15% were obsidian. These data can be compared with the site-wide results for chipped stone (Chapter 20) which show tools (including unretouched blades) account for 38% of chipped stone by count while the obsidian proportion of the chipped stone assemblage (tools and debitage) is 26% by count. The mix of material and artefact types in the Space 27 assemblage is indicative of tool manufacture rather than of tools being used in other activities or repaired.

These results point to an area where chipped stone was being worked, and although it is possible that the chips were collected and dumped in this area, few other spaces have been found with significantly high densities of chipped stone. Two contexts in the overlying Space 29 do have much higher than average densities of chipped stone. There are some indications that knapped chipped stone debitage was being deliberately discarded on these sloping external surfaces that overlay Building 5 in Trench 10.

One other area, Space 11 in Trench 7, also produced large amounts of chipped stone with more than 850 pieces recorded from context C1172 (Chapter 20). The assemblage was again dominated by chert debitage at >95% of the total, found in a small pit cut into the surface. Within the chipped stone recovered from this space, there were many small fragments which suggest that the knapping took place very close to where the debitage was deposited. In the same

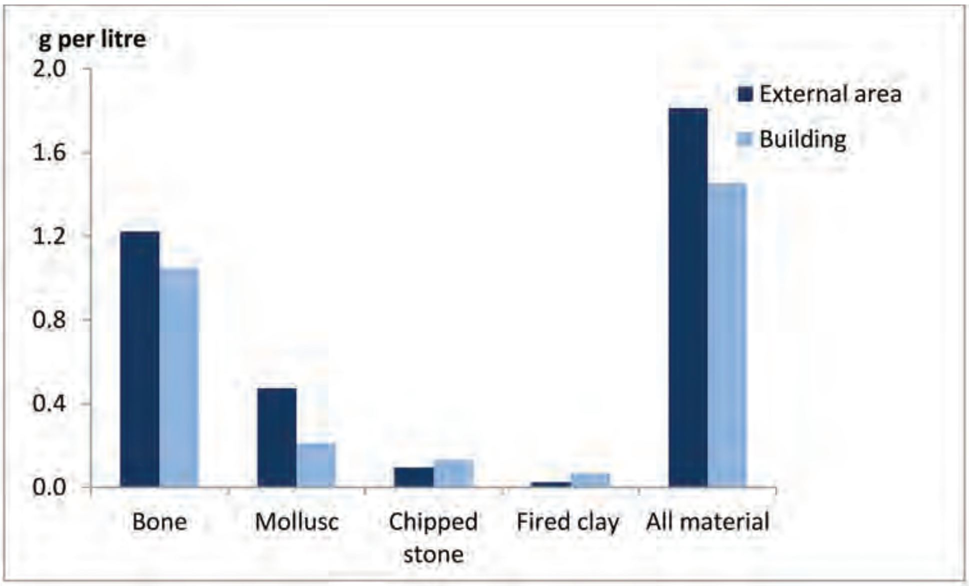


Figure 14.20. Shimshara: density of microartefacts, by spatial category and material type.

area, albeit at different levels, there is evidence for a range of other activities such as a mollusc cluster and ground stones and, so while the space may not have been used for all the activities at the same time, the area was likely to have been one which was repeatedly used for both work and food preparation/consumption. In sum, the microartefact evidence supports an interpretation that chipped stone was knapped at Bestansur within distinct areas where the debitage was carefully discarded.

Animal processing

Trench 9 had a high density of animal bone across the whole trench, at three times the site average and, significantly, showed the lowest overall variation within a trench. Examining the types of animal bones in the heavy residue assemblage shows that it was dominated by medium to large animals with close to 90% falling into this category compared with a site-wide proportion of around 80%. The amount of fish bones was minimal, and microfauna and small animals too were much less well represented in this assemblage than for the site as a whole (Chapter 15).

These results point to the likelihood that this area, Trench 9, was used for the processing of medium to large animals, taking place over a relatively wide area, at the very least the extent of the 6 × 6m trench. As well as indications of butchery, seen in the bias of where on the carcass the bones came from, there are also indications of marrow extraction and processing in the fragmented and burned limb bones. Animals here may also have been processed for their hides. Of the ten samples with the highest density of animal bone, eight came from contexts with burning, four characterised as *in situ* burning and four with burnt material. At the other extreme, the samples with the lowest density of animal bone were collected from a range of deposit types including many with evidence of some sort of burning but not described as contexts with *in situ* burning. This suggests that while fire was being used for a variety of reasons in this area, the more intensive processing of animal bones involved heat and resulted in the deposition of animal bone debris in their 'primary' contexts. The mix of animal bone types also argues against this as an area primarily for discard, although some of the concentrated clusters of animal bones, as shown in the high density of some samples, within the space indicate that animal bone debris was pushed to one side from time to time, probably to clear space for the next event.

Space 29 in Trench 10, a large open area in use following the closure of Building 5, is an area where a range of activities was undertaken, including the processing of animal bones. The assemblage is similar to that found in Trench 9 but in Space 29 the intensity of the butchery and marrow processing appears to have been lower, as attested by the lower density of animal bones. Within the space, there is a clear spatial pattern with more animal bone microdebris in the east half of the trench than the west, in the upper Neolithic levels, and a greater density in the packing deposits in the stratigraphically lowest levels. While the deposits are noted as ashy and some with redeposited material, none of the contexts have *in situ* burning and there is no pattern between animal bone density and burnt material. Space 29 also produced the largest concentration of fragments of worked bone, as well as a number of clay objects, and there were visible clusters of molluscs suggesting some eating,

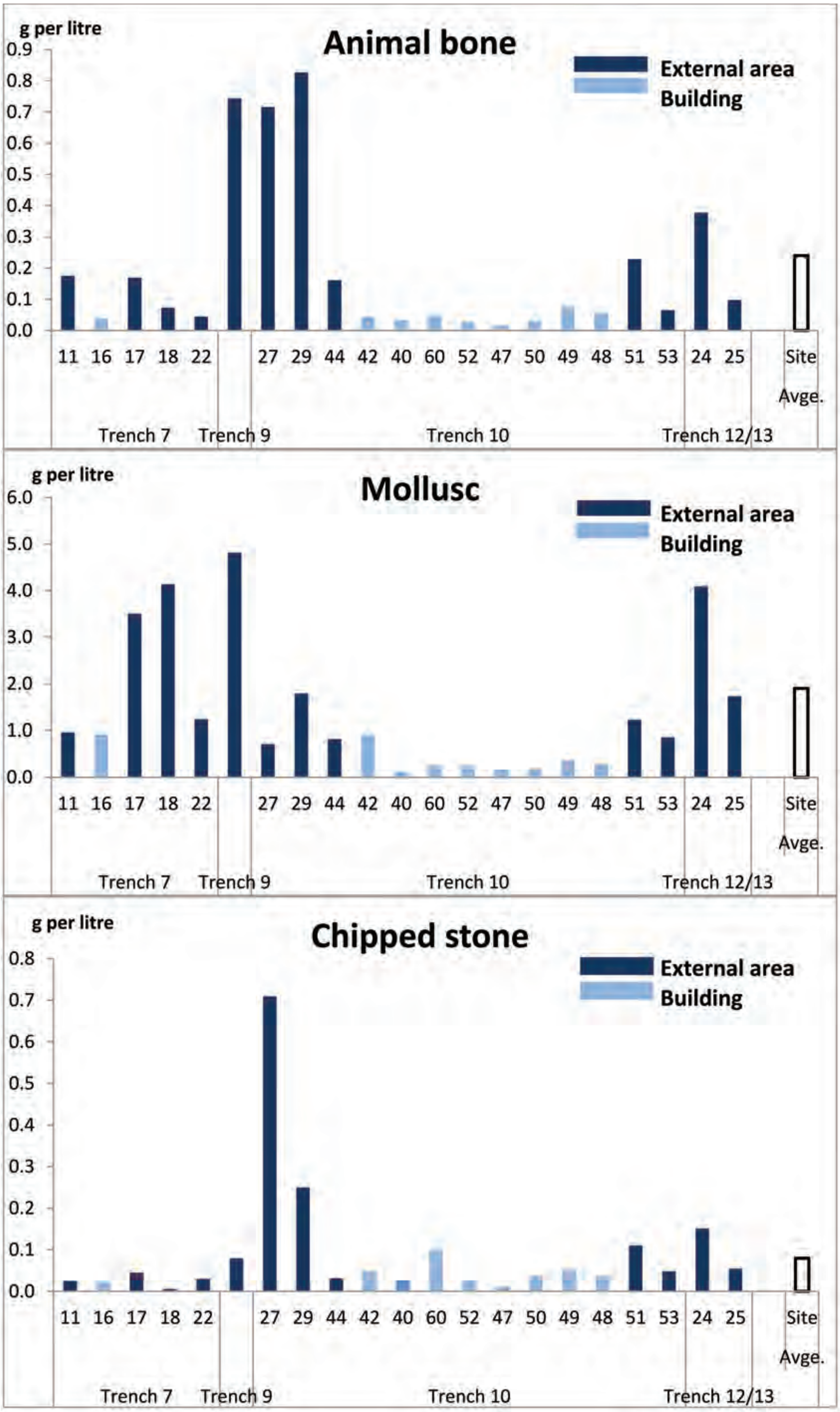


Figure 14.21. Density of microartefacts by space and material type.

although the numbers do not indicate more than the occasional snack.

Comparing the two areas with the highest density of animal bone as a result of processing, rather than discard, highlights the difference in intensity. In Trench 9 the processing appears more 'industrial' with more debris and the activity spread across a large 6 × 6m area, while in Trench 10 the processing appears to have been contained in smaller areas. In Trench 10 there is evidence of other activities in the vicinity, suggesting it was on a smaller scale and possibly more episodic. No other area of the site produced as much animal bone and in such concentrations, although in Trench 12/13 there is evidence for the discard of animal bone debris, suggesting that some areas were chosen for this activity and then used repeatedly.

Multiple activities

Many of the varied activities at Bestansur did not happen in isolation, as most of the areas with concentrated evidence of one activity also produced evidence of other activities, indicating that they were spaces where a number of activities took place, possibly at the same time. In some areas there is evidence of a range of activities without any one dominating. One such area is Space 17 in Trench 7, where a series occupation surfaces with chipped stone debris, animal bones and molluscs were extensively sampled. Animal bone and mollusc debris showed patches of more concentrated activity in this space but overall the density of material points to this area of the site being used less intensively or for shorter periods than other areas with a similar mix of artefacts, for example, Space 29 in Trench 10.

The activities associated with molluscs are discussed in detail in Chapter 17 and so the discussion here will be limited to an interpretation of the overall results. This shows that molluscs were consumed across the site, as indicated by both clusters and extensive spreads of trampled mollusc fragments, and usually in areas where there is evidence for other activities. Both the chipped stone cache in Trench 7, discussed above, and the meat processing in Trenches 9 and 10 were found in areas which also had mollusc clusters and spreads. The cooking and eating of molluscs were communal activities, which most likely took place at different scales but the practice was spatially structured with distinct areas for discarding the debris. Mollusc consumption was tied into other activities, providing a focus for socialising in work-spaces and indicating that people carried out craft and food processing activities in small groups while enjoying snacks of roast land snail.

Fire: heating, cooking and processing

Evidence for the use of fire is found across the site, with different types of fire installations as well as more ephemeral indications seen in fire-spots, blackened surfaces, burnt material and ashy deposits. When the different types of burning are analysed a pattern emerges for the different activities, as has already been referred to above. The fire installations are associated with low densities of material, possibly because of the high temperatures reached, or due to periodic rake-out of the ashes and other debris during repeated use, while fire spots or areas with evidence of *in situ* burning show a higher than average density of material.

Taking the rubbish out

Care needs to be exercised in defining what is rubbish, as this is a culturally specific term (Moore 1982). Hayden and Cannon (1983) used ethnographic observations to argue that a number of factors will determine how and where refuse ends up. The effort of disposing of rubbish will be tempered by the potential value of the items (recycling and re-use) and the hindrance caused by leaving it where it is. While these are clearly factors which may influence behaviour, applying them as principles which govern rubbish disposal in all contexts misses the point that both the concept of what is rubbish and how it is treated varies hugely, within and between human societies.

Using rubbish as an "exploratory label, as a starting point in analysis and discussion", Martin and Russell (2000) examine how materials are discarded and moved around at the site of Çatalhöyük. A number of common characteristics encourages the definition of certain deposits as rubbish: they are found in outside areas or in fill within buildings as at Çatalhöyük, contain a mixture of many types of material, produce a high density of material and the artefacts are broken. The deposition and redeposition of material, however, which may broadly be defined as rubbish, was extremely complex and the rules which govern practices of discard will be hard to discern from the archaeological record.

Noting the characteristics listed by Martin and Russell (2000), while taking into account the difficulties of defining what is rubbish, it is possible to identify deposits and areas with evidence of repeated discard. No distinct middens have been recovered at Bestansur although a couple of areas have been identified as mollusc middens, as discussed in Chapter 17. There may be a number of reasons for the absence of middens. The excavations by necessity only covered a relatively small area and any middens may fall outside this area, or the middens may be at some distance from the settlement site. In Trench 12/13 some deposits have been characterised as 'midden-like' showing a high density of mixed microdebris, but of short duration, repeatedly covered with thin packing and plasters. In particular, the density of microbone, made up in part by large numbers of fish bone and other small animal bones, with larger mammal remains in proportions lower than in other parts of the site, points to discard after consumption, rather than butchery. Some of the microfauna appear to be intrusive, based on the better preservation of their bones (Chapter 15). On balance, it appears that the concentrations of certain types of debris, that is, molluscs and animal bones, are the result of secondary deposition rather than an indication of primary activities, and so while not a typical midden deposit this was an area chosen for periodic discard of rubbish.

If the absence of full-blown middens is a real attribute rather than an element of excavation bias, then it may be explained by the practice of not removing debris any distance from its place of use. The intensity of occupation, both in terms of time and population density, will influence how rubbish is treated. As settlements are occupied more intensively rubbish becomes more of a nuisance and so needs to be moved away from activity areas, the so-called 'garbage crisis' (Schiffer 1972; Hardy-Smith and Edwards 2004). One solution is to move to another area of the settlement, and another is to cover the debris with earth to create a clean surface on which to live and work (Pollock and Bernbeck 2010). At Bestansur, there are several areas with successive surfaces with occupation debris, in particular in Trenches 7 and 10, indicating that this might have been one strategy which was adopted. The areas with midden-like deposits may be a sign that a 'garbage crisis' was developing, indicating that the site was being used with increasing intensity.

Schiffer (1972: 162, original emphasis) argues that "*with increasing site population (or perhaps site size) and increasing intensity of occupation, there will be a decreasing correspondence between the use and discard locations for all elements used in activities and discarded at a site*" and the results from Bestansur can be viewed in this light. While there are no obvious middens, there was a degree of rubbish management evident at the site. Some debris was left where it was produced, or at least just pushed to one side, but other rubbish was collected and discarded in specific places. This is certainly true of mollusc debris and possibly also of cooking waste. The inhabitants of Bestansur may not have faced a 'garbage crisis' but repeated activities necessitated the dumping of rubbish in specific places, pointing to more than occasional occupation.

Eating together

Much of the material collected from heavy residue is indicative of the processes involved in subsistence. The *chaîne opératoire* of food production involves a number of stages where people interact with food and also with each other. The food needs to be acquired or produced, through hunting, gathering, husbandry or cultivation, then processed, involving both the initial stages of preparation such as butchery or threshing and pre-consumption processes such as grinding and cooking (Twiss 2012: 362). This is followed by eating the food. The debris will be discarded at each of these stages (Table 14.1). There is evidence for many of these activities at Bestansur but here the practice of sharing meals is briefly discussed.

Much food related research has focused on larger-scale feasting and its importance in ritual, power, status and identity, but more mundane daily meals would have been one of the key activities in structuring society (e.g., Aranda Jiménez *et al.* 2011). The consumption of food is normally a daily activity and the choice of food and how it is prepared and consumed will be shaped by not only what is available but also will be learned through practice and reinforced through daily repetition. It is "the ultimate *habitus* practice" (Atalay and Hastorf 2006: 283), connecting producers with consumers, with meals providing the opportunity for social interactions and a means by which social structure is reproduced. Eating together involves people sharing physical, social and temporal space as it is not solely the food itself which is shared but also the place, time and experience (Pollock 2012: 3). The sharing of meals is important in creating and sustaining social bonds and in ensuring the cohesion of the group.

The evidence from Bestansur suggests that food, its production and consumption, involved the whole community and so would have been critical in structuring social relationships. Animals were hunted, killed and butchered, and then cooked and eaten in a number of open areas, molluscs were gathered and then cooked and eaten across the settlement, and other foods will have been cooked in spaces where there is evidence for hearths and other fire installations. The whole community appears to have eaten similar food and it is likely that a large proportion were involved in its procurement and preparation, men and women, young and old. The biological and social aspects of food represent key entanglements between humans and humans, between humans and things, and between humans, plants and animals.

Outside and inside

Spaces inside buildings, consistently and without exception, produced a very low density of material at Bestansur. Extensive sampling showed little variation within buildings either spatially or chronologically. The lack of material suggests that internal rooms were not used for activities which made a mess and that surfaces were cleaned and maintained, and in some cases covered with mats (Chapter 12). In Trench 7 the small room, Space 16 in Building 3, had a large number of ground stones inside and little else, and was probably a space where the stones were stored.

Discussion of seasonally used sites point to ground stones as one of the material types which might be cached for return visits and this is one possible explanation for the use of this space (Binford 1979; Wright 1994).

Intensity of occupation: evidence from heavy residue

The issue of whether the settlement at Bestansur was permanent or occasional/seasonal is better addressed in non-binary terms by looking at evidence for the nature and intensity of occupation. On the way to becoming fully settled, many sites were visited seasonally repeatedly and it is likely that settled communities included a degree of transhumance and herding to take advantage of seasonal resources (Oates 1973 : 159; Mortensen 2014: 121–127).

Density of material

The density of material provides some clues to the intensity and/or duration of the use of certain spaces. Parts of the site produced a much higher density of material than others pointing to their relatively greater use but this does not in itself prove that the site was inhabited year-round. There are many problems in comparing results from heavy residue processing from other sites, as methods and measurements vary between projects, and the following interpretations need to be viewed cautiously. The results from Bestansur, however, suggest it as a site with a relatively low density of material. The samples collected at Shimshara are directly comparable in terms of the method employed and, although the results are based on a relatively small number of samples (28 in total) and a lack a diversity of spatial types, they demonstrate that the density of animal bone is four times that of Bestansur but with a similar density of chipped stone. At Boncuklu, an Early Neolithic site in Central Anatolia, the method adopted is different so only the smaller size fraction (2mm) can be safely compared, and this shows the density of animal bone at over 2.5g per litre on average compared with less than 0.1g per litre at Bestansur. Chipped stone is also higher, at four times the Bestansur level, at 0.08g per litre and 0.02g per litre respectively, in the comparable 2mm size fraction (Iversen 2015, 212–227).

The data from Boncuklu include samples collected in middens, where it would be expected that the density would be much higher but, even when those samples are excluded, the density of animal bone and chipped stone is still well above levels found at Bestansur, and in addition the range of microartefacts is much greater. The contrasting results from samples collected from inside and outside spaces, and the large numbers of samples taken from the generally clean Building 5, do bias the overall averages. Comparing the results for animal bone and chipped stone collected from external spaces at a wide range of sites, both chronologically and across a wide geographic area, places Bestansur as a site with a low density of microartefacts (Cessford 2003; Rainville 2003; Cessford and Mitrovic 2005b; Özbal 2006; Parker *et al.* 2009; Saeedi 2010).

15. ANIMAL REMAINS AND HUMAN–ANIMAL–ENVIRONMENT RELATIONSHIPS AT EARLY NEOLITHIC BESTANSUR AND SHIMSHARA

Robin Bendrey, Wim Van Neer, Salvador Bailon, Juan Rofes, Jeremy Herman, Mel Morlin and Tom Moore

Introduction

Research context

The shift from reliance upon hunted wild populations to the control and exploitation of domestic animals is one of the great step changes in the human past (Harris 1996; Barker 2006). It is now argued that the early domestication of sheep, goat, pig and cattle developed in multiple centres of the Fertile Crescent in Southwest Asia and as a gradual process, evolving from hunting strategies and the intensification of relationships between humans and wild animals into the management of, at first, morphologically unchanged animals, generally within their natural habitat (Zeder 2005; 2009; Conolly *et al*. 2011; Vigne *et al*. 2011; Arbuckle 2014). These evolving human–animal relationships were connected with a range of fundamental economic, social and ritual transformations, especially those related to mobility and sedentarisation (Barker 2006; Vigne 2011).

The study area encompassed by the Central Zagros Archaeological Project offers opportunity to explore and develop existing models for the development and spread of animal management. Following early pioneering work in the Eastern Fertile Crescent (EFC) (Braidwood and Howe 1960; Braidwood *et al*. 1983), in recent decades such models have largely been developed out of fieldwork programmes conducted in other regions of the Fertile Crescent. Narratives of agricultural origins, including animal domestication, increasingly recognise local trajectories over 'one size fits all' approaches, stressing the need to examine each region on its own terms (Arbuckle *et al*. 2016). Importantly, renewed investigations in the Central Zagros region enable us to re-examine the early processes of goat domestication (Zeder 2008). Current evidence indicates that initial goat domestication, possibly occurring multiple times, arose between around 8700 and 7900 BC in the region stretching from the Zagros Mountains, in the EFC, to the highlands of Southeastern Anatolia (Peters *et al*. 2005a; Zeder 2008; Pereira and Amorim 2010; Vigne 2011). The uplands of the Central Zagros region lie within the heart of this zone in the natural habitat of wild goats and provides evidence for early goat management (Zeder 2005; Pereira and Amorim 2010). The earliest zooarchaeological evidence for the presence of domestic goats from this region comes from Ganj Dareh and dates to *c*. 7900 BC. Here, the demographic profile indicates a managed population, with the subadult males being selectively culled with delayed slaughter of females, but these early managed goats are morphologically unaltered from wild animals (Hesse 1978; Zeder and Hesse 2000; Zeder 2005; 2008). The earliest morphologically altered goats in the region are identified from Ali Kosh at *c*. 7500 BC, in a lowland area beyond the core preferred natural habitat of wild goats and therefore under human management and protection (Hole *et al*. 1969; Zeder 2008).

With regard to domestication of other animals, current evidence indicates that domestic sheep appear in the Central Zagros from *c*. 7000 BC (Zeder 2008), whereas initial sheep domestication may have occurred during the ninth millennium BC in Southeastern Anatolia (Peters *et al*. 2005a). Predating this episode, evidence for the intensive exploitation of wild sheep, as at Körtik Tepe, Anatolia, in the tenth millennium BC, may represent highly selective hunting that was perhaps a precursor to strategies of herd management in the region (Arbuckle and Özkaya 2006). Domestic pigs are identified from Ceramic Neolithic Jarmo, dating to the early to mid-seventh millennium BC (Flannery 1983; Stampfli 1983; Price and Arbuckle 2015). There are some indications that domestic pigs were present in the Aceramic Neolithic levels at Jarmo, dating to the mid- to late eighth millennium BC, although this is not yet confirmed (Price and Arbuckle 2015). In the EFC, domestic cattle appeared suddenly in the sixth millennium BC, likely imported from settlements in the Euphrates basin (Arbuckle *et al*. 2016). In the western Zagros piedmont, domestic goat, sheep and pig are all thus confirmed as present at Jarmo at least by the Ceramic Neolithic in the seventh millennium BC (Stampfli 1983; Zeder 2008; Price and Arbuckle 2015).

Research aims and objectives

Analyses of zooarchaeological assemblages excavated within the CZAP research programme are aimed at contributing new data and interpretations on animal management and domestication in the EFC and examining a range of overlapping research themes related to the origins of agriculture and sedentism in this region through investigation of settlement, resource management, diet, networks and ritual (Chapters 1 and 24). The main aim of this chapter is to investigate the evidence for the complex interactions of humans, animals and environments at Bestansur and Shimshara in the context of the social, economic, and ritual transformations occurring in the Early Neolithic EFC. Key research questions considered in this chapter include:

- What range of animals were being exploited at Bestansur and Shimshara and how did they contribute to human diet, economy, society and ritual?
- Can we reconstruct details of the local environments from the animal remains?
- What evidence is there for the timing, context and nature of animal management and domestication in this region or of the introduction of animal husbandry from elsewhere?
- What insights can the animal remains provide in terms of human sedentism, seasonal strategies, and territorial use?

Here we present data and interpretations on zooarchaeological assemblages recovered from Early Neolithic Bestansur and Shimshara. The larger and well-stratified assemblage from Bestansur is the primary focus of the chapter, with comparative analysis of the smaller quantity of material from Shimshara. The chapter presents and evaluates key new data on the taxa identified, and skeletal element representation, population demography, and body size where relevant, and discusses this evidence in order to examine the context of changing human–animal–environment relationships in Early Neolithic Southwest Asia associated with the transition to farming and associated changes.

Materials and methodology

Recovery, analysis and materials reported

Animal bones were collected by three different methods: hand-picking during excavation; dry sieving of the excavated sediments using a 4mm mesh; and wet sieving using a 1mm mesh. The resulting 'heavy residue' from wet sieving was sorted by Endecotts sieves into >4mm, 4–2mm and 2–1mm fractions (Chapter 14). Material recovered from the integrated wet sieving and flotation programme typically consisted of 30–50 litres of deposit per context processed by machine-assisted water flotation (see Chapters 2, 14 and 18 for discussion of adjustments to this strategy and details of strategic sampling).

This report analyses material from undisturbed Neolithic contexts, with later, mixed contexts (containing intrusive material), and contexts of uncertain date excluded here. All faunal remains recovered by hand-excavation, dry sieving and the >4mm fraction from wet sieving are recorded. Faunal material recovered from the >1mm and >2mm fractions was all scanned and diagnostic elements were recorded. This size fraction largely pertains to bird, fish, herpetofauna and mammalian microfauna, as expected (Meadow 1980). The decision not to record the total >1mm and >2mm fraction of the heavy residue is based on the observation in the material that it provides limited taphonomic data, which when present generally replicates the better-quality data from the >4mm fraction, as observed at Çatalhöyük (Russell and Martin 2005: 34).

The quantity of materials generated and recorded from Neolithic layers at Bestansur and Shimshara is presented in Tables 15.1–15.2 and Figures 15.1–15.2. The larger quantity of material generated from Bestansur (Table 15.1) is the primary focus of the current chapter, with the smaller assemblage from Shimshara acting as a regional comparison for this material, slightly separated as it is in time, space and environmental context, by *c*. 110km. To a large degree the quantities of faunal remains recovered from the different trenches at Bestansur reflect the size and extent of archaeological investigation in these areas (Chapter 9), with the largest assemblages by both number and weight deriving from Trenches 7, 9, and 10 (Fig. 15.1; Table 15.1). A relatively high proportion by number of fragments is also recovered from Trenches 12 and 13, though not by weight, representing a greater range of smaller material recovered via the wet sieving sampling programme. The excavation at Shimshara constituted a more limited programme of excavations, consisting of two trenches and a quantity of material recovered from section cleaning and sampling (Table 15.2). The relatively large size of fragments recovered from the section cleaning can be seen in the high weight to fragment count ratio (Fig. 15.2).

Table 15.1. Numbers of bone fragments (NISP) recovered by hand picking, dry sieving and wet sieving from Bestansur.

Trench	*Dry sieved*	*Wet sieved*	*Hand recovered*	*Total*
1	4	98	12	114
2	7	29	106	142
4	47	414	44	505
5	–	22	13	35
7	149	1891	658	2698
8	7	159	14	180
9	181	1939	569	2689
10	681	3516	2247	6444
11	–	181	–	181
12	82	2949	182	3213
13	51	1982	60	2093
Total	1209	13,180	3905	18,294

Table 15.2. Numbers of bone fragments (NISP) recovered by hand picking, dry sieving and wet sieving from Shimshara.

Trench	*Dry sieved*	*Wet sieved*	*Hand picked*	*Total*
1	45	925	409	1379
2	192	1826	215	2233
Section	89	–	300	389
Total	326	2751	924	4001

Where possible, faunal remains were identified in the field during the excavation season. Any materials that could not be identified in the field were exported for identification against modern osteological reference collections. In the field, faunal remains were identified to animal class and were weighed and quantified by number of fragments (Figs 15.3 and 15.4).

Assessment of these data indicates that large mammals produced by far the bulk of the assemblage, by number of fragments and by weight, indicating a dietary and economic focus on these taxa. Similarities in the structure of the data from both Bestansur and Shimshara indicate similarities in the animal economies of the two sites. Here we present studies on the different subsets of the recovered material according to zoological classification and human-animal relationships (large mammals, fish, bird, small mammals, and so on). Specific details of analytical methodologies are articulated in the relevant subsections below.

Preservation and taphonomy

The assemblages were scored for general conditions of preservation (excellent, good, fair, and poor) and

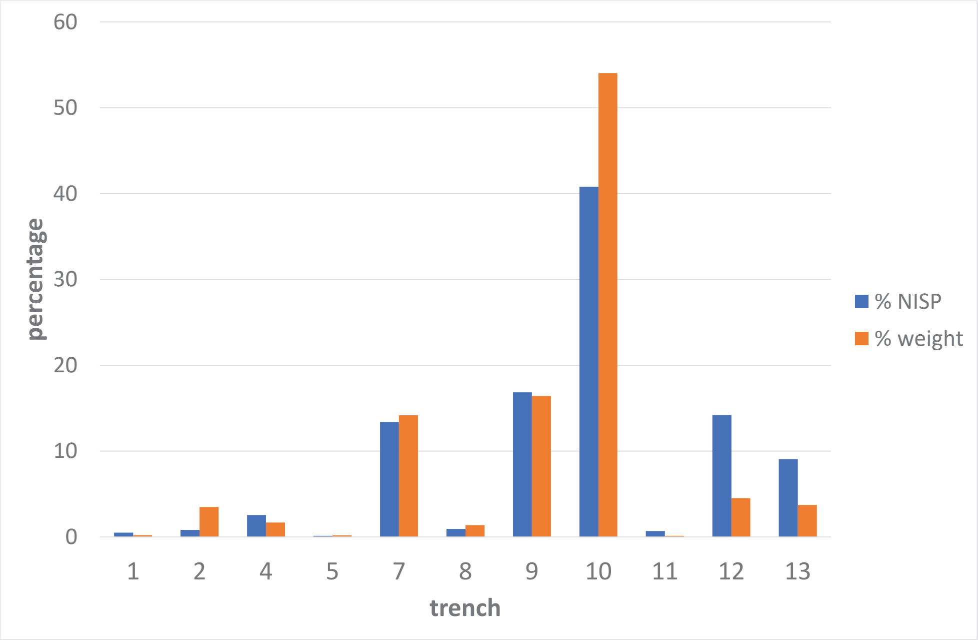


Figure 15.1. Animal bones from Bestansur by trench by NISP and weight.

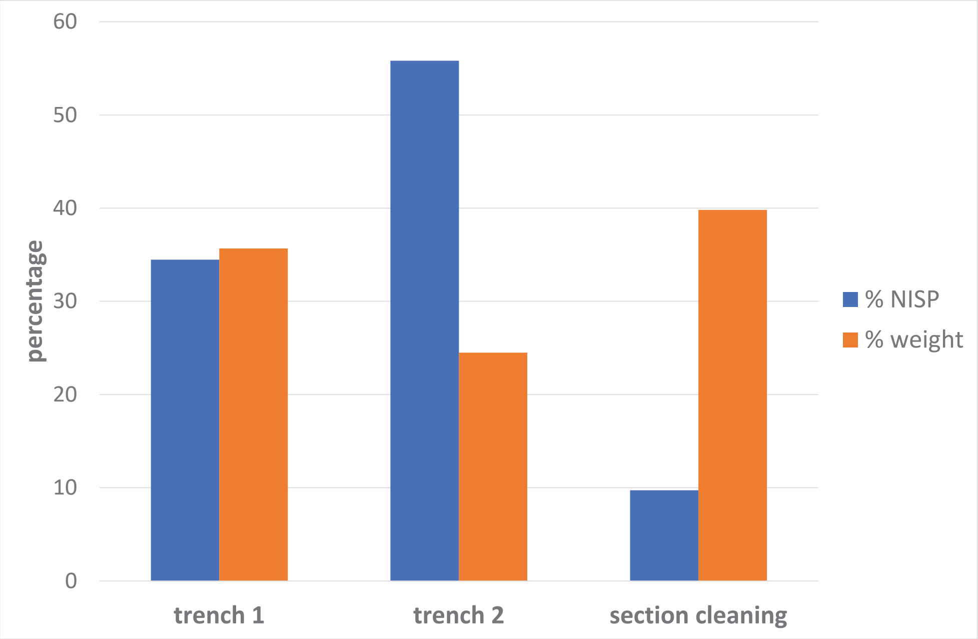


Figure 15.2. Animal bones from Shimshara by trench by NISP and weight.

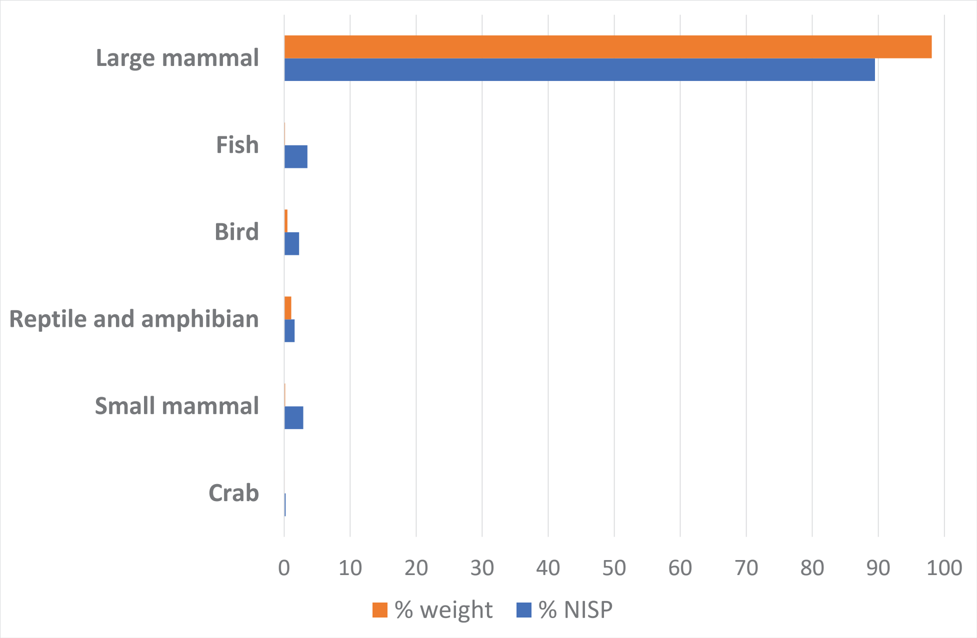


Figure 15.3. Recovery of different types of animal remains from Bestansur, by % NISP and % bone weight.

broad taphonomic characteristics (battered, rounded, spikey, and variable; O'Connor 1991: 234–235). The latter was assessed in order to distinguish between those contexts where bone fragments retained sharply angular margins to old breaks, those that exhibited a rolled/abraded appearance, and those that exhibited impact pitting/battering.

Overall, the Bestansur assemblage is well preserved, with most of the material exhibiting a good quality of preservation and a 'spikey' appearance (i.e. not abraded). Limestone concretions are variably present on some of the Bestansur material, with the high and fluctuating local water table likely being responsible for depositing this material on the bones. The Bestansur material also presents variable evidence for black-staining (manganese), which can closely resemble patches of carbonisation from burning and causes some uncertainty in identifying burning. The material from Shimshara exhibits a slightly better state of preservation than that recovered from Bestansur. The quality of preservation of the animal bones recovered was very good, with material

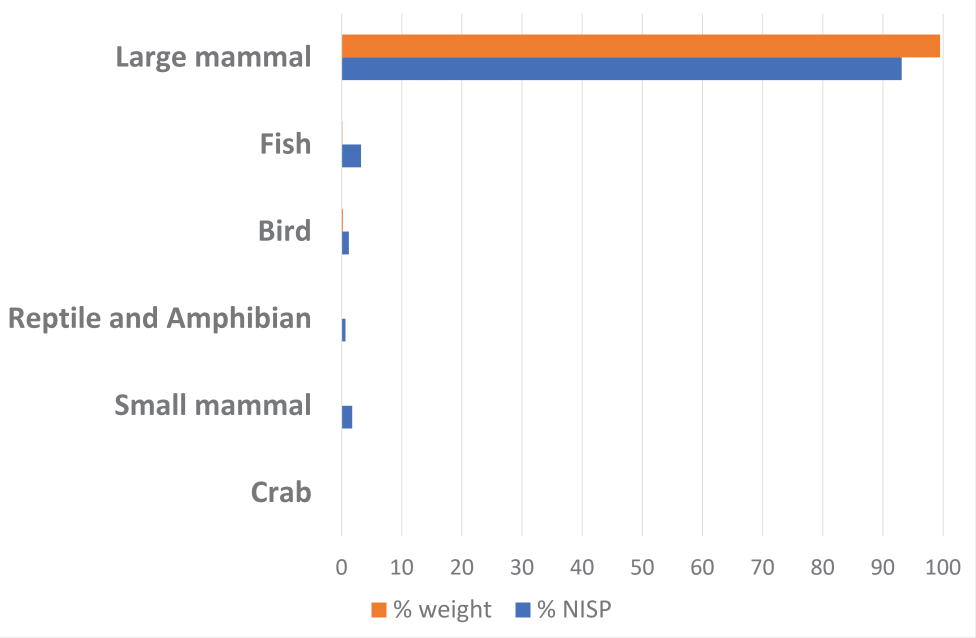


Figure 15.4. Recovery of different types of animal remains from Shimshara, by % NISP and % bone weight.

Table 15.3. Bestansur large mammal by NISP and bone weight (g).

Large mammal	*NISP*	*Weight (g)*
Bos	11	470.9
Cervus elaphus	54	1472.3
Cervid-large	30	236.2
Cattle-size indeterminate	336	2179.9
Sus scrofa	166	1868.9
Dama dama	1	4.3
Pig-size indeterminate	110	429.5
Ovis	55	1057
Ovis/Capra	203	1135.2
Capra	24	236.4
Capreolus capreolus	4	42.9
Gazella	23	111
Sheep-size indeterminate	2430	4111.9
Vulpes vulpes	9	13
Lepus	5	1.4
Martes	1	0.1
Castor fiber	1	11.2
Carnivore-medium	14	24.1
Hare-size indeterminate	87	42.1
Indeterminate	12809	2956
Total	16373	16,404.2

tending to receive scores of either excellent or good for all contexts. Bone fractures also exhibited 'spikey' appearances, suggestive of relatively quick burial and limited post-depositional taphonomic attrition of the sample. Further taphonomic details are included below, where relevant.

Large mammals

The recording system for the mammal remains is largely based on the protocols used at Çatalhöyük by Russell and Martin (2005: 34–38). The bones were identified to species or genus where possible with the aid of standard published protocols (Boessneck 1969; Schmidt 1972; Prummel and Frisch 1986; Lister 1996; Halstead and Collins 2002; Zeder and Lapham 2010; Zeder and Pilaar 2010). Material that could not be identified in the field was exported for verification against modern osteological reference collections. Animal-size classes have also been assigned to specimens that could not be identified to a more precise classification, such as species or genus. The following list of animal-size categories detail the typical taxa that they represent (following Russell and Martin 2005): cattle-size (cattle, red deer); pig-size (pig, fallow deer, small equid); sheep-size (sheep, goat, gazelle, roe deer, dog/wolf); hare-size (hare, fox, mustelids). The material is quantified by the bone weight of fragments, the number of identified specimens (NISP), and the number of diagnostic zones (DZ) (Watson 1979; Russell and Martin 2005).

Relative frequencies of main taxa at Bestansur and Shimshara

Tables 15.3 and 15.5 present breakdowns of the number of fragments and weight of large mammal bone fragments from Bestansur and Shimshara. Material identified to species or genus level is presented in Tables 15.4 and 15.6 by NISP, weight and diagnostic zone count.

At Bestansur, caprines (sheep and goat) are the most common taxon by all quantification measures, followed by pig/boar, then red deer. Of the bones specifically identified to sheep or goat, 70% (55/79)

Table 15.4. Bestansur large mammal remains identified to species or genus by number of fragments (NISP), diagnostic zone (DZ) count and weight (g).

Species or genus	*NISP*	*DZ*	*Weight (g)*	*% NISP*	*% DZ*	*% weight*
Bos	11	4	470.9	2	2.7	7.3
Cervus elaphus	54	18.5	1472.3	9.7	12.3	22.9
Sus scrofa	166	24	1868.9	29.8	15.9	29.1
Dama dama	1	0	4.3	0.2	0	0.1
Ovis	55	38.5	1057	9.9	25.5	16.5
Ovis/Capra	203	41.5	1135.2	36.4	27.5	17.7
Capra	24	8.5	236.4	4.3	5.6	3.7
Capreolus capreolus	4	3	42.9	0.7	2	0.7
Gazelle	23	6.5	111	4.1	4.3	1.7
Vulpes vulpes	9	4.2	13	1.6	2.8	0.2
Lepus	5	1.2	1.4	0.9	0.8	0
Martes	1	0	0.1	0.2	0	0
Castor fiber	1	1	11.2	0.2	0.7	0.2

Table 15.5. Shimshara large mammal by NISP and bone weight (g).

Taxa	*NISP*	*Weight (g)*
Bos	9	241
Cervus elaphus	3	133.6
Cervid-large	4	22.8
Cattle-size indeterminate	67	506.2
Sus scrofa	163	1533.5
Dama dama	6	80.4
Pig-size indeterminate	37	111.5
Ovis	28	500.4
Capra	21	273.1
Ovis/Capra	37	303.1
Capreolus capreolus	4	19.1
Gazella	2	27.3
Sheep-size indeterminate	600	1268.8
Vulpes vulpes	3	3.6
Carnivore-medium	1	0.1
Lepus	1	0.9
Lagomorpha	1	0.1
Hare-size indeterminate	18	9.4
Indeterminate	2721	640.5
Total	4001	5703.6

are identified to sheep by NISP and 82% (38.5/47) by diagnostic zone count, implying that 70–80% of the material identified to the level of sheep/goat in fact represents sheep. The bone weight of remains positively identified to sheep is less than that identified to pig or red deer (both larger-bodied animals), but a significant portion of the bone weight of material identified to sheep/goat likely represents sheep which would equate to a similar bone weight as represented by pig (Table 15.4). If bone weight is broadly proportional to usable meat weight (Uerpmann 1970), this would imply that sheep and pig may have contributed similar quantities to the diet, although more sheep were consumed.

At Shimshara, by far the most common taxon by every measure is pig/boar, followed by caprines (Table 15.6). Of the bones specifically identified to sheep or goat, 57% (28/49) are identified to sheep by NISP and 41% (8.5/20.5) by diagnostic zone count, implying that around half of the material identified to the level of sheep/goat likely represents sheep.

Table 15.6. Shimshara large mammal remains identified to species or genus by number of fragments (NISP), diagnostic zone (DZ) count and weight (g).

Taxa	*NISP*	*DZ*	*Weight (g)*	*% NISP*	*% DZ*	*% weight*
Bos	9	2	241	3.2	3.3	7.7
Cervus elaphus	3	1	133.6	1.1	1.6	4.3
Sus scrofa	163	23	1533.5	58.6	37.6	49.2
Dama dama	6	5	80.4	2.2	8.2	2.6
Ovis	28	8.5	500.4	10.1	13.9	16.1
Capra	21	12	273.1	7.6	19.6	8.8
Ovis/Capra	37	5	303.1	13.3	8.2	9.7
Capreolus capreolus	4	1	19.1	1.4	1.6	0.6
Gazelle	2	1.5	27.3	0.7	2.5	0.9
Vulpes vulpes	3	2	3.6	1.1	3.3	0.1
Lepus/Lagomorpha	2	0.2	1	0.7	0.3	0
Total	278	61.2	3116.1	100	100	100

Sheep are over-represented in the NISP count by a number of fragmentary horn cores from an uncertain number of specimens (NISP = 18; weight = 359.4g). The diagnostic zones count therefore can be taken as a more accurate representation of the presence of goat relative to sheep (Table 15.6; Fig. 15.5).

The high proportion of pig (*Sus scrofa*) bones at Shimshara is particularly notable. This proportion is higher than in other contemporaneous assemblages from the Central Zagros region (Bökönyi 1977; Hesse 1978; Stampfli 1983; Bendrey *et al*. 2013), and may in part be related to the particular local ecological conditions of the site, located in the catchment of the Lesser Zab river system. This issue will be discussed further below.

Caprines (sheep and goat)

Caprines – sheep (*Ovis aries*, *O. orientalis*) and goat (*Capra hircus*, *C. aegagrus*) – are the most numerous taxonomic group at Bestansur and the second most numerous at Shimshara. They are considered here together given the difficulties of distinguishing the taxa. Amongst the caprine material examined from Bestansur, a significant portion of the material (72.2% by NISP; 46.2% by diagnostic zone counts) could only be identified to sheep/goat. At Shimshara, these values are 43% by NISP and 18% by diagnostic zone counts. If we take the diagnostic zone count as the most accurate representation of relative importance, then we have sheep to goat ratios of 4.5:1 at Bestansur and 1.4:1 at Shimshara (Tables 15.4 and 15.6; Fig. 15.5).

Body-part representation and butchery

The distribution of caprine skeletal parts at Bestansur shows that elements from throughout the skeleton are present suggesting that whole carcasses were likely being brought onto the site and processed (Tables 15.7 and 15.8). Combining sheep, goat, and sheep/goat together suggests that the pattern of element representation may be linked to well-known attritional processes (Lyman 1994), where the less robust and smaller elements are preferentially destroyed (Tables 15.7 and 15.8). Evidence for butchery was recorded on a range of skeletal elements: a few fragments show evidence for dismemberment and filleting, but most evidence relates to limb bones and phalanges fractured to extract marrow and grease. The numbers of some skeletal elements may be under-represented due to such fragmentation. Also, straight-sided limb bones, such as the metatarsal, may be under-represented as a product of bone bead or other artefact manufacture (Chapter 21).

Although the evidence from Shimshara is more limited, most areas of the body are also represented (Tables 15.9 and 15.10). In the NISP data, there is an indication that head elements are relatively well-represented suggesting that the excavated area may have incorporated primary butchery areas. A small number of caprine limb bones had been fractured while fresh, for marrow.

Metrical analysis

The bodies of goats exhibit sexual dimorphism and comparisons of bone measurements can be used to

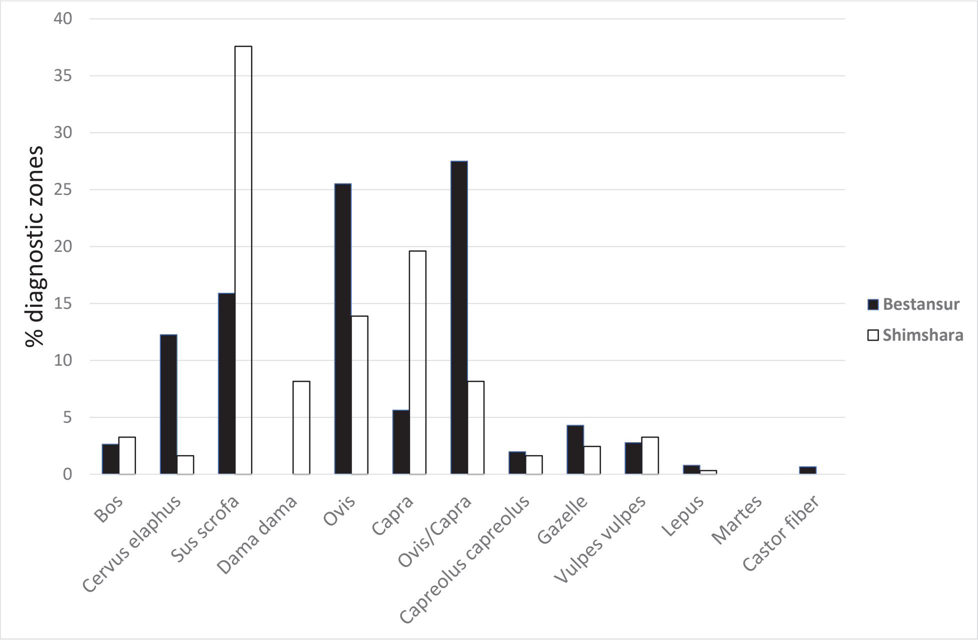


Figure 15.5. Comparison of material identified to species and genus from Bestansur and Shimshara by diagnostic zone (DZ) counts.

Table 15.7. Bestansur: skeletal element representation by fragment count (NISP).

	Ovis/Capra	*Ovis*	*Capra*	*Sus scrofa*	*Cervus elaphus*	*Gazella*	*Bos*	*Capreolus capreolus*	*Dama dama*	*Vulpes vulpes*	*Lepus*	*Castor fiber*	*Martes*
cranial fragment	9	2	1	16	3	3	0	0	0	0	0	0	0
mandible	9	5	6	16	3	1	0	0	0	1	1	0	0
loose teeth	63	7	7	48	1	8	2	0	0	2	0	0	1
vertebrae	10	1	0	4	2	0	2	0	0	1	0	0	0
scapula	3	1	0	16	2	0	0	1	0	0	0	0	0
humerus	5	2	0	2	2	0	0	0	0	1	0	0	0
radius	14	6	0	4	3	0	0	1	0	0	0	0	0
ulna	7	3	0	6	2	1	2	0	1	0	0	0	0
carpal	13	0	0	5	1	0	0	0	0	0	0	0	0
pelvis	4	0	0	2	1	0	2	0	0	2	1	1	0
femur	3	1	0	3	1	0	0	0	0	1	1	0	0
patella	2	0	0	1	0	0	0	0	0	0	0	0	0
tibia	9	0	1	6	4	0	1	0	0	0	0	0	0
fibula	0	0	0	4	0	0	0	0	0	0	0	0	0
os malleolare	1	0	0	0	0	1	0	0	0	0	0	0	0
astragalus	1	8	0	1	0	0	0	0	0	0	0	0	0
calcaneus	4	3	0	3	1	0	0	0	0	0	0	0	0
central+fourth tarsal	3	0	0	0	1	2	0	0	0	0	0	0	0
metacarpal	9	8	1	4	4	0	0	2	0	0	0	0	0
metatarsal	11	3	0	3	6	2	2	0	0	0	0	0	0
metapodial	2	1	1	7	2	3	0	0	0	0	0	0	0
first phalanx	8	2	7	3	5	1	0	0	0	1	2	0	0
second phalanx	9	1	0	1	5	1	0	0	0	0	0	0	0
third phalanx	4	0	0	2	1	0	0	0	0	0	0	0	0
lateral phalanx	0	0	0	9	0	0	0	0	0	0	0	0	0
sesamoid	0	0	0	0	4	0	0	0	0	0	0	0	0
Total	203	54	24	166	54	23	11	4	1	9	5	1	1

explore the different ratios of smaller females and larger males in archaeological samples (Zeder 2001; 2008). Due to the modest sample size from Bestansur, log-size index (LSI) values (Meadow 1999) have been calculated to enable comparisons to be drawn from a range of elements using the standard animal published by Uerpmann and Uerpmann (1994; based on averaged measurements of male and female *Capra aegagrus* from the Taurus Mountains). LSI values are shown in Figure 15.6. The data are positively skewed (skewness = 0.5809165; kurtosis = 1.022045; mean = –0.03609049) – a distribution with the tail extending further to the right of the mean (Fig. 15.6). This distribution is consistent with a managed herd, where there is focus on the retention of females, as demonstrated in the survey of population profiles in Arbuckle and Atici (2013). Comparison of individual measurements in the Bestansur material to element size ranges shown in Zeder (2001) for modern and archaeological animals from the Zagros confirms the interpretation that females dominate this population, and thus it is likely a managed herd based on the inferred sex-profile.

Like goats, sheep skeletons are also sexually dimorphic, although to a lesser degree (Davis 2000; Zeder 2008; Arbuckle and Atici 2013). The analysis of osteometrical data from archaeological sheep populations can be used to explore the relative ratios of males and females in samples (Zeder 2008; Arbuckle and Atici 2013). For the Bestansur assemblage, log-size index (LSI) values (Meadow 1999) have been calculated using a modern wild male sheep from Kermanshah, Iran, as a standard (Zeder 2008, 263), to standardise comparisons between different elements. These are shown in Fig. 15.7. All measurements listed by Zeder (2008: fig. 10) were used. The data are negatively skewed (skewness = –0.3142228; kurtosis = –0.4904807), a distribution with the tail extending further to the left of the mean (Fig. 15.7). This distribution compares well with the assemblages surveyed and analysed by Arbuckle and Atici (2013) interpreted as caprine hunting, i.e. ones which are focussed more on the larger males.

The greatest quantity of measurements from a single sheep element type at Bestansur derive from the astragalus (Fig. 15.8). When we compare the

Table 15.8. Bestansur: skeletal element representation by diagnostic zone (DZ) count.

	Capra	*Ovis*	*Ovis/Capra*	*Bos*	*Gazella*	*Lepus*	*Cervus*	*Sus*	*Castor*	*Capreolus*	*Vulpes vulpes*
Maxilla	0	1	0	0	1	0	0	3	0	0	0
Mandible	4	4	0	0	1	1	0	1	0	0	1
Atlas	0	0	0	0	0	0	0	0	0	0	0
Axis	0	0	0	1	0	0	0	0	0	0	0
Sacrum	0	0	0	0	0	0	0	0	0	0	0
Scapula	0	1	1	0	0	0	2	2	0	1	0
Proximal humerus	0	0	0	0	0	0	0	0	0	0	0
Distal humerus	0	1	2	0	0	0	2	1	0	0	1
Proximal radius	0	4	1	0	0	0	0	1	0	0	0
Distal radius	0	1	1	0	0	0	1	2	0	1	0
Ulna	0	3	1	1	1	0	2	3	0	0	0
Radial carpal	0	0	4	0	0	0	1	1	0	0	0
Intermediate carpal	0	0	1	0	0	0	0	2	0	0	0
Ulnar carpal	0	0	0	0	0	0	0	0	0	0	0
Second and third carpal	0	0	5	0	0	0	0	0	0	0	0
Fourth carpal	0	0	1	0	0	0	0	0	0	0	0
Proximal metacarpal	0	5	2	0	0	0	2	1	0	1	0
Distal metacarpal	1	2	2	0	0	0	1	0	0	0	0
Pelvis	0	0	3	1	0	0	0	0	1	0	1
Proximal femur	0	1	0	0	0	0	0	0	0	0	1
Distal femur	0	0	0	0	0	0	0	0	0	0	0
Patella	0	0	1	0	0	0	0	0	0	0	0
Proximal tibia	0	0	1	0	0	0	2	0	0	0	0
Distal tibia	1	0	1	0	0	0	1	0	0	0	0
Os malleolare/ distal fibula	0	0	0	0	1	0	0	0	0	0	0
Calcaneus	0	3	2	0	0	0	0	1	0	0	0
Astragalus	0	8	1	0	0	0	0	1	0	0	0
Central + fourth tarsal	0	0	3	0	2	0	1	0	0	0	0
Proximal metatarsal	0	1	1	0	0	0	0	1	0	0	0
Distal Metatarsal	0	2	0	1	0	0	0	0	0	0	0
First phalanx	2.5	0.5	2	0	0.5	0.2	1.5	0.5	0	0	0.2
Second phalanx	0	0	2.5	0	0	0	1.5	0.5	0	0	0
Third phalanx	0	0	1	0	0	0	0.5	1	0	0	0
Total	8.5	37.5	39.5	4	6.5	1.2	18.5	22	1	3	4.2

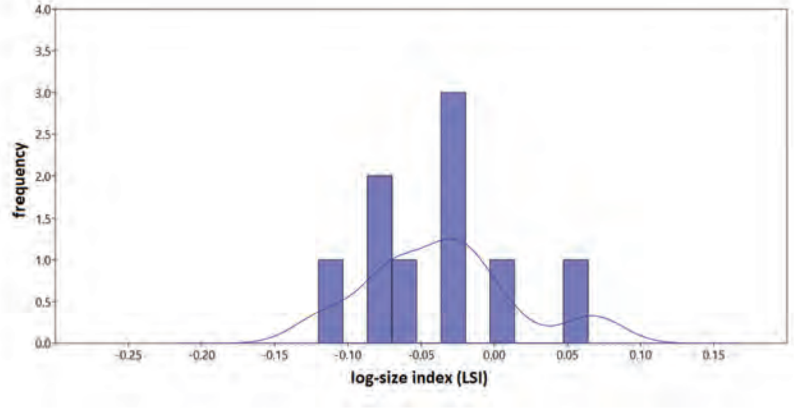


Figure 15.6. Distribution of log-size index (LSI) values calculated from Bestansur goat measurements relative to a standard animal published by Uerpmann and Uerpmann (1994; averaged measurements of male and female Capra aegagrus from the Taurus mountains). Kernel density estimation curves show a smooth estimator of the histogram (PAST version 3.25).

Table 15.9. Shimshara: skeletal element representation by fragment count (NISP).

	Sus scrofa	*Ovis/Capra*	*Ovis*	*Capra*	*Bos*	*Dama dama*	*Capreolus capreolus*	*Cervus elaphus*	*Gazella*	*Lepus* incl lagomorpha	*Vulpes vulpes*
antler	0	0	0	0	0	0	1	0	0	0	0
cranial fragment	22	6	18	3	3	0	0	0	0	0	0
mandible	23	2	0	5	0	0	0	0	1	0	0
loose teeth	37	12	1	1	0	0	2	1	0	0	0
vertebrae	4	2	1	0	0	0	0	0	0	1	0
scapula	17	4	1	0	0	0	0	1	0	0	0
humerus	4	3	2	1	0	0	1	0	0	0	0
radius	7	0	0	3	1	0	0	0	0	0	2
ulna	1	0	0	1	1	0	0	0	0	0	0
carpal	1	1	0	0	1	0	0	0	0	0	0
pelvis	10	1	0	0	0	1	0	0	0	0	0
femur	4	1	0	0	1	0	0	0	0	0	0
tibia	3	0	2	0	0	1	0	0	0	0	0
fibula	3	0	0	0	0	0	0	0	0	0	0
astragalus	0	0	0	3	0	0	0	0	0	0	0
calcaneus	2	0	1	2	0	0	0	0	0	0	0
tarsal	1	0	0	1	0	0	0	0	0	0	0
metacarpal	3	4	1	0	1	1	0	0	0	1	1
metatarsal	4	0	0	1	0	1	0	1	0	0	0
metapodial	4	1	0	0	1	0	0	0	0	0	0
first phalanx	4	0	1	0	0	2	0	0	0	0	0
second phalanx	1	0	0	0	0	0	0	0	1	0	0
third phalanx	3	0	0	0	0	0	0	0	0	0	0
lateral phalanx	5	0	0	0	0	0	0	0	0	0	0
Total	163	37	28	21	6	6	4	3	2	2	3

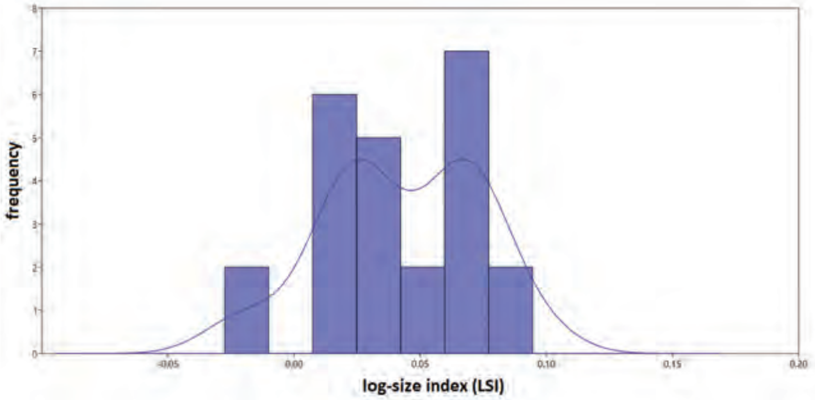


Figure 15.7. Distribution of log-size index (LSI) values calculated from Bestansur sheep measurements relative to a modern wild male sheep from Kermanshah, Iran, as a standard (Zeder 2008, 263; astragalus Bd; humerus Bd; 1st phalanx GL; tibia Bd; metacarpal Bd; metatarsal Bd; radius Bp; radius Bd). Kernel density estimation curves show a smooth estimator of the histogram (PAST version 3.25).

distribution of the mean and range of these values with other sites in the EFC published by Zeder (2008: appx 2), the data from Bestansur plot with the assemblages identified as wild hunted populations, as at Asiab and Ganj Dareh, being larger than the smaller bodied domestic populations identified at the later settlement levels at Jarmo and Sarab. This picture likely reflects a chronological change in emphasis

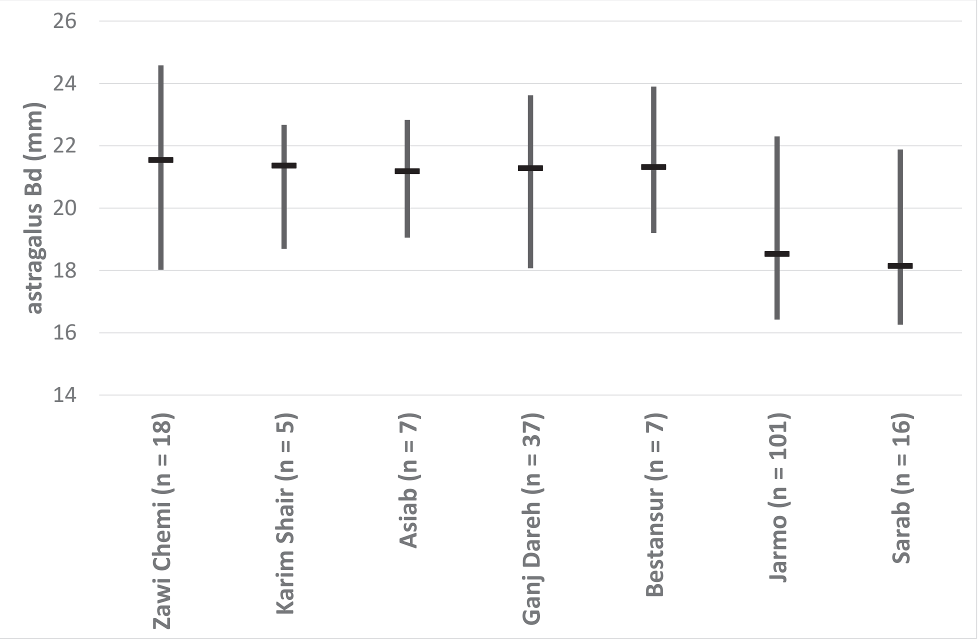


Figure 15.8. Sheep astragalus distal breadth (Bd) measurements (mm) – mean and range (Bestansur compared to other sites in the EFC published by Zeder (2008: appx 2)).

from larger males at Bestansur, Asiab and Ganj Dareh to smaller females at Jarmo and Sarab, but might also include a degree of size reduction through time associated with the domestication process in addition to a change in sex ratios.

Cull patterns

For Bestansur, caprine postcranial epiphyseal fusion data are shown in Table 15.11. Including the sheep/goat data with the sheep calculation (as most sheep/goat remains likely represent this species) suggests that most animals lived beyond the first few years. This pattern indicates no particular focus on a young cull that might be associated with a managed herd, although the sample size is modest. Caprine tooth eruption and wear data are too limited to provide a detailed demographic profile of either sheep or goats. A single shed goat milk tooth (dP_2) was recorded from Bestansur (Trench 7 C1094 SA174). Recovery of such finds if occurring in higher numbers and densities could be seen as evidence of penning (Brochier *et al.* 1992). At Shimshara, two caprine (goat/sheep) post-cranial remains were identified as of late foetal age (following Prummel 1989). This evidence suggests that either domestic animals were being husbanded on site, or pregnant wild animals had been hunted and brought back to the settlement.

Health and disease

Pathological remains are rare in the material excavated. One notable example is a left goat mandible from C1653 at Shimshara (Fig. 15.9). In this specimen, the loss of the opposing M^2 has resulted in the M_2 (distal column) and M_3 (mesial column) being significantly less worn. Although we cannot draw firm conclusions from a single specimen, studies of pathology in large samples can indicate changes in the environment, demography, and use of animals through time and can potentially make valuable contributions to understanding of early domestic animal husbandry and animal health and living conditions (Bendrey 2014a; 2014b).

In addition to direct evidence of pathology, understanding the nature and frequency of human–animal interactions can also contribute potential insights into past health experiences such as the ecology of infectious diseases, an important outcome associated with the emergence of farming (Pearce-Duvet 2006). Epidemiological models can be used to generate hypotheses about factors promoting the circulation and maintenance of pathogens within past populations. Following this approach, mathematical simulation models have been developed and fitted to reconstructed Neolithic domestic goat populations to explore the potential for the emergence of zoonotic brucellosis in the Central Zagros region (Fournié *et al.* 2017). The models indicate that the causative pathogen of brucellosis (*Brucella*) could have been sustained, even for low levels of transmission, in small populations that lie within the likely ranges estimated for these early farming settlements. This was due to the creation of dense domestic goat populations, and also the decisions made by early goat farmers on the demographic composition of their herds. It is difficult, given the available demographic data from Bestansur and Shimshara to apply this approach

Table 15.10. Shimshara: skeletal element representation by diagnostic zone (DZ) count.

	Sus scrofa	*Capra*	*Ovis*	*Ovis/Capra*	*Capreolus capreolus*	*Bos*	*Cervus elaphus*	*Dama dama*	*Gazella*	*Lepus*	*Vulpes vulpes*
Maxilla	1	0	0	0	0	0	0	0	0	0	0
Mandible	4	3	0	0	0	0	0	0	1	0	0
Atlas	0	0	0	0	0	0	0	0	0	0	0
Axis	0	0	1	0	0	0	0	0	0	0	0
Sacrum	0	0	0	1	0	0	0	0	0	0	0
Scapula	5	0	1	2	0	0	1	0	0	0	0
Proximal humerus	0	0	0	0	0	0	0	0	0	0	0
Distal humerus	1	1	2	1	1	0	0	0	0	0	0
Proximal radius	1	0	0	0	0	0	0	0	0	0	1
Distal radius	1	1	0	0	0	0	0	0	0	0	1
Ulna	1	0	0	0	0	0	0	0	0	0	0
Radial carpal	0	0	0	0	0	0	0	0	0	0	0
Intermediate carpal	0	0	0	0	0	1	0	0	0	0	0
Ulnar carpal	0	0	0	0	0	0	0	0	0	0	0
Second and third carpal	1	0	0	0	0	0	0	0	0	0	0
Fourth carpal	0	0	0	0	0	0	0	0	0	0	0
Proximal metacarpal	0	0	1	0	0	0	0	0	0	0	0
Distal metacarpal	0	0	0	0	0	1	0	1	0	0.2	0
Pelvis	2	0	0	1	0	0	0	1	0	0	0
Proximal femur	1	0	0	0	0	0	0	0	0	0	0
Distal femur	0	0	0	0	0	0	0	0	0	0	0
Patella	0	0	0	0	0	0	0	0	0	0	0
Proximal tibia	0	0	1	0	0	0	0	0	0	0	0
Distal tibia	0	0	1	0	0	0	0	1	0	0	0
Os malleolare/distal fibula	0	0	0	0	0	0	0	0	0	0	0
Calcaneus	1	2	1	0	0	0	0	0	0	0	0
Astragalus	0	3	0	0	0	0	0	0	0	0	0
Central + fourth tarsal	0	1	0	0	0	0	0	0	0	0	0
Proximal metatarsal	1.5	1	0	0	0	0	0	0	0	0	0
Distal Metatarsal	0	0	0	0	0	0	0	1	0	0	0
First phalanx	0.5	0	0.5	0	0	0	0	1	0	0	0
Second phalanx	0.5	0	0	0	0	0	0	0	0.5	0	0
Third phalanx	1.5	0	0	0	0	0	0	0	0	0	0
Total	23	12	8.5	5	1	2	1	5	1.5	0.2	2

Figure 15.9. Left goat mandible from Shimshara (C1653). Loss of the opposing M_2 has resulted in the M_2 (distal column) and M_3 (mesial column) being significantly less worn (projecting up ~10mm from the occlusal line).

Table 15.11. Bestansur and Shimshara caprine postcranial epiphyseal fusion data (fusion ages from Zeder 2006).

				Ovis/Capra			Ovis			Capra		
	Age class	*Age (months)*	*Element*	*Unfused*	*Fusing*	*Fused*	*Unfused*	*Fusing*	*Fused*	*Unfused*	*Fusing*	*Fused*
Bestansur	A	0–6	prox radius	0	0	1	0	0	4	0	0	0
			Total	0	0	1	0	0	4	0	0	0
	B	6–12	distal scapula	0	0	0	0	0	1	0	0	0
			distal humerus	0	0	2	0	0	2	0	0	0
			Total	0	0	2	0	0	3	0	0	0
	C	12–18	prox phalanx 1	0.5	0	0.5	0	0	0	1	0	1.5
			prox phalanx 2	0	0.5	1.5	0	0	0	0	0	0
			Total	0.5	0.5	2	0	0	0	1	0	1.5
	D	18–30	distal tibia	0	0	1	0	0	0	0	0	1
			distal metacarpal	1	0	1	0	0	2	0	0	1
			distal metatarsal	0	0	0	0	0	2	0	0	0
			calcaneus	0	0	0	0	0	1	0	0	0
			Total	1	0	1	0	0	5	0	0	1
	E	30–48	prox femur	0	0	1	0	0	0	0	0	0
			prox tibia	0	0	1	0	0	0	0	0	0
			distal femur	0	0	1	0	0	0	0	0	0
			distal radius	0	0	0	0	0	1	0	0	0
			Total	0	0	3	0	0	1	0	0	0
Shimshara	A	0–6	prox radius	0	0	0	0	0	0	0	0	1
			Total	0	0	0	0	0	0	0	0	1
	B	6–12	distal humerus	1	0	0	0	0	1	0	0	1
			Total	1	0	0	0	0	1	0	0	1
	C	12–18	prox phalanx 1	0	0	0	0	0	0.5	0	0	0
			Total	0	0	0	0	0	0.5	0	0	0
	D	18–30	distal tibia	0	0	0	0	0	1	0	0	0
			distal metapodial	1	0	0	0	0	0	0	0	0
			calcaneus	0	0	0	1	0	0	0	0	1
			Total	1	0	0	1	0	1	0	0	1
	E	30–48	prox tibia	0	0	0	0	0	1	0	0	0
			distal femur	1	0	0	0	0	0	0	0	0
			distal radius	0	0	0	0	0	0	1	0	1
			Total	1	0	0	0	0	1	1	0	1

Table 15.12. Pig/boar epiphyseal fusion data (fusion ages from Lemoine et al. 2014).

			Bestansur				*Shimshara*			
Elements fusing	*Age class*	*Age (months)*	*Unfused*	*Fusing*	*Fused*	*% Fused/ fusing*	*Unfused*	*Fusing*	*Fused*	*% Fused/ fusing*
Scapula	D	7–8	0	0	2		1	0	4	
P. Radius	D	7–8	0	0	1		0	0	1	
	D	Total	0	0	3	100	1	0	5	83
2 Phalanx	E	8–18	0	0	0.5		0	0	0.5	
D. Humerus	E	8–18	0	0	1		0	0	1	
	E	Total	0	0	1.5	100	0	0	1.5	100
1 Phalanx	F	18–24	0	0	0.5		0	0.5	0	
D. Tibia	F	18–24	0	0	2		0	0	0	
	F	Total	0	0	2.5	100	0	0.5	0	100
Calcaneus	H	36–48	0	0	1		0	0	0	
P. Femur	H	36–48	0	0	0		1	0	0	
	H	Total	0	0	1	100	1	0	0	0
D. Radius	I	48–60	2	0	0		0	0	1	
	I	Total	2	0	0	0	0	0	1	100

here. Further, goats appear to have been a relatively minor component of the human diet, based on relative abundance, and whether they were maintained in high enough numbers to support the disease is currently unclear, although connections with the regional metapopulation may have enabled this scenario. Key risk factors for the spread of brucellosis to humans from livestock reservoirs include direct contact, as would occur during regular interactions between herders and their animals, and also through consumption of dairy products (Bendrey *et al.* 2020). There are also other risk factors for infection that may be relevant for the Early Neolithic communities under study here. It is known, for example, that the pathogen can survive in dung for up to seven weeks (Wallach *et al.* 1997), and the collection and processing of dung as fuel, as extensively attested at Bestansur and Shimshara (Chapters 12 and 16) could therefore have acted as an additional infection pathway to humans.

Pig

Pig remains are relatively well represented at both Bestansur and Shimshara, likely reflecting the favourable local conditions of both settlements close to water sources with associated vegetation such as banks of reeds and rushes.

Body-part representation and butchery

At both Bestansur and Shimshara all parts of the body are present, indicating that whole animals were being processed on site. The NISP data indicate that heads are reasonably well represented (Tables 15.7 and 15.9), and an under representation of hind limb bones seems to be present in the diagnostic zone data (Tables 15.8 and 15.10) although these elements are not absent from the assemblage. Butchery evidence observed in the Bestansur assemblage primarily relates to fragmentation of limb bones for marrow and grease extraction, and there is a single example of disarticulation cut marks where a humerus and ulna were separated. There is a limited amount of butchery evidence from the Shimshara pig bones, primarily characterised by marrow and grease extraction but also some evidence for dismemberment.

Metrical analysis

We can compare the Bestansur and Shimshara pig evidence with data from Asiab dated to the tenth millennium BC (Bangsgaard *et al.* 2019) and Ceramic Neolithic Jarmo dated to the early to mid-seventh millennium BC (Price and Arbuckle 2015). The samples from Asiab are identified as wild boar (Bangsgaard *et al.* 2019), whilst those from Ceramic Neolithic Jarmo include a significant proportion of domestic animals (Price and Arbuckle 2015; Price and Evin 2017). Figure 15.13 compares metrics from elements for which comparable data are published for both Asiab and Jarmo. These include lower M_2 WP and lower M_3 L. For the humerus, radius and tibia, where multiple measurements were recorded from a single specimen, the mean LSI value was used for the comparison in Fig. 15.10. In order to standardize comparisons between different elements, log-size index (LSI) values (Meadow 1999) have been calculated using the Kizilcahamam wild boar as a standard (Payne and Bull 1988). It is clear that in terms of both teeth and postcranial element size, the eighth millennium BC pigs from Bestansur and Shimshara were equivalent in size, if not larger than, the Asiab wild boar (Fig. 15.10) and can therefore be characterised as morphologically wild.

Cull patterns

Pig postcranial epiphyseal fusion data from Bestansur are shown in Table 15.11, indicating primarily older pigs at Bestansur. Beyond the fusion data, there are very few immature fragments of pig recorded in the assemblage. The data are more limited from

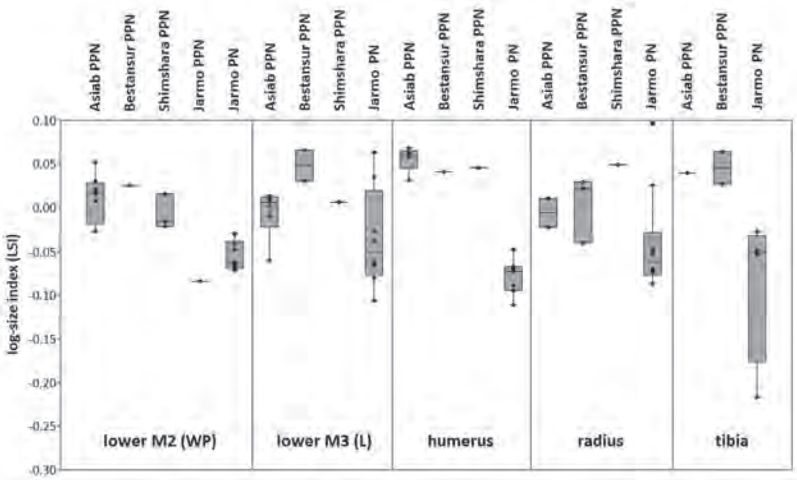


Figure 15.10. Distribution of log-size index (LSI) values (Meadow 1999) calculated from pig measurements relative to the Kizilcahamam wild boar as a standard (Payne and Bull 1988). These include lower M_2 WP and lower M_3 L. For the humerus, radius and tibia, where multiple measurements were recorded from a single specimen, the mean LSI value was used.

Shimshara, but younger animals <1 year are present in the assemblage (Table 15.12). Two foetal pig bones are also recorded in the Shimshara assemblages, one each from C1648 (Trench 1) and C1659 (Trench 2), suggesting the presence of pregnant females on site, which could either be from a breeding, early managed herd or from hunted wild sows. Canine morphology varies between male and female pigs/wild boars (Mayer and Brisbin 1988). Within the Bestansur assemblage, considering just lower dentition, one male mandible is recorded and one loose female canine. Within the Shimshara assemblage, one mandible (with no teeth) is recorded as male, and single loose male and female canines are also recorded. Collectively this is not enough to draw conclusions on potential status and management of the animals, but does indicate both sexes as being present.

Other taxa

A range of other taxa are represented by smaller numbers of skeletal elements (Tables 15.7 and 15.9). For Bestansur, this range includes red deer (*Cervus elaphus*), gazelle (*Gazella subgutturosa*), cattle (*Bos primigenius*), roe deer (*Capreolus capreolus*), fallow deer (*Dama dama*), fox (*Vulpes vulpes*), hare (*Lepus* spp.), beaver (*Castor fiber*) and marten (*Martes* spp.). For Shimshara, the range includes red deer, gazelle, cattle, roe deer, fallow deer, fox and hare.

At Bestansur, red deer are represented by 54 fragments (DZ = 18.5) from across different areas of the skeleton, indicating that whole animals were likely being brought back to the site. These numbers are slightly inflated by an articulating foot (NISP = 7; DZ = 2). The latter was found in articulation and represents discard from during primary butchery of the animal (SF79 C1220, Trench 7). Notably, extensive pathology is visible on this specimen with new bone deposition on the medial and lateral sides of the metacarpal and proximal phalanges, also extending onto the posterior surfaces of these elements, perhaps from a longstanding infection (Fig. 15.11).

This pathology raises a number of interesting potential implications. Firstly, was the animal compromised by this pathology and therefore easier to catch? The second aspect is that despite the presence of pathology, one of the first phalanges was broken open for marrow and therefore any visible sign of disease does not appear to have put off the butcher from using these elements for food or other uses. A range of butchery modifications are noted from the red deer material. In total, 14 fragments have been broken for marrow/grease extraction, of which four are first and second phalanges. Disarticulation cut marks were noted on two specimens: a mandible and a metatarsal. Marrow from phalanges may have been preferred for its better taste, because of its relatively high content of unsaturated fatty acids (Morin 2007; Jin and Mills 2011). Red deer is less well represented at Shimshara, providing only 1.6% of identified remains by diagnostic zone counts (Fig. 15.5).

At Bestansur, gazelle is represented by 23 fragments from across the body, but only by two fragments at Shimshara. The specimens probably represent *Gazella subgutturosa*. At Bestansur, burning on a mandible may be associated with marrow/grease extraction. A metatarsal and metapodial fragment exhibit saw marks, where they have been used for artefact manufacture.

Cattle bones are not common at either site, with 11 fragments recorded from Bestansur and nine from Shimshara (Tables 15.7 and 15.9). Fox is also represented at both sites, with nine recovered fragments from Bestansur and three from Shimshara.

Figure 15.11. Pathological red deer foot (Bestansur SF79 C1220 Trench 7).

Figure 15.12. Beaver pelvis (Bestansur C1550 Trench 10).

Although a modest sample size, elements are present from across the body at Bestansur, with burning (carbonisation) recorded on the caput of a femur fragment, potentially suggesting roasting. In addition to red deer, deer species are also represented by roe deer and fallow deer in small numbers at each site. A small number of fragments of hare are recorded from Bestansur and Shimshara (Tables 15.3 and 15.5), two of which exhibit burning at the former site. At Bestansur, a single fragment of pelvis represents beaver (Fig. 15.12) and a single loose tooth derives from a marten.

Interpretation

Regional contextualisation of large mammal taxa

The first point for discussion relates to which taxa were domestic. Assessment of the caprine metrical data suggests that the sheep at Bestansur were wild and the goats domestic. This interpretation agrees with the existing narrative for the archaeological sequence in the Central Zagros, which sees the earliest evidence for managed goats in the upland zones around 8000 BC, with the introduction of domestic sheep happening in the Later Neolithic from further north (Zeder 2008). The pigs from Bestansur and

Shimshara are morphologically wild (Fig. 15.10), which does not, however, mean that they were not under an early form of management. There is evidence, for example, for omnivore coprolites from a range of contexts across the site (Chapters 12, 13 and 16). Although GC-MS analyses indicate that some of these are human in origin, at least one is of suid origin (Chapter 16), and there are a few potential other indicators such as the perinatal bones at Shimshara to highlight the possibility of early pig management, which needs future investigation.

The second issue for discussion relates to how the data on taxonomic representation relates to the regional picture from other sites. Table 15.13 compares the representation of identified taxa from Bestansur and Shimshara with a selection of other sites in the region. This comparison employs the data published in the original analyses of these sites, although there has been some reanalysis of material indicating differences in species proportions than those first published. Zeder (2008: table 4), for example, has published re-analyses of sheep, goat and gazelle data, but other taxa are not included and it is difficult to combine the datasets from different publications on the same sites, so the earlier published analyses are used in Table 15.13 and Figure 15.13 with caveats. The comparison employs published fragment count data (NISP). It compares all material identified to species or genus from the large- and medium-sized mammal categories, which includes those animals providing the bulk of the meat to the human diet and also those species domesticated in Southwest Asia (Zeder 2011). No assumption or inference is made here in relation to the wild or domestic status of the taxa. The logic behind the following consideration of the quantitative data is that the ecological characteristics of the wild and early domestic populations of the same species are likely similar (Grigson 2007; Bendrey 2011; Conolly *et al.* 2013). This analysis also makes an adjustment to the data in terms of the material identified as sheep/goat (*Ovis*/*Capra*). As discussed above, sheep and goats have very similar skeletons (Zeder and Lapham 2010; Zeder and Pilaar 2010), and it is often the case that disarticulated and fragmented bones of these species are not separated during archaeological analysis. As a relatively high proportion of sheep and goat remains can end up being classified as sheep/goat, then comparison of just those remains recorded to species level using published fragment counts can significantly under-estimate the representation of these species relative to other species. Here, those remains identified to 'sheep/goat' are re-apportioned to 'sheep' and 'goat' according to the ratio of the identified bones to these two taxa in the total assemblage. Table 15.13 also includes calculations of the relative proportions of the mammalian taxa exploited at Early Neolithic Bestansur and Shimshara following the same procedure as above, which

Table 15.13. Regional comparison of large mammal taxa (%NISP).

Site (phase)	*Regional setting*	Bos	Cervus elaphus	Capra	Ovis	Sus scrofa	Gazella	Dama dama	Capreolus capreolus	Equus hemionus	*NISP*	*Reference*
Bestansur	piedmont	2.03	10.0	15.8	36.3	30.7	4.3	0.2	0.7	0.0	541	–
Shimshara	piedmont	3.30	1.1	13.5	18.0	59.7	0.7	2.2	1.5	0.0	273	–
Karim Shahir	piedmont	5.50	0.0	7.4	68.7	11.7	6.7	0.0	0.0	0.0	163	Stampfli 1983
East Chia Sabz	piedmont	1.32	0.0	28.7	64.9	3.0	2.1	0.0	0.0	0.0	531	Darabi *et al.* 2011
Qermez Dere	steppe	0.90	0.0	0.0	6.3	0.0	92.5	0.0	0.0	0.2	1269	Dobney *et al.* 1999
Nemrik (I-III)	steppe	3.30	1.1	2.6	11.6	7.6	73.9	0.0	0.0	0.0	92	Lasota-Moskalewska 1994
Nemrik (IV)	steppe	35.40	0.0	5.9	8.3	9.0	41.4	0.0	0.0	0.0	268	Lasota-Moskalewska 1994
Nemrik (V)	steppe	46.40	0.9	4.7	8.8	12.8	26.3	0.0	0.0	0.0	1720	Lasota-Moskalewska 1994
M'lefaat	steppe	1.50	0.0	0.0	37.9	5.3	55.3	0.0	0.0	0.0	132	Turnbull 1983
Sheikh-e Abad (I)	highland	0.00	0.0	79.5	20.5	0.0	0.0	0.0	0.0	0.0	22	Bendrey *et al.* 2013
Sheikh-e Abad (II)	highland	6.50	0.0	63.0	23.9	2.2	0.0	0.0	4.3	0.0	46	Bendrey *et al.* 2013
Asiab	highland	6.50	38.2	24.8	10.8	18.6	0.1	0.4	0.0	0.5	751	Bökönyi 1977
Ganj Dareh	highland	0.6	0.2	87.8	10.2	1.1	0.0	0.0	0.0	0.0	27,517	Hesse 1978

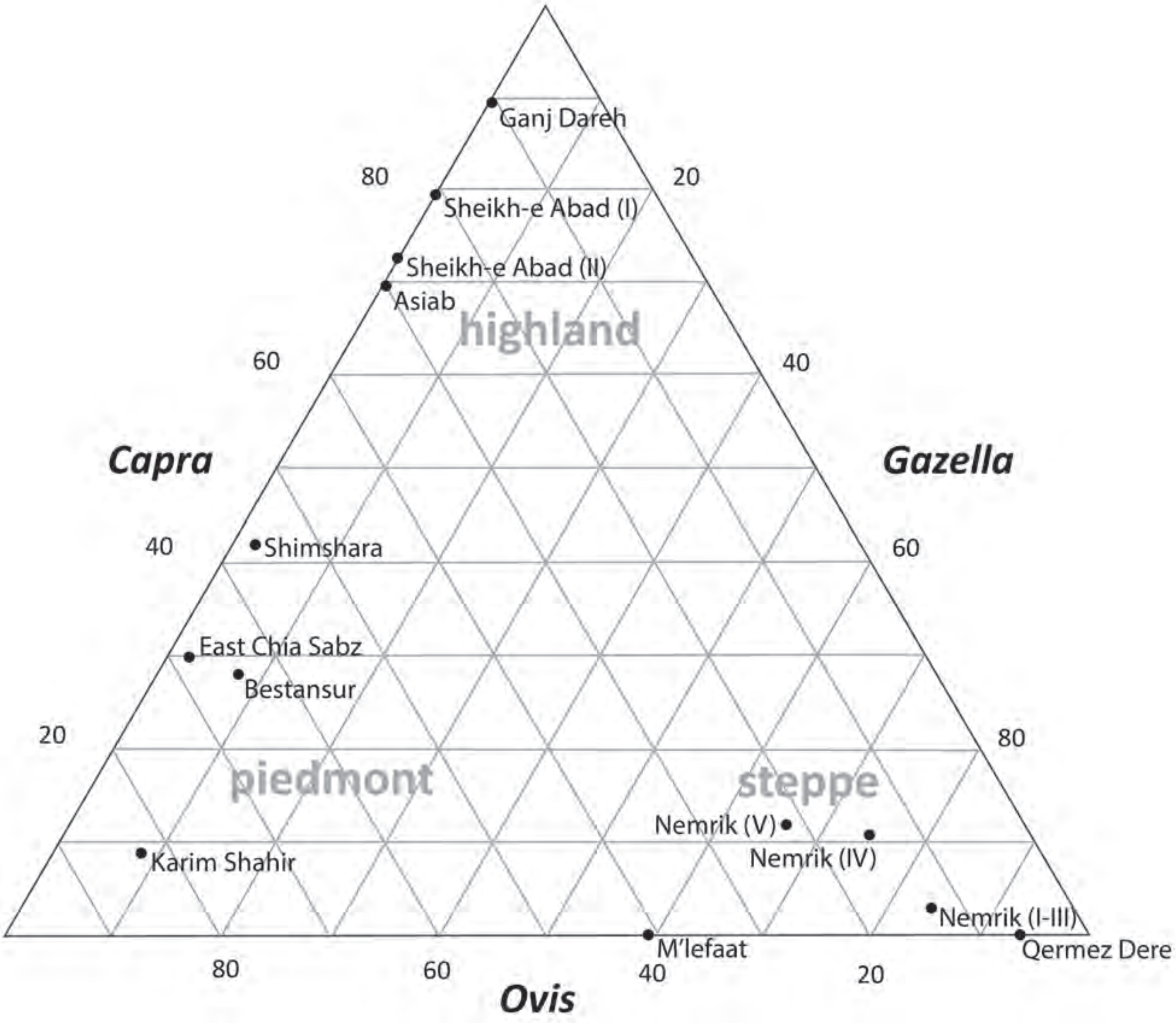


Figure 15.13. Relative proportions of goat, sheep and gazelle from Bestansur and Shimshara compared to some regional sites (NISP; see text for adjustments).

indicates sheep as the most common taxon, followed by pig and then goat. Relating this pattern to broadly contemporaneous regional assemblages provides a context for understanding the animals represented. A number of features can be drawn out from this summary data set.

The first reflection is that, in the regional setting, gazelle, goat and sheep proportions generally reflect the relationship between these taxa and variation in environments. Plotting the relative proportions (by NISP) of gazelle, goat and sheep together separates the sites according to the environmental/landscape context (Fig. 15.13).

This pattern agrees with the known ecological preferences of these three animals. Wild bezoar goats (*Capra aegagrus*) are adapted to rocky substrates and steep slopes, habitats where their morphology enables them the agility to escape predators (Korshunov 1994; Weinberg 2001; Shams *et al*. 2010). Although they are predominantly found in mountain ranges, they are not only restricted to high altitudes and can be found from sea-level to >4km asl (Korshunov 1994). Extant populations of Asiatic mouflon (*Ovis orientalis*) inhabit moderately to very arid habitats and particularly grasslands, including mountains, foothills and rolling steppes (Bashari and Hemami 2013). They prefer open pastures as they escape predators by running away (Heptner *et al*. 1961: 931; Bashari and Hemami 2013). The habitat preferences of wild sheep and goats mean that there is minimal competition for food resources between the two animals (Korshunov 1994). It would also be expected for the wild taxa to follow seasonal movements throughout the year to make use of available resources at different altitudes (Korshunov 1994; Shams *et al*. 2010). Goitered gazelles (*Gazella subgutturosa*) are predominantly grazers and inhabit a broad range of semi-desert and desert habitats, preferring steppe areas, especially plains and adjacent hill slopes, and also gently rolling or terraced deserts with firm soils (Heptner *et al*. 1961: 618; Martin 2000; Hemami and Groves 2001; Mallon 2008; Farhadinia *et al*. 2009).

The second reflection is the notably high representation of pig/boar at Shimshara within the context of the EFC data, followed by that at Bestansur (Table 15.13). Grigson (2007) summarises previously published information on environmental tolerances of pigs. At temperatures of 30°C or more, pigs have to drink every day and at temperatures above 35–36°C they can quickly die without shade or ability to wallow. Given the regional seasonal highs in temperature of the direct summer sun, which exceed 30–36°C, rising to *c*. 40–50°C at Bestansur today, pigs would clearly favour areas with shade and water. It may thus be argued that the local environments of Shimshara particularly, but also at Bestansur, offered local ecological conditions that favoured pigs. Grigson (2007) reviewed the representation of pig bones at sites around the Fertile Crescent for the fifth to the third millennia BC. She identified that the geographical distribution of sites with significant numbers of pigs was almost entirely dependent on rainfall, only being in areas moist enough to support at least dry farming. The latter area is that within which the cultivation of wheat and barley is possible without irrigation, identified as demarcated by 200–400ml annual rainfall. Beyond this area, apart from moist micro-ecological areas, cultivation is not possible without irrigation. The representation of pigs (as a percentage of sheep, goat, cattle and pig) at the Neolithic sites, all of which are located within the area of dry farming identified by Grigson, are broadly comparable with Grigson's fifth millennium BC data except for Shimshara, where pigs are more strongly represented. This issue is discussed further below.

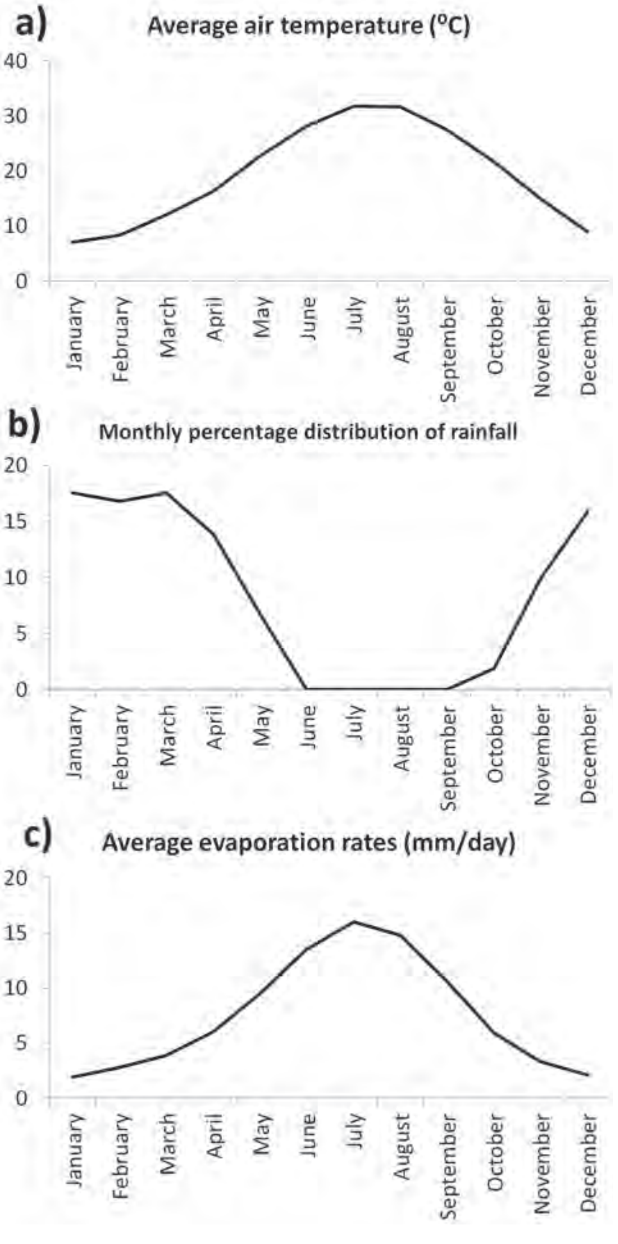


Figure 15.14. Seasonal variation in the climate of Iraqi Kurdistan: a) average air temperature (°C) for Erbil (1959–1972) (Haddad et al. 1975 cited in Maran and Stevanovic 2009); b) annual monthly percentage distribution of rainfall (1941–1975) (typical data for the annual distribution of rainfall in Iraqi Kurdistan, no location given: Maran and Stevanovic 2009: 24); c) average evaporation rates (mm/day) for Erbil (1966–1973) (Haddad et al. 1975 cited in Maran and Stevanovic 2009).

Animals in a spatially and seasonally varying landscape

The Central Zagros has a semi-arid climate with a strong continental component causing significant seasonal fluctuations in temperature and rainfall (Fig. 15.14; Maran and Stevanovic 2009) which can provide another context for considering wild and domestic animal ecology in the past (Bendrey *et al*. 2016; 2011).

Seasonality of reproduction in both goats and sheep under natural conditions in subtropical, middle and high latitudes is regulated by environmental variables, particularly photoperiod, but also other factors such as available nutrition (Donet *et al*. 1982; Chemineau *et al*. 1988; Martin *et al*. 1994; Amoah *et al*. 1996). In his study of Southwest Asian sheep and goat husbandry, Redding (1981: 91) states that in wild goats (*Capra aegagrus*), the rut generally lasts through August, September and October, with kidding running through January, February and March. Modern unimproved regional goat breeds – the Mountain, Damascus and Negev – also kid from January to March (Epstein and Herz 1964; cited in Redding 1981: 91). The timings given by Redding are also in agreement with the latitudinal transect in seasonality indicated by the survey of rutting and birth seasonal timings for wild goats across their range by Weinberg (2001: table 2). Further, a 5 month gestation period is also seen in modern domestic goats

Figure 15.15. New-born lamb suckling from its mother (Zarzi, Sulaimaniyah Province; January 2013).

(Peaker 1978; Amoah *et al*. 1996). Thus, assuming seasonality of the reproductive cycle in early domestic goat populations to be similar to that in the wild goat, we would expect the rut to last August–October with kidding during January–March.

Indicators of seasonality from the caprine zooarchaeological remains are limited, but it is possible to propose season estimates from foetal remains. Assuming the reproduction cycle set out above, the late-stage foetal remains from Shimshara may be assigned to December to March, indicating activity at Shimshara at this time of year. This timing would be the case if either domestic animals were being husbanded on site (e.g. Fig. 15.15) or pregnant wild animals had been hunted and brought back to the settlement. Foetal and neonatal losses in a husbanded population might relate to a number of factors including environmental aspects such as maternal malnutrition and abortifacient pathogens such as *Brucella* spp. (Mellor and Stafford 2004; Givens and Marley 2008; Bendrey *et al*. 2020). Seasonal movements of early livestock would certainly be possible. In recent times, for example, the villagers of modern Bestansur grazed their sheep and goat herds in the nearby limestone foothills for the months during lambing and kidding as there were crops in the fields around the village (Bendrey *et al*. 2016; Chapter 7).

Goitered gazelles migrate seasonally in search of pasture and water across much of their range, with diverse patterns of movement that include animals ascending into foothills and mountain valleys, mainly in spring (Heptner *et al*. 1961: 618; Mallon 2008). These summer migrations are triggered by the desiccation of desert vegetation and locations are determined by the availability of good grazing grounds in close proximity to water sources (Heptner *et al*. 1961: 623–624). Warm-season pasture locations are abandoned with the arrival of significant snows, as goitered gazelles are poorly adapted to living in such environments as their narrow hooves make it difficult to forage for food under the snow (Heptner *et al*. 1961: 625; Martin 2000). Given the location of Bestansur and Shimshara in the western Zagros piedmont, their surrounds may not therefore have been preferred summer or winter location, but were perhaps ones where gazelle would pass through in spring and autumn. The fact that gazelle bones are found in small numbers in the assemblages may also support this speculation.

Fish remains

The site of Bestansur is located near to a major karst aquifer spring head at the base of the Zagros mountains, the second largest on the Shahrizor plan (Saeed Ali 2008: 72–77, fig. 3.2, after Sissakian 2000), which flows year-round. The ensuing local river is relatively small but at about 3km south of the site there is the larger Tanjero river ultimately part of the Diyala and Tigris basins. The Lesser Zab river is located close to the site of Shimshara.

The fish remains were identified by comparison with the modern reference collections housed at the Royal Belgian Institute of Natural Sciences (RBINS). Of each identifiable specimen, the skeletal element and the taxon were recorded and when possible the corresponding fish length was established. Fish bones were attributed to length classes through direct comparison with skeletons of fish of known size. Size was expressed as standard length (SL), i.e. the length from the anterior-most part of the snout to the base of the caudal fin. Information on the taxonomy of species, their distribution, habitat and biology, was taken from Coad (2010), unless stated otherwise.

Table 15.14. Fish remains analysed from Bestansur and Shimshara by NISP.

	Bestansur NISP	*Shimshara NISP*
Acanthobrama cf. *marmid*	1	0
Barbus sp.	1	0
Capoeta sp.	11	0
Cyprinion sp.	1	0
Squalius sp.	6	0
Cyprinidae indet.	421	108
Cobitoidea	2	0
Glyptothorax sp.	2	0
Mastacembelus mastacembelus	1	0
Total identified	446	108
Unidentified fish	161	22

Material

In Table 15.14 a species list is given of the number of fish remains studied. Besides some fragments of unidentifiable fish, the smaller sample from Shimshara yielded only bone of cyprinids none of which could be identified more precisely. At Bestansur four times more fish bone was retrieved during excavation and there as well cyprinids were the major group represented. Twenty of these cyprinids could be identified beyond family level. The presence of the genus *Acanthobrama* is attested by a pharyngeal plate of a fish that measured 5–10cm SL. This piece has been attributed to *Acantobrama marmid* which is the only species of that genus occurring in Iraq today. Another pharyngeal plate, of a fish measuring 20–30cm SL, has the typical morphology and dentition of the genus *Barbus*, of which at least 11 species are known from the Tigris basin. The presence of the genus *Cyprinion*, of which two species are known from Iraq, is attested by a pharyngeal plate of an individual measuring 5–10cm SL. Also, in the case of *Squalius*, represented in Iraq by *S. cephalus* and *S. lepidus*, all six bones that could be assigned to this genus were pharyngeal plates. Three of them were from fish 10–20cm SL, the three others measured 20–30cm SL. A final taxon identified among the cyprinid remains is the genus *Capoeta*, of which four species have been reported for the Tigris basin. Unlike the cyprinids mentioned above, *Capoeta* is not represented by pharyngeal plates, which are more brittle in this genus. The diagnostic elements are five articulars, four dentaries and two basioccipitals of fish from various sizes: 10–20cm SL (3 specimens), 20–30cm SL (5 spec.) and 30–40cm SL (3 spec.). The size distribution of all cyprinids, identified and unidentified specimens combined, is discussed below. Only five bones were found at Bestansur that are not from cyprinids. Of these, two caudal vertebrae are from loaches, measuring 5–10cm SL, and have been labelled as Cobitoidea. This is a superfamily that includes the families Cobitidae and Balitoridae the systematics of which is still poorly understood. The fish bone assemblage also yielded a dorsal and a pectoral fin spine of a sisorid catfish belonging to the genus *Glyptothorax*, of which several species have been described from the Tigris–Euphrates basins. The catfish bones from Bestansur come from the same context and may have belonged to a single individual of about 10–12cm SL. A precaudal vertebra, belonging to a fish of 20–30cm SL, is the only evidence for the presence of the spiny eel (*Mastacembelus mastacembelus*).

When investigating the spatial distribution of the fish bones, it is not relevant to focus on the sole distribution of taxa because all but five bones are from cyprinids and within this family only 20 out of 549 specimens were identifiable to genus. However, it may be worth verifying the spatial distribution of the various size classes and checking the density of cyprinid occurrence. Table 15.15 and 15.16 present the (calculated) numbers of cyprinids within the various size classes by trench and by space number. These figures are also used to calculate the number of fish bones per unit volume (in fact it is only the cyprinids for which a size reconstruction was possible). Assessment of fish bone density by volume per trench is discussed further below.

Interpretation

As in general in Southwest Asia, information on the exploitation of freshwater fish in the Tigris–Euphrates region is very limited for the Neolithic period (Van Neer *et al*. 2005). Of the seven Neolithic sites in the region with reported fish remains, Early Neolithic M'lefaat is the sole site where systematic sieving was carried out. The ichthyofaunal assemblage consists of more than 300 identifiable bones that give a good impression of the exploited fish, both in terms of species spectrum and targeted sizes. The only other Neolithic site in Southwest Asia with ample published evidence for freshwater fish exploitation is Çatalhöyük (Van Neer *et al*. 2013).

Table 15.15. Bestansur: 'bones' are only cyprinids of which size could be reconstructed; values are corrected for % sample

Trench	*Space*	*No. litres*	*<10*	*10–20*	*20–30*	*30–40*	*40–50*	*Total*	*No. bones/ litre*100*
7	16	48	0	0	1	0	0	1	2.08
7	17	152	0	9	2	32	0	43	28.29
9	28	263	0	15	0	2	2	19	7.22
10	0	104	0	6	2	0	0	8	7.69
10	27	338	0	21	10	6	0	37	10.95
10	29	17	0	8	0	0	0	8	47.06
10	42	41	0	5	1	0	0	6	14.63
10	43	49	0	6	0	0	0	6	12.24
10	44	25	0	1	0	0	0	1	4
10	50	24	0	1	0	0	0	1	4.17
10	51	24	0	0	2	0	0	2	8.33
10	52	50	0	1	0	0	0	1	2
10	53	169	0	9	2	1	0	12	7.1
10	60	21	0	6	1	0	0	7	33.33
12	0	1137	26	301	71	25	1	424	37.29
13	0	415	0	35	14	4	1	54	13.01
13	24	168	0	27	4	2		33	19.64
13	25	453	12	117	22	5	1	157	34.66
13	26	43	0	1	0	0	0	1	2.33
Total		3541	38	569	132	77	5	821	23.19

Fig. 15.16 shows percentages based on these figures.

Table 15.16. Shimshara: 'bones' are only cyprinids of which size could be reconstructed; values are corrected for % sample

Size class in cm	*10–20*	*20–30*	*30–40*	*40–50*	*50–60*	*Total*	*No. litre*	*No. bones/ litre*100*
Trench 1	24	10	6	5	2	47	262	17.94
Trench 2	74	21	16	0	0	111	299	37.12
Total	98	31	22	5	2	158	561	28.16

Fig. 15.16 shows percentages based on these figures.

At M'lefaat, 98% of the fish are cyprinids, while the remaining bones are from *Mastacembelus* (1 bone) and from two catfish species namely *Mystus pelusius* (4 bones) and *Silurus triostegus* (1 bone). Also at Çatalhöyük, cyprinids dominate the assemblage (91%) followed by loaches (9%). There is hence a great similarity in the exploited fish taxa across these geographically distant regions >1500km apart, with a heavy reliance on Cyprinidae, which in terms of biomass are the major family in Southwest Asian freshwaters.

Inter-site differences, however, are observed when the proportions of the various size classes are considered (Fig. 15.16). These differences may be a reflection of the exploited fishing grounds, fishing methods and the season that fishing was practised. The proportions of the different size classes indicated in the figure are based on corrected values that take into account the percentage of the sediment samples that was actually sieved and analysed. The size distributions at Bestansur and Shimshara, where a 2mm sieve was used, are rather similar with the 10–20cm SL class being the most abundant. Shimshara did not yield any bone of fish below 10cm SL which may be due to small sample size. However, despite the lower number of fish bones at Shimshara, this site yielded proportionally more larger fish than Bestansur, doubtless indicative of the site's proximity to the Lesser Zab river. The size range of the cyprinids at M'lefaat is rather similar to Shimshara but there are also a few specimens reaching lengths of 60–70cm SL. The proportions of the various size classes are different from those seen at Bestansur and Shimshara with the mode at size class 30–40cm SL. At M'lefaat a 3mm mesh was used during sieving and it is not excluded that this explains the lower amount of fish in the smaller size classes. In that case fishing practices may have been similar at all three sites. A completely different size distribution is seen at Çatalhöyük where sieving was conducted using a 1mm mesh. Here, however, there are virtually no fish larger than 20cm SL: most of the cyprinids (72%) are less than 10cm long, and the remaining 28% 10–20cm SL. This smallest size class is typical for the exploitation of juveniles and small taxa in shallow waters, and is hardly represented at M'lefaat, Shimshara and Bestansur.

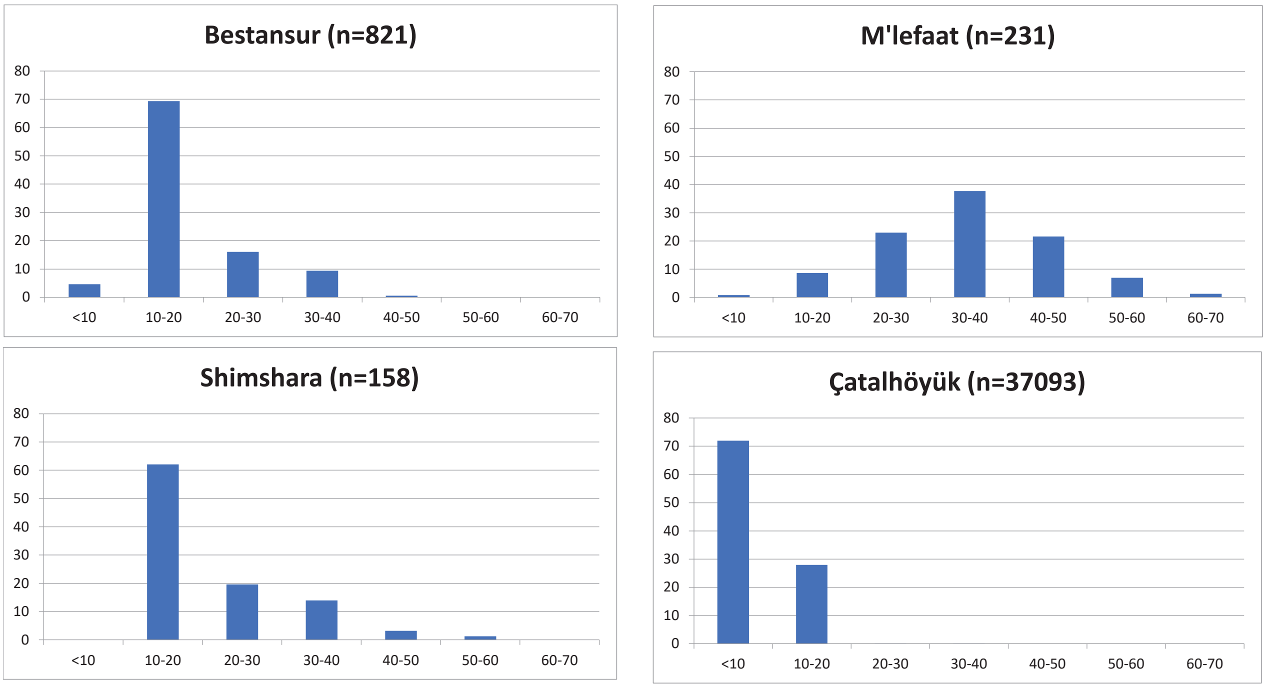


Figure 15.16. Reconstructed sizes of the cyprinids of Shimshara and Bestansur compared to those of M'lefaat and Çatalhöyük. Fish size is expressed as standard length in 10cm classes; n = number of bones on which proportions are calculated.

The archaeological evidence indicates that net fishing took place in the rivers around Bestansur in the Neolithic. Along with isolated examples, two large clusters of deliberately broken, trapezoidal, perforated flat stones were recovered. The presence of net sinkers across the Neolithic settlement, in conjunction with the scattered remains of aquatic taxa demonstrates the important role of the local river in subsistence practices. One deposit contained more than 30 fragmented net sinkers, demonstrating considerable investment in the shaping and drilling of these objects (Chapter 21). Deposits on the surfaces of the sinkers indicate that they were submerged under water for several weeks at a time, perhaps strung across the river, with the fish caught in them periodically collected (Chapter 22). Although fishing may not have provided the calorific returns that hunting of large game could, it clearly played an important role in the diets of the Neolithic inhabitants.

Birds

A small and relatively fragmentary collection of bird remains was recovered from Bestansur and Shimshara. The bird remains were identified using the comparative ornithology skeletal collection at the Natural History Museum in Tring, UK, and analysed by TM and RB. Bones not identifiable to species were identified to the closest taxonomic group possible, e.g. genus, or were allocated to small, medium or large indeterminate bird (Table 15.17). The skeletal elements were recorded following the zoning system of Serjeantson and Cohen (1996).

Table 15.17. Bird remains from Bestansur and Shimshara, by fragment count (NISP).

	Bestansur	*Shimshara*
Anas spp.	5	0
Anas (cf *querquedula/crecca*)	2	0
Duck (Anatidae)	2	1
Grus grus	2	1
Grus	2	0
cf. *Grus*	1	0
Crex crex	1	0
Otis tarda	2	0
Scolopacidae (small wader)	1	0
Alectoris spp.	2	2
Francolinus francolinus	1	0
Alectoris spp./*Francolinus*	3	0
large indet	56	1
medium indet	143	30
small indet	186	40
bird indet	8	0
Total	422	75

Taxa and environments represented

Birds typical of wetland habitats are best represented in the Bestansur assemblage. The ducks are the most common bird group represented (Table 15.17). A variety of sized ducks is represented in the material. The largest is comparable in size with mallard (*Anas platyrhynchos*) and the smallest deriving from

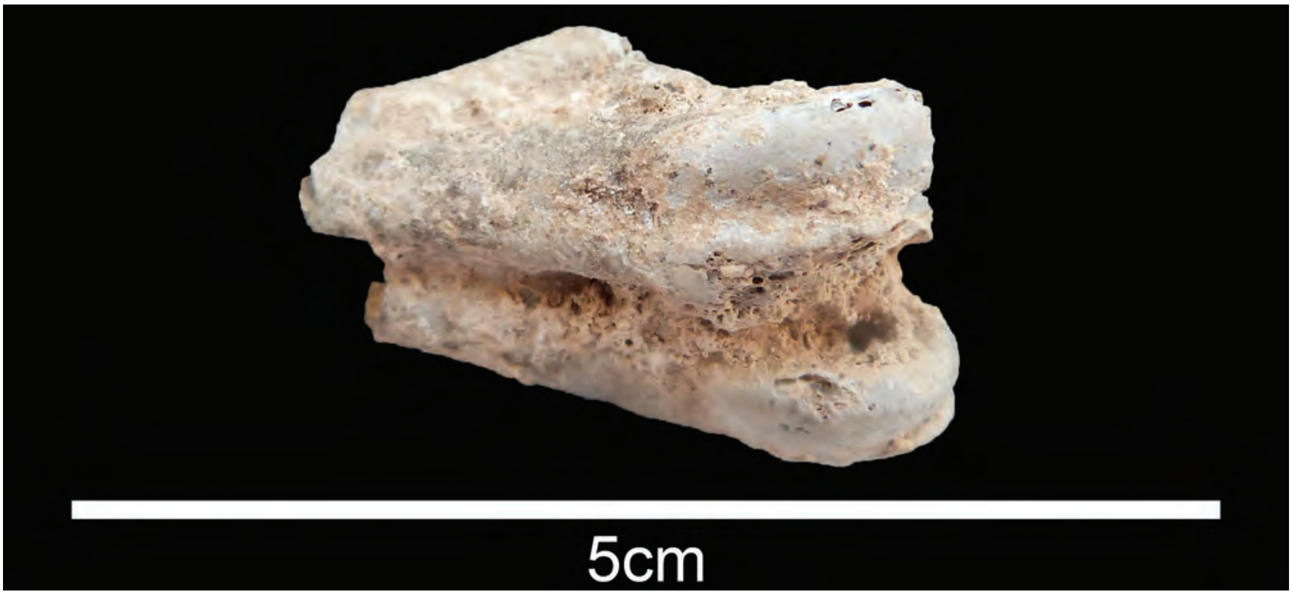


Figure 15.17. Common crane (Grus grus) distal tarsometatarsal (C1675, Trench 10: the fire installation associated with Building 5).

garganey (*A. querquedula*) or teal (*A. crecca*). Diving ducks (*Aythya* spp.) may also be represented but positive identification was not possible on the material. A single duck fragment is also recorded from Shimshara. Also indicative of aquatic habitats is common crane (*Grus grus*) and a single bone of a small wader (Scolopacidae). The common crane is positively identified in both Bestansur and Shimshara assemblages, and three further fragments from Bestansur identified to *Grus* and cf. *Grus* probably also derive from this species. The corncrake (*Crex crex*), whilst being a ground feeding land bird, prefers moist river margins (Cramp *et al*. 1980: 570) and so is also indicative of wetlands.

A smaller proportion of ground feeding birds can be observed in the assemblages. Representative of a more open, steppe habitat are the two fragments of great bustard (*Otis tarda*). *Alectoris* spp. is identified from both Bestansur and Shimshara. Positive identification to species was not made, but three species are currently present in northern Iraq: *Alectoris chukar*, *A. graeca* and *A. rufa*. Black francolin (*Francolinus francolinus*) is also recorded from Bestansur. These taxa would be more representative of open hilly or rocky areas. The ground feeders avoid woodland and forest, and most water-bird species also avoid such areas (Cramp *et al*. 1980; 1977), suggesting that as a whole the birds recorded from Bestansur and Shimshara represent relatively open country with local wetlands and riverine environments.

Body-part distribution and modifications

Some insights may be drawn from the distribution of skeletal elements recorded. Table 15.18 summarises the body-part distribution by taxonomic categories from Table 15.17, with shaded elements indicating the meatier parts (following Russell and McGowan 2012). In the duck and small ground feeding bird categories (*Alectoris* spp. and *Francolinus francolinus*), elements from meaty and non-meaty parts are present, suggesting use of the whole bird for food.

By contrast, the crane bones only derive from non-meaty parts, suggesting that their use was not primarily for human consumption. At other sites in Neolithic Southwest Asia, crane bones often receive special treatment and cranes are depicted in paintings in dance, indicating a close human–crane relationship (Russell 2018). Of the five crane fragments at Bestansur (Tables 15.17 and 15.18), two tarsometatarsal fragments derive from C1675 (Trench 10), the fire installation associated with Building 5 (Fig. 15.17).

Both these crane fragments are heavily calcined and likely derived from the same specimen. A crane ulna shaft from C1351, an external area in Trench 9, has signs of working perhaps indicative of bead manufacture. A tarsometatarsal fragment was recovered from C1248, a mollusc midden in Trench 7, and a carpometacarpus came from C1153 an external area in Trench 9. As Russell (2018) discusses, birds are often seen as spirits or messengers communicating with the spirit world. Given the mortuary significance of Building 5 (Chapter 19; Walsh and Matthews 2018), the context of calcined crane material from C1675 may imply an association of cranes with the spirit world within the context of the disposal and burial of the human dead at Bestansur.

Seasonality

Table 15.19 shows the seasonal movements of the

Table 15.18. Bird body-part distribution. Shaded elements indicate meaty parts, following Russell and McGowan (2012).

		Bestansur						*Shimshara*		
Body zone	*Element*	Anas	Grus	Crex crex	Otis tarda	Scolopacidae	Alectoris/ Francolinus	Anas	Grus	Alectoris
Head	skull	0	0	0	0	0	0	0	0	0
	mandible	0	0	0	0	0	0	0	0	0
Neck	vertebrae	0	0	0	0	0	0	0	0	0
Breast/body	rib	0	0	0	0	0	0	0	0	0
	coracoid	3	0	0	0	0	1	0	0	2
	furcula	0	0	0	0	0	0	0	0	0
	scapula	0	0	0	0	0	0	0	0	0
	sternum	1	0	0	0	0	0	0	0	0
	synsacrum	0	0	0	0	0	0	1	0	0
Wing	humerus	0	0	0	0	1	0	0	0	0
	radius	1	0	0	0	0	0	0	0	0
	ulna	0	1	0	0	0	1	0	0	0
	carpals	0	0	0	0	0	0	0	0	0
	carpometacarpus	4	1	1	0	0	3	0	1	0
	first phalanx, major digit	0	0	0	0	0	0	0	0	0
	minor phalanges	0	0	0	0	0	0	0	0	0
Leg	femur	0	0	0	0	0	0	0	0	0
	tibiotarsus	0	0	0	2	0	2	0	0	0
	tarsometatarsus	0	3	0	0	0	0	0	0	0
Foot	phalanges	0	0	0	0	0	0	0	0	0

positively identified birds from Bestansur and Shimshara with regard to modern northern Iraq (information from Cramp *et al*. 1977; 1980). A number of species are resident throughout the year, including all the species of partridge in the region (*Alectoris* spp.) and black francolin. These birds could have been hunted at any point throughout the year. Of species giving season-specific information, both crane and great bustard are winter visitors to Iraq. The corncrake is a passage migrant in the region, which means they pass through in autumn and spring when moving from Europe further south to warmer regions for the summer months (Cramp *et al*. 1977: 530; 1980: 571). None of the possible identifications of bird taxa refer to species that are summer only visitors. Teal is a winter visitor to the region and garganey is a passage migrant. Together the bird bone assemblage indicates exploitation of these animals in the winter, and possibly the spring and/or autumn.

Table 15.19. Seasonal information for bird remains identified to species or genus for northern Iraq (data from Cramp et al. 1977; 1980).

	Passage migrant	*Resident*	*Winter visitor*
Crex crex	+		
Grus grus			+
Otis tarda			+
Alectoris spp.		+	
Francolinus francolinus		+	

There are three possible species for the identified partridge remains (*Alectoris chukar*, *A. graeca* and *A. rufa*). Although these species are resident throughout the year, they may move around the local region seasonally, flying down from upland regions to avoid the cold and snow of winter (Cramp *et al*. 1980; Afrasiab 2007). Autumn migrations from upland areas in modern birds can be up to 50km (Afrasiab 2007). It may be suggested that whilst the partridge is resident throughout the year they could have been more abundant in the winter months when upland flocks descended to the Zagros foothills and were hunted at this point perhaps when other resources may have been scarcer for the inhabitants of Bestansur and Shimshara. The black francolin is the only species that is resident all year round without moving between upland and lowland, although it prefers lowland plains.

Interpretation

The bird assemblage at Bestansur and Shimshara indicates relatively open country with local wetlands and riverine environments. The seasonality evidence indicates that birds at Bestansur were most likely exploited in the winter months with some being exploited in spring and autumn. Two important resource areas may have been exploited: the nearby spring and surrounding hills. The perennial spring near the mound would have been ideal for the water-birds (Cramp *et al*. 1977). The modern spring is 500m east of the mound and a Neolithic precursor of this spring would likely have been in close proximity, attracting human settlement at Bestansur in the first instance. During the winter months this spring would have been home to various water-birds that the inhabitants of Bestansur could have opportunistically exploited. A similar situation is presented for Shimshara where the Lesser Zab river flows close by the mound. In this respect, the sites are similar to Asiab on the bank of the Kara Su river, which has the highest proportion of water-birds in the region (Bökönyi 1977: 4). A key difference between the assemblages is that duck is dominant at Bestansur whereas geese are dominant at Asiab.

The ground feeding birds, partridge and black francolin, may have been relatively common in the piedmont regions during the winter (Cramp *et al*. 1980) as well as being vulnerable due to their evasion tactics being hampered by the snow and being in flocks, which makes them easier to hunt at this time of year (Menzdorf 1975: 148). Partridge are also particularly well represented at the upland site of Ganj Dareh (Hesse 1978). These ground feeding birds flock together during winter and when disturbed, run away rather than fly (Cramp *et al*. 1980), making it easy to channel such birds into nets. When they do fly, they fly low which means flyways could also be covered with nets (Satterthwait 1986; Serjeantson 2009: 235). Whilst there is no direct way of knowing how the birds were captured, deposits of pierced stones found at Bestansur are most likely fishing net sinkers (see above; Chapter 22), but nets could also have been used to catch ground feeding, low-flying birds such as partridge.

At both Bestansur and Shimshara, the modest size of the bird assemblage indicates that they were a supplementary rather than a primary food resource (Figs 15.3 and 15.4). At Shimshara, the assemblage is too small for firm conclusions to be drawn, but similar, if fewer, taxa are present. In addition to being a food source, there are indications that birds also held symbolic value to the Early Neolithic residents of Bestansur, in line with other sites in Neolithic Southwest Asia (Russell and McGowan 2003; Peters 2005; Russell 2018). Although the assemblage cannot yet support interpretations of the use of feathers or articulated wing-bones from some taxa, the possible association of crane with mortuary ritual in Building 5 suggests an association with the spirit world.

Amphibians and squamate reptiles

The excavations at Bestansur and Shimshara produced amphibian and squamate reptile remains representing at least eight species, analysed by SB and JR. The bone fragments are identified following the osteological criteria given by Böhme (1977) and Bailon (1999) for amphibian anurans, Lécuru (1969) and Bailon (1991) for squamate lacertilians and Bailon (1991) and Szyndlar (1991a; 1991b) for snakes. Comparisons were made using the dry skeleton collections of the Muséum national d'histoire naturelle (MNHN), Paris, France.

The Bestansur assemblage consists of 180 bones, collected in the Neolithic levels of Trenches 1, 2 and 9–13 and representing at least eight species (Table 15.20). The Shimshara assemblage includes 21 bones from Neolithic levels (Trenches 1 and 2). An amphibian anuran and four snakes are present (Table 15.21). The taxa identified include two amphibian anurans (*Bufotes* sp. and *Pelophylax* sp), one lizard (cf. *Eumeces* s.l.) and six snakes (*Eryx* cf. *jaculus*., *Natrix* cf. *tessellata*, cf. *Elaphe sauramates*, cf. *Malpolon insignitus*, cf. *Dolichophis jugularis* and cf. *Macrovipera lebetina*). The remains identified consist of disarticulated and broken bone fragments, essentially vertebrae.

Systematic account and ecological data

The following presents a systematic account of the remains followed by interpretation. Detailed anatomical descriptions are provided as this material represents a first important corpus for understanding past biogeography of these taxa in this region.

Amphibian anurans (frogs and toads)

Anurans are represented by 12 remains, belonging to at least two taxa.

Bufotes sp. and Bufonidae indet. (toads)

Material: Shimshara: *Bufotes* sp.: 1 fragment of left ilium; Bufonidae indet: 2 vertebrae, 1 radius-ulna,1 fragment of a right humerus and a tibio-fibula. Bestansur: Bufonidae indet.: 2 vertebrae and 1 tibio-fibula (Trenches 10 and 12). The ilium (Fig. 15.18A) lacks a dorsal crest, the superior tubercle is low, round and bilobated and a well-developed preacetabular fossa is present. The latter two characters are used to identify the ilium of *Bufotes* clade. Traditionally, the current species of *Bufotes* were included in the *Bufo viridis* group. The vertebrae are procoelous with developed centra and neural arches almost as long as wide. The neural spine is present and thin. The humerus has a slightly curved and relatively thick shaft and the distal condyle is slightly displaced laterally. The tibio-fibulas are shorter than in Ranidae, with a wider central portion and carrying a thin inner ridge. Unfortunately, these elements do not allow a precise specific attribution in the Bufonidae family.

Table 15.20. (continued overleaf) Bestansur amphibians and squamate reptile remains: identifications and distribution.

Trench	*Context*	*Sample*	*Taxon*	*NISP*	*Bone*
1	1006	27	Colubridae s.l. (E)	1	vertebra
	1013	77	*Natrix* cf. *tessellata*	1	vertebra
	1100	84	Colubridae s.l. (M-D)	1	vertebra
2	1028	45	Colubridae s.l.	1	vertebra
	1035	160	Colubridae s.l.	1	caudal vertebra
9	1333	924	Colubridae s.l.	1	vertebra
	1343	1158	Colubridae s.l. (E)	1	vertebra
			Colubridae s.l.	2	vertebrae
			Colubridae s.l.	1	vertebra
	1347	939	Snake	1	caudal-vertebrae
	1350	957	Colubridae s.l.	1	cemtrum vertebra
	1354	950	Colubridae s.l. (M-D)	1	vertebra
	1356	952	Snake	2	vertebrae
			Colubridae s.l.	4	cervical vertebrae
			Colubridae s.l. (M-D)	8	vertebrae
			Colubridae s.l.	3	caudal-vertebrae
			Colubridae s.l. (E)	2	vertebrae
10	1164	277	Anura	1	radio-ulna
	1332	1109	cf. *Macrovipera lebetina*	1	vertebra
			Colubridae s.l.	1	vertebra
	1409	1114	Colubridae s.l.	1	vertebra
	1412	1117	Colubridae s.l.	1	vertebra
			Snake	1	vertebra
		1118	Colubridae s.l.	1	vertebra
	1414	1121	Colubridae s.l.	1	vertebra
			cf. *Macrovipera lebetina*	1	vertebra
			Colubridae s.l.	1	cervical vertebra
	1423	1126	Snake	2	vertebrae
			cf. *Dolichophis jugularis*	1	vertebra
	1550	1447	Anura	1	urostyle
	1554	1449	Colubridae s.l.	1	vertebra
	1555	1453	Snake	1	caudal-vertebra
	1625	1654	Colubridae s.l. (M-D)	1	caudal vertebra
	1627	1656	*Pelophylax* sp.	1	ilium (d)
	1667	1725	Colubridae s.l.	1	cervical vertebra
	1675	1619	Colubridae s.l.	1	caudal vertebra
	1738	1932	*Eryx* cf. *jaculus*	1	centrum vertebra
			Colubridae s.l. (M-D)	1	vertebra
			Bufonidae	1	Tibio-fibula
			cf. *Eumeces* s.l.	1	humerus
	1739	1935	Colubridae s.l.	1	caudal vertebra
	1740	2008	Colubridae s.l.	2	vertebra
			Colubridae s.l.	2	caudal vertebrae
	1749	2010	Colubridae s.l.	1	vertebra
	1751		Colubridae s.l. (M-D)	1	vertebra
	1752	2016	*Eryx* cf. *jaculus*	1	vertebra
			Colubridae s.l.	2	vertebrae
		2019	Colubridae s.l.	3	vertebrae
			Colubridae s.l.	3	caudal vertebra
			Colubridae s.l. (M-D)	3	vertebrae
			Colubridae s.l.	1	caudal vertebra
		2017	cf. *Malpolon insignitus*	10	fragment vertebrae
			Colubridae s.l.	2	caudal vertebrae
	1755	2104	Colubridae s.l.	1	vertebra
			Pelophylax sp.	1	Tibio-fibula
		2105	Colubridae s.l.	2	caudal vertebrae
	1756	2094	Colubridae s.l.	1	vertebra
11	1250	642	Colubridae s.l.	1	caudal vertebra
			Colubridae s.l.	1	vertebra

Table 15.20. (continued from previous page) Bestansur amphibians and squamate reptile remains: identifications and distribution.

Trench	*Context*	*Sample*	*Taxon*	*NISP*	*Bone*
12	1383	1017	Colubridae s.l.	1	vertebra
	1388	1022	Snake	1	vertebra
	1469	1226	Colubridae s.l.	1	vertebra
	1470	1228	Colubridae s.l.	1	vertebra
	1471	1233	Colubridae s.l.	1	vertebra
	1488	1266	Colubridae s.l.	1	vertebra
	1514	1375	Colubridae s.l. (M-D)	1	vertebra
			Bufonidae	1	vertebra-2
	1522	1380	Colubridae s.l.	1	vertebra
	1523	1382	Bufonidae	1	vertebra 5-7
			Colubridae s.l.	4	vertebrae
			Colubridae s.l.	1	caudal-vertebra
			Colubridae s.l.	1	caudal vertebrae
			Snake	6	vertebrae
			cf. *Macrovipera lebetina*	2	vertebrae
		1394	Snake	1	caudal-vertebra
			Colubridae s.l.	2	vertebrae
	1524	1395	Colubridae s.l.	1	vertebra
		1397	Snake	1	centrum vertebra
	1525	1399	Colubridae s.l.	3	vertebrae
			Eryx cf. *jaculus*	1	vertebra
			Colubridae s.l.	1	vertebra
		1401	cf. *Dolichophis jugularis*	1	vertebra
		1403	Colubridae s.l.	1	vertebra
	1526	1408	Snake	1	caudal-vertebra
		1409	Colubridae s.l. (M-D)	1	vertebra
		1412	Colubridae s.l. (M-D)	1	vertebra
	1528	1413	*Eryx* cf. *jaculus*	5	vertebrae
			Eryx cf. *jaculus*	1	cervical vertebra
			Colubridae s.l.	3	vertebrae
			Colubridae s.l.	2	caudal vertebrae
			Colubridae s.l.	1	vertebra
			cf. *Malpolon insignitus*	3	vertebrae
		1424	Colubridae s.l.	1	vertebra
		1429	Colubridae s.l. (M-D)	4	vertebrae
			Colubridae s.l.	1	caudal-vertebra
		1524	Colubridae s.l.	1	caudal-vertebra
	1529	1409	Snake	1	Vertebra
			Eryx cf. *jaculus*	1	Vertebra
13	1375	1002	Colubridae s.l.	2	vertebrae
	1378	1012	Colubridae s.l. (M-D)	2	vertebrae
			Colubridae s.l.	1	caudal vertebra
	1473	1242	Colubridae s.l.	1	vertebra
	1491	1273	Colubridae s.l.	1	vertebra
	1515	1305	Colubridae s.l.	1	vertebra
	1521	1484	Colubridae s.l.	1	vertebra
		1492	*Eryx* cf. *jaculus*	1	ant-caudal-vertebra
	1569	1311	Colubridae s.l.	1	vertebra
			Colubridae s.l.	1	vertebra
	1570	1310	*Eryx* cf. *jaculus*	1	vertebra
	1574	1316	Colubridae s.l.	1	vertebra
	1575	1324	Colubridae s.l.	1	vertebra
	1579	1331	Colubridae s.l.	1	cervical-vertebra
	1580	1494	Colubridae s.l.	1	caudal vertebra
			Eryx cf. *jaculus*	1	vertebra
			Colubridae s.l.	3	vertebrae
	1582	1487	Calubridae s.l.	1	caudal vertebra

Table 15.21. Shimshara amphibians and squamate reptile remains: identifications and distribution.

Trench	*Context*	*Sample*	*Taxon*	*NISP*	*Bone*
1	1637	1660	Colubridae s.l.	2	vertebrae
	1649	1670	*Bufotes* sp.	1	radius-ulna
			Colubridae s.l.	1	centrum vertebra
	1660	1739	Colubridae s.l.	1	caudal vertebra
			cf. *Dolichophis jugularis*	1	vertebra
		1741	Colubridae s.l.	1	cervical vertebra
		1742	*Bufotes* sp.	1	sacral vertebra
	1661	1675	*Bufotes* sp.	1	ilium
			cf. *Dolichophis jugularis*	2	vertebrae
			Colubridae s.l.	2	vertebrae
			Eryx cf. jaculus	1	vertebra fragment
	1664	1678	Colubridae s.l.	1	vertebra
2	1651	1711	cf. *Dolichophis jugularis*	1	vertebra
	1652	1713	*Bufotes* sp.	1	humerus
	1659	1719	*Bufotes sp.*	1	vertebra (5-7)
			Snake	1	caudal vertebra
			cf. *Macrovipera lebetina*	1	vertebra
	1662	1722	Snake	1	vertebra

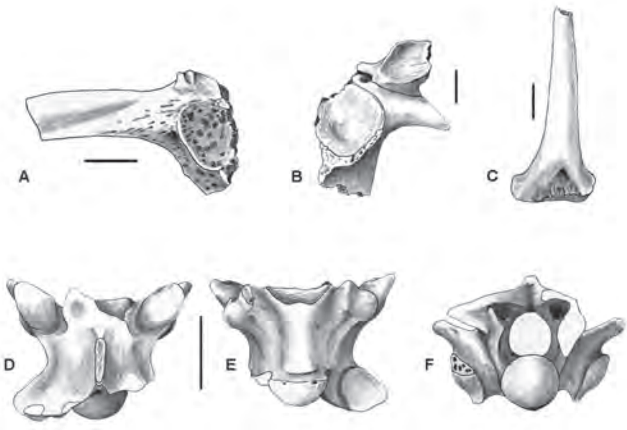


Figure 15.18. A) Bufotes sp., left ilium, lateral view (Shimshara, C1661, Trench 1); B) Pelophylax sp. right ilium, lateral view (Bestansur, C1627, Trench 10); C) cf. Eumeces s.l., left humerus, ventral view (Bestansur, C1738, Trench 10); D–F) Eryx cf. jaculus, trunk vertebra, dorsal, ventral and posterior views (Bestansur, C1570, Trench 13). Scale = 2mm.

Ranidae (frogs)

Pelophylax sp.

Material: Bestansur: 1 posterior fragment of right ilium and 1 proximal fragment of tibio-fibula (Trench 10).

Only the most posterior part of the ilium is preserved (Fig. 15.18B). The tuber superior is well developed, laterally protruding and with a concave lateral surface. A deep concavity is present between the tuber superior and the more anterior end of the dorsal iliac crest. The supracetabular fosse is present and the ventral acetabular wall is wide. The described features unequivocally characterize the ilia of the genus *Pelophylax* (Böhme 1977; Bailon 1999; Gleed-Owen 2000). Ranid tibio-fibula is more lengthened and with a narrower central part than in bufonids.

Currently, only the Eurasian marsh frog (*P. ridibundus*) is present in Sulaimaniyah province. It is a semi-aquatic frog, inhabiting and breeding in a wide variety of flowing and stagnant water habitats. It is a highly opportunistic species, living in mixed and deciduous forest, forest steppe, and steppe and other grasslands, semi-desert and desert zones. Arid areas are colonised through river valleys. Generally, hibernation occurs in water from November–December to January–February, but this species may remain active throughout the winter.

A fragment of radio-ulna and a fragment of urostyle have been identified only at order rank.

Squamates (lizards and snakes)

Lacertilians (lizards)

Scincidae

cf. *Eumeces* s.l.

Material: Bestansur: 1 humerus.

Lacertilians are represented at Bestansur only by a distal half of a humerus (Fig. 15.18C). The distal epiphysis is absent (not fused), a juvenile condition.

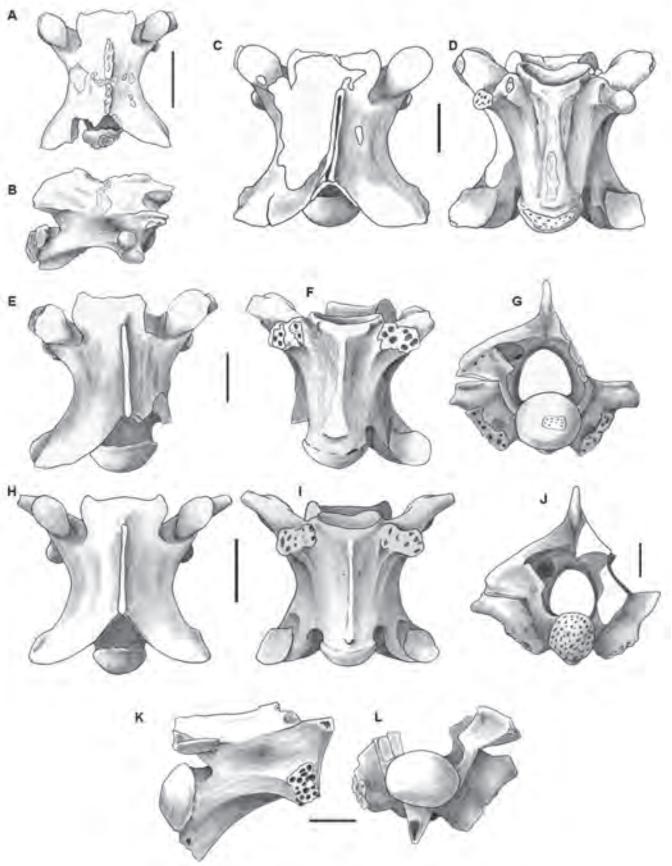


Figure 15.19. A–B) Natrix cf. tessellata, trunk vertebra, dorsal and right lateral views (Bestansur, C1013, Trench 1); C–D) cf. Elaphe sauromates, trunk vertebra, dorsal and ventral views (Bestansur, C1006, Trench 1); E–G) cf. Dolichophis jugularis, trunk vertebra, dorsal, ventral and posterior views (Shimshara, C1661, Trench 1); H–J) cf. Malpolon insignitus, trunk vertebrae (H and I: dorsal and ventral views, Bestansur, C1528, Trench 12; J: posterior view, Bestansur, C1752, Trench 10); K–L) cf. Macrovipera lebetina, fragment of trunk vertebra, lateral right and posterior views (Bestansur, C1414, Trench 10). Scale = 2 mm.

However, it presents the typical features of the family Scincidae (Lécuru 1969): presence of a single epicondylar fossa; entepicondyle medially stretched; ectepicondyle small and ectepiconylian foramen present. The size of this element corresponds well to that of the current members of the genus *Eumeces* s.l., but a more precise attribution cannot be established. *Eumeces* species are found on stony, semi desert regions of hard compacted ground scattered with sandy deposits.

SNAKES

Boidae (Erycinae)

Eryx cf. *jaculus*

Material: Shimshara: 1 precaudal vertebra. Bestansur: 13 precaudal vertebrae.

Vertebrae are small-sized (centrum length less than 5mm) (Fig. 15.18D, E and F). They are short, their centra are wider than they are long, and have reduced prezygapophyseal processes. The neural arch is flattened and the neural spine is low. The centrum is convex in transversal section and possesses a broad and flattened haemal keel. All the described characteristics are typical of the genus *Eryx* (Bailon 1991; Szyndlar 1991a).

Today, the javelin sand boa (*Eryx jaculus*) is the only erycine present across Iraq. Thus we attribute erycine of Bestansur to this taxon following geographical criteria. This species prefers dry, sandy areas suitable for burrowing, open dry steppes and semi-deserts. It generally becomes inactive between October and March or April.

Colubridae (s.l.)

The Colubridae constitutes an enormous morphologically homogeneous, non-monophyletic assemblage of snakes. Many attempts of subdividing the traditional Colubridae into several monophyletic 'clades' have been made, most recently based on molecular data (Lawson *et al*. 2005; Vidal *et al*. 2007). However, in archaeozoological and palaeontological contexts, the differentiation of such subgroups is very difficult. Given these difficulties we retain the traditional meaning of this term. Based on the vertebral morphology, in Colubridae s.l., it is possible to clearly distinguish two groups: 'natricines', where the hypapophyses are present in the entire trunk region and 'colubrine' where the hypapophysis of the trunk vertebrae is reduced to a haemal keel (Szyndlar 1984; 1991).

Natricine colubrids
Natrix cf. *tessellata*

Material: Bestansur: 1 trunk vertebra (Trench 1) (Fig. 15.19A and B)

The basic feature differentiating natricine trunk vertebrae from those of the other members of Colubridae s.l. is the presence of hypapophyse. They differ from the Viperidae in having a sigmoid hypapophyse, posteriorly vaulted neural arches, shorter parapophyseal processes and a smaller cotyle and condyle (Bailon 1991; Szyndlar 1991b).

Dice Snake (*Natrix tessellata*) is the most common natricine in Iraq. This is a largely aquatic species associated with rivers, streams, lakes, ponds and the surrounding terrestrial habitat.

Colubrine colubrids
The 'colubrines' are an artificial assemblage used for palaeontological and zooarchaeological purposes. In contrast to natricines, hypapophyses in colubrines only occur in the cervical vertebrae.

Material: Shimshara: 12 vertebrae. Bestansur: 136 vertebrae

Colubrine vertebrae are by far the most common elements of the herpetofauna in Shimshara and Bestansur sites. Two morphological types seem to be represented. A first type is characterised by the presence of a flattened and moderately widened haemal keel (Fig. 15.19C and D). This vertebral morphotype is similar to that of the current species *Elaphe sauromates* (the botched rat snake) (Szyndlar 1991a). In the second vertebral type, the haemal keel is thin and sharp (*Malpolon/ Dolichophis* type) (Szyndlar 1991a). In *Dolichophis jugularis* (large whip snake) (Fig. 15.19E, F and G), the haemal keel becomes wider and flatter than in *Malpolon insignitus* (Eastern Montpellier snake) immediately before the condyle (Fig. 15.19H, I and J). Furthermore, the first one has a more developed condyle than the second.

The different morphological types are represented by variable-size vertebrae including young and adult specimens. For the latter, the maximal length of the centrum is 6mm for *D. jugularis*, 6.3mm for *E. sauromates*, and 8.5mm for *M. insignitus*, that is, large-size colubrines with an estimated total length between of 100 and 160cm.

These three species have similar ecological affinities, commonly found in arid open areas, meadows, dunes, rocky and stone regions, and scrublands.

Viperidae
cf. *Macrovipera lebetina*

Material: Shimshara: 1 vertebra. Bestansur: 4 vertebrae.

Only five fragmentary vertebrae are attributed to a large-sized Viperid, the centrum length of the more complete vertebra being equal to 7mm. These vertebrae display a well-developed hypapophysis, cotyle and condyle. The condyle is ventrally attached to the hypapophysis basis; the centrum is short and well limited laterally; the neural arch is posteriorly depressed and the zygapophyseal articular facets are dorsally inclined. Size, morphology and biogeographical data are congruent with an attribution of these vertebrae to *Macrovipera lebetina* (the Levant blunt-nosed viper) (Fig. 15.19K and L). This snake is found principally in semi-arid regions.

Taphonomic data

The study of the bone surfaces revealed the presence of dissolution marks linked to the action of predator digestive juices. The percentage of digested snake vertebrae, the most abundant herpetofaunal remains of Shimshara and Bestansur, is high (87.5% in Shimshara and 74% in Bestansur). The intensity of this dissolution can be strong enough to partially destroy the different vertebral structures: neural spine, neural arch, centrum, zygapophysis, prezygapophyseal process, diapophyses, parapophyses and condyle (Fig. 15.20A, B and C), corresponding to the digestion categories 4 or 5 of Andrews (1990). Around 69% of the snake vertebrae are broken in Shimshara and 40% in Bestansur. However, this latter parameter (fragmentation) seems to be undervalued because most likely part of it has not been precisely quantified as being camouflaged by subsequent digestion. Only 5% of the snake vertebrae are burnt.

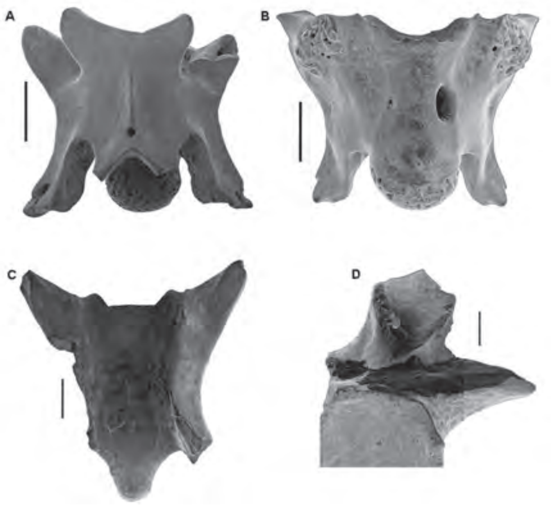


Figure 15.20. Taphonomic alterations. Snakes, digested vertebrae: A–B) Eryx cf. jaculus, trunk vertebra, dorsal and ventral views; C) 'Colubrine' indet, trunk vertebra, dorsal view; D) Anurans, fragmented and digested ilium, Pelophylax sp. Scale = 1 mm.

Publications on taphonomy of snake remains are scarce, the absence of reference collections being the main cause (Bailon 2011). Hence, the results of this work will need to be confirmed by further studies. The high percentage of fragmented and digested vertebrae, and the strong degree of digestion, suggest that these snake remains come from mammal predation. Among those predators, humans should not be excluded. In anurans, *Pelophylax* remains are also fragmented and digested (Fig. 15.20D) and only bufonids (*Bufotes* sp.) do not present dissolution marks, and probably derive from *in situ* mortality.

Interpretation

Herpetofauna samples of the Neolithic Shimshara and Bestansur sites include the presence of eight taxa: two amphibian anurans (*Bufotes* sp. and *Pelophylax* sp.), one lizard (cf. *Eumeces* s.l.), and six snakes (*Eryx* cf. *jaculus*., *Natrix* cf. *tessellata*, cf. *Elaphe sauramates*, cf. *Malpolon insignitus* and cf. *Dolichophis jugularis* and cf. *Macrovipera lebetina*). Snake remains are the most abundant in both sites (NRT= 188; 93.5% of the total herpetofaunal assemblage; NR= 21 and 76% in Shimshara and 172 and 95.5% in Bestansur). Snakes include specimens whose size is between 50cm (javelin sand boa and young Colubrids) and 160cm for the largest Colubrids.

The taxa represented prefer a habitat characterised by open dry areas and a temperate–warm climate, with the presence of *Pelophylax* and *Natrix tessellata* at Bestansur indicating a water habitat near to the site. Most of the herpetological remains present in Shimshara and Bestansur sites are digested and seem to come from predation by mammal carnivores, in which humans may be included. The herpetological assemblage includes mainly diurnal species. Currently, these species are active between March and October, which could be the main period when they were preyed upon.

Tortoise remains

Tortoise remains were recovered from both Bestansur and Shimshara, slightly more commonly at the former (Table 15.22). At Bestansur, there are a number of collections of carapace and plastron fragments from individual contexts likely from single animals and the quantity of tortoise may therefore be over-represented by NISP. Seven tortoise carapace/plastron fragments from six separate contexts showed clear signs of burning and cut marks were also recorded on the inside of another piece. Similar patterns of burning and butchery attest to the use of tortoises as a desirable small prey for food at other sites in Southwest Asia, including Hallan Çemi (Starkovich and Stiner 2009).

Table 15.22. Summary of tortoise remains by site and trench: quantification by number of fragments (NISP) and diagnostic zone (DZ) count; taphonomic data (burning and cut marks) by NISP.

Site	*Trench*	*NISP*	*DZ*	*Burnt (NISP)*	*Cut marked (NISP)*
Bestansur	2	1	0	0	0
	4	1	0	0	0
	7	13	0	0	0
	9	3	0	0	0
	10	93	1	6	1
	12	3	0	1	0
	13	2	2	0	0
	Total	116	3	7	1
Shimshara	1	1	0	0	0
	2	1	0	0	0
	Total	2	0	0	0

Small mammals

The analysis of the small mammal remains was conducted (by MM and JH) using the osteological reference collection of the National Museums of Scotland, and drew on a wide range of mammalogical literature (Barratt-Hamilton 1910; Miller 1912; Hinton 1926; Ellerman 1941; Brown and Twigg 1969; Corbet and Southern 1977; Corbet and Ovenden 1980; Vigne 1995; Nagorsen 2002; Hillson 2005; Coşkun *et al*. 2016; Mohammidi and Parvizi 2016). The state of preservation of the remains was good enough to attempt the identification of the post-cranial elements, which represented most of the samples. Although cranial or dental morphology can often be used to distinguish species, post-cranial remains may often be identified only to genus. In addition, the limited range of available reference material may lead to further uncertainty, for example in distinguishing *Rattus* from other rodents of similar size, such as *Nesokia* and *Spalax*. When taxonomic identification was not possible, size-ranges were used. Where possible, unidentified fragments were placed in one of three categories, namely 'indeterminate small rodent', 'indeterminate large rodent' and 'indeterminate'. Remains were then quantified by the number of identified specimens (NISP).

Taxa represented in relation to current species in the region

At both Bestansur and Shimshara, *Mus* is the most common positively identified genus of micromammal, followed by *Microtus* (Tables 15.23 and 15.24). Today, two species of the genus *Mus* are recognised within the Zagros range of Iraq (Firouz 2005; IUCN 2017): *Mus musculus* (house mouse) and *M. macedonius* (Eastern Mediterranean short-tailed mouse). The two species may only be distinguished by a limited range of characteristics, confined to the skull and dentition,

Table 15.23. Small mammal remains from Bestansur (NISP), by trench.

Taxon	*T1*	*T4*	*T5*	*T7*	*T8*	*T9*	*T10*	*T11*	*T12*	*T13*	*Total*
Mus	10	0	0	0	1	1	75	0	38	25	150
cf *Mus*	1	0	0	1	1	1	20	0	13	11	48
Microtus	0	0	0	1	0	4	14	0	4	4	27
cf *Microtus*	0	0	0	0	0	0	6	0	1	4	11
cf *Apodemus*	0	0	0	0	0	0	2	0	0	0	2
cf *Apodemus/Mus*	4	0	0	1	0	0	21	0	20	18	64
Erinaceus concolor	0	0	0	0	0	0	0	0	1	0	1
Hemiechinus auritus	0	0	0	0	0	1	0	0	0	0	1
Spalax ehrenbergi	0	0	0	0	0	0	1	0	1	0	2
Arvicola amphibius	0	1	0	0	0	0	0	0	0	0	1
Tatera indica	0	0	0	0	0	1	0	0	0	0	1
Nesokia indica	0	0	0	0	0	2	0	0	0	0	2
Rattus	0	0	1	1	0	0	1	1	0	2	6
cf *Rattus*	0	2	0	5	0	0	4	0	3	3	17
Indeterminate small rodent	2	1	0	0	0	1	11	0	2	5	22
Indeterminate large rodent	1	5	0	5	0	7	15	0	15	7	55
Indeterminate	2	2	0	6	0	2	34	0	24	34	104
Total	20	11	1	20	2	20	204	1	122	113	514

Table 15.24. Small mammal remains from Shimshara (NISP), by trench.

Taxon	*T1*	*T2*	*Total*
Erinaceus concolor	0	1	1
Microtus	10	1	11
cf *Microtus*	1	0	1
cf *Apodemus/Mus*	7	5	12
Mus	7	8	15
cf *Mus*	7	3	10
Rattus	1	0	1
cf *Rattus*	1	1	2
Indeterminate small rodent	0	1	1
Indeterminate large rodent	5	1	6
Indeterminate	6	5	11
Total	45	26	71

and it was therefore not generally possible to identify them positively from the remains here, which are fragmentary and mostly comprised post-cranial elements. However, the house mouse is currently ubiquitously distributed in Iraq and is a highly commensal species closely associated with human dwellings, so it is arguably more likely to be found in remains from settlements like those at Bestansur and Shimshara. Indeed, the commensalism of the house mouse is considered to have originated in Southwest Asia from where the species expanded westwards (Cucchi *et al*. 2005; Rajabi-Maham *et al*. 2008). Voles of the genus *Microtus* inhabit areas of grassland or other low vegetation and, although there is little consensus regarding their taxonomy (Wilson and Reeder 2005), at least three species are potentially native to the Zagros (Table 15.25; IUCN 2016; 2017; Karami *et al*. 2008). Current biogeography indicates *Rattus rattus* (black rat) is present in Iraq (IUCN 2017), although earlier sources also note *Rattus norvegicus* (brown rat) (Hatt 1959). Although they are here assigned as cf. *Rattus*, a number of post-cranial specimens were probably *R. rattus* given their small size. Similar to the house mouse, the spread of black rats from Southwest Asia into Europe is likely to have been linked to their commensality (O'Connor 2013).

Remains of field mice from the genus *Apodemus* are potentially also present in the assemblage (Table 15.23). Three species of field mouse may currently be present in the Zagros and might associate with human settlements (Hatt 1959; Firouz 2005; IUCN 2017). Field mice are anthrophilic, rather than strongly commensal, yet they are common in Neolithic and Bronze Age settlements of western and central Europe (O'Connor 2013: 83).

A range of other small mammals were also identified among the remains from Bestansur and Shimshara, although they were less common (Table 15.23 and 15.24). Although it was only possible to identify a small fraction of the many micromammal species present in this part of the world, the variety of species permits us to build up a more comprehensive understanding of the Early Neolithic habitat there.

Local site environments

Small vertebrates can provide good evidence of local environments. The dietary and habitat preferences of micromammal species that were positively identified, or potentially present, in the assemblages from Shimshara and Bestansur are shown in Table 15.25. These species were collated from regional zoological and ecological studies (Hatt 1959; Harrison 1964; 1972; Lay 1967; Corbet and Ovenden 1980; Nowak and Paradiso 1983; Firouz 2005; IUCN 2017). The range of species suggests that the Early Neolithic settlements were surrounded by open areas with

Table 15.25. Diet and habitat preferences for micromammal species identified, or potentially present, in the assemblages from Shimshara and Bestansur.

Taxon	*Diet*	*Habitat*
Erinaceus concolor	Carnivore	Crop fields, woodland, scrub
Hemiechinus auritus	Carnivore	Crop fields, scrub
Spalax ehrenbergi	Herbivore	Crop fields, grassland, scrub
Arvicola amphibius	Herbivore	Wetlands with vegetation cover
Microtus	Herbivore	Grassland, low vegetation
Tatera indica	Omnivore	Habitations, crop fields, grassland, scrub
Apodemus	Omnivore	Habitations, crop fields, woodland, scrub
Mus	Omnivore	Habitations, crop fields, grassland, scrub
Nesokia indica	Herbivore	Habitations, wetlands, grassland, scrub
Rattus	Omnivore	Habitations, crop fields, grassland, scrub

Sources: Harrison (1964; 1972); Corbet and Ovenden (1980); Firouz (2005); Myers *et al.* (2017).

grassland, scrub and low vegetation (Chapters 3 and 6). Some limited woodland may also have been present, as suggested by the presence of hedgehog (Edwards and Martin 2007: 168). There would also be water or wetland, given the presence of *Nesokia* and *Arvicola*. The relative abundance of taxa suggests that the predominant habitat from which they derive is of scrub, which correlates with the numbers of *Helix salomonica* present in the molluscan assemblage at Bestansur (Chapter 17; Iversen 2015: 246).

Neolithic or intrusive?

Small rodent remains are highly susceptible to translocation and fragmentation (Stahl 1996) and the risk of intrusive burrowing species is problematic for data reliability. Living rodents and their burrows were observed in the now deserted mound at Bestansur during excavation during March–April 2012 and June 2017, including the Persian jird *Meriones persicus*. Such burrowing is a frequent issue for archaeological mounds of Southwest Asia (Reed 1958). Burrowing is a characteristic behaviour of all represented taxa to varying degrees (Corbet and Ovenden 1980; Firouz 2005; Myers *et al.* 2016). Mole rats (*Nannospalax*) were particularly notorious burrowers found at the Neolithic site of Jarmo (Reed 1958). Their storage of food in tunnels, which are up to 195m long (Nowak and Paradiso 1983 626–627), likely affected the botanical evidence (Chapter 18). Among the species that were identified here, the mole rat (Spalax), Indian gerbil (*Tatera*) and bandicoot rat (*Nesokia*) have the greatest propensity for subterranean storage (Nowak and Paradiso 1983: 626, 734–735). Together with the mice (*Mus* and *Apodemus*), these animals are the most likely to be intrusive from later levels. Some of the house mouse and other small mammal remains were better preserved than macromammals in the same context (Fig. 15.21), indicating that they may be more recent in origin and therefore intrusive within the Neolithic levels.

This variation in preservation indicates different possible taphonomic pathways as the material entered the archaeological record, which does not necessarily imply that they were not contemporaneous. There is also at least one association between a concentration of small mammal remains from house mouse and intrusive lentils, radiocarbon dated to the Iron Age, from C1388, Trench 12 (Chapter 11). One interpretation is that these lentil patches (<6–15cm in diameter) might be remains from within the cavities of intrusive house mouse burrows (Schmid-Holmes *et al.* 2001). House mice dig extensive burrows, 2–3cm in diameter and up to 8m long, and are inveterate hoarders (Schmid-Holmes *et al.* 2001). Based on considerations of this taphonomy and house mouse ecology it is possible that at least some of the house mouse remains are intrusive within the Neolithic levels at Bestansur. These examples might be commensals associated with the Iron Age and Sasanian settlements overlying the Early Neolithic occupation.

The presence of burrowers, however, need not imply that all remains are intrusive, especially as rodents are more commonly found outside burrows and are considered less vulnerable in their burrows (Morlan 1994; Stahl 1996; Hashemi *et al.* 2006). Predation however would have ensured that few taxa lived to advanced age or great numbers by controlling local distribution and diversity (Miller and Getz 1972; Stahl 1996; Hashemi *et al.* 2006; Vasileiadou *et al.* 2009). A range of potential predators is visible in the Bestansur assemblage, including mammalian carnivores and snakes. Foxes and mustelids were drawn to other Neolithic sites such as Çatalhöyük in pursuit of the abundant *Mus* populations and may have been tolerated by the inhabitants for their useful removal of such pests (Jenkins 2005; 2009; 2012; Pawlowska and Marciszak 2018). This situation is also similar to that of modern hedgehogs, which are kept as pets and said to rid houses of insects, small rodents and even snakes (Firouz 2005: 49). There is no clear evidence from macroscopic assessment for predation as a primary factor in the assemblage. In such circumstances, typical taphonomic marks of predation are visible on small mammal remains, such as digestive acid erosion (Andrews 1990). Human predation is not an entirely unlikely avenue to consider either, though it is notoriously difficult to identify, and micromammals are not productive meat sources (Morlan 1994: 138; Stahl 1996).

Figure 15.21. Small mammal remains tend to be better preserved than macromammals in the same context (C1528, S1429, Trench 12 – 2mm fraction).

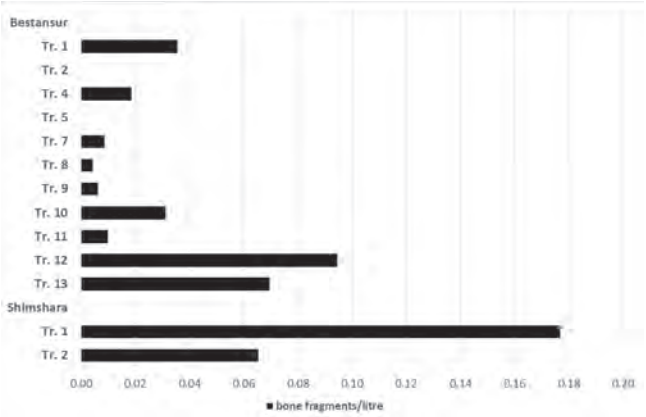


Figure 15.22. Spatial distribution of small mammal remains from Bestansur and Shimshara by number of fragments per sampled volume (NISP/litre).

Spatial distribution of small mammal remains

Higher rodent densities in certain areas may be associated with refuse disposal patterns, habitation structures and also food storage (Fig. 15.22). Built storage facilities for seeds, nuts, dried fruits and other plant parts and sharing of animal meats for instance is often a fundamental strategy to protect and sustain food supplies and the social and economic demands of agriculture in sedentary sites (Bogaard *et al*. 2009: 650). Formalised household storage was widely developed during the Early Neolithic in Southwest Asia.

The spatial assessment of waste at Bestansur highlights a pattern of food refuse disposal that likely made waste more readily accessible in certain areas of the site. Some secondary deposition of refuse in open areas in Trenches 12–13, for example, may have

Table 15.26. Summary of fresh-water crab (Potamon spp.) remains by site and trench: quantification by number of fragments (NISP) and numbers of burnt fragments (NISP).

Site	*Trench*	*NISP*	*Burnt (NISP)*
Bestansur	7	3	0
	9	3	0
	10	21	9
	12	8	2
	13	6	1
	Total	41	12
Shimshara	1	1	0
	Total	1	0

been attractive to rodents but was frequently buried by deliberately laid layers of packing to ensure that dirtier activities or refuse was either sanitised by renewing surfaces (Chapter 12) or allocated to areas away from domestic/living areas (Hardy-Smith and Edwards 2004), although few middens have to date been identified within the settlement. In addition, one might argue as Hardy-Smith and Edwards (2004: 285) do that such practices are typical of sedentary village practice, which has implications for the intensity and continuity of occupation at Bestansur.

Interpretation: commensalism and sedentarisation

At both Bestansur and Shimshara, *Mus* is the most commonly identified small mammal (Tables 15.23 and 15.24). If the house mouse remains are Neolithic, then they may offer perspectives on the nature and continuity of settlement at both sites. Owing to the propensity for dramatic population increases in house mouse under favourable conditions (Stahl 1996: 39), their synanthropic relationship with humans is likely to have emerged quickly with the longer-term habitats offered by more permanent settlements (Tchernov 1984; Wyncoll and Tangri 1991; Cucchi *et al*. 2012: 70–71). On this basis, the relative frequency of *Mus* at sites like Hayonim Cave, Eynan-Mallaha and Ganj Dareh has been argued to reflect the sedentary status of these prehistoric sites (Hesse 1979; Tchernov 1984). Whilst *Mus* presence within many sites appears to rise dramatically from the onset of the Neolithic (Lieberman 1998; Weissbrod 2014), there is some doubt as to whether these patterns can be considered characteristic of full sedentarisation. The argument is based on quantitative evidence for rodents as well as the deposits they represent. NISP values may appear high relative to the amount of food/waste with which they are associated, but the context behind these figures is as likely to be a sizable deposit of material as it is of smaller continuous ones that attracted commensals, and wild taxa (Hardy-Smith and Edwards 2004: 257–259). Whilst strong patterns of association with early sedentary sites are apparent, use of density alone may not be ideal as a single measure for characterising the residential status of a site. Whilst relationships at Bestansur and Shimshara may imply *Mus* likely adopted a commensal relationship at this time to end up as the foremost pest represented, their association alone is not a sufficient measure to characterise permanent occupation. We may need to explore more nuanced forms of sedentism to define Bestansur's less obvious pattern (Hardy-Smith and Edwards 2004: 279) and living conditions, as discussed in Chapter 12.

Figure 15.23. A live crab found sheltering beneath a stone beside the stream in a scrubby habitat (c. 10m from the water; April 2014).

Land crabs

Small numbers of freshwater crab remains (*Potamon* spp.) were recovered from Bestansur and Shimshara (Table 15.26). The typical habitat of these taxa is the margins of freshwater streams and rivers. During excavation seasons at Bestansur, both live and dead modern crabs were observed along the margins of the spring head and river (Fig. 15.23). Freshwater crabs in the region might be expected to be less active and hibernate in the winter months, and thus may have been collected by humans and animal predators in the warmer months. Cooking of crab may be indicated by burning observed on a number of the remains (Table 15.26).

Spatial distribution of taxa

Spatial patterning of animal bones at archaeological

Table 15.27. Relative densities of bone fragments per sampled volume of sediment processed by wet sieving (NISP/litres volume) per trench from Bestansur and Shimshara.

	Bestansur											Shimshara	
	Tr. 1	*Tr. 2*	*Tr. 4*	*Tr. 5*	*Tr. 7*	*Tr. 8*	*Tr. 9*	*Tr. 10*	*Tr. 11*	*Tr. 12*	*Tr. 13*	*Tr. 1*	*Tr. 2*
Large-sized mammal	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05
Medium-sized mammal	0.00	0.00	0.03	0.00	0.05	0.02	0.10	0.05	0.05	0.12	0.06	0.34	0.37
Hare-sized mammal	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
Micro-mammal	0.04	0.00	0.02	0.00	0.01	0.00	0.01	0.03	0.01	0.09	0.07	0.18	0.07
Bird	0.00	0.01	0.01	0.00	0.01	0.00	0.02	0.02	0.00	0.06	0.05	0.05	0.05
Fish	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.28	0.10	0.21	0.18
Reptiles and amphibians	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.05	0.01	0.07	0.02
Crustacea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Total bone recovered (frags/litre)	0.18	0.22	0.71	0.09	0.73	0.35	1.11	0.53	1.81	2.25	1.19	3.81	3.68

sites is a well-understood aspect of settlement archaeology, with assemblage compositions varying according to spatial variations in activities across the site in question (Wilson 1996). The excavation programme has tested the archaeology across the site of Bestansur by excavating a number of separate trenches of varying size across the site. These trenches represent sub-samples of the spatial patterning of animal remains across the Early Neolithic site with which to attempt to characterise separate areas/zones of the settlement (Orton 2000: 112–148). Excavations at Shimshara were much more limited, but the two trenches here can also be compared with the data from Bestansur to investigate variation in animal bone patterning at and between the sites.

As the abundance and relative proportions of taxa recovered may depend on the excavation technique employed (Payne 1975; Meadow 1980), this assessment considers the relative densities per sampled volume of sediment processed by wet sieving (NISP/litres volume) which will ensure consistent recovery of all taxa. Due to the modest absolute assemblage sizes and relative densities of identified taxa, the material is divided into broader taxonomic categories: large-sized mammals (e.g. *Bos*); medium-sized mammals (e.g. *Sus*, *Ovis*); small-sized mammals (e.g. *Lepus*, *Vulpes*); very small-sized mammals (e.g. *Mus*); birds; fish; herpetofauna; crustacea (Table 15.27). The principle behind this categorisation is that food animals with different carcass sizes may be treated differently within the structure of a settlement, depending on the butchery and food preparation processes, for example with larger taxa requiring greater butchery and the smallest being cooked whole (Wilson 1996: 28).

Assessment of the relative densities of remains from the various trenches underlines the low density of material recovered from Bestansur, and the relatively higher densities from the two trenches at Shimshara (Table 15.27). At Bestansur, some areas produced material indicative of butchery discard on open surfaces, as in Trenches 7 and 9, but this material was relatively limited in terms of quantity and no substantial middens have yet been identified. Trenches 12 and 13 produced some deposits suggestive of midden-like character, represented in some of the higher bone densities from Bestansur. Comparing three taxonomic groups that showed the highest variation between the trenches – medium-sized mammals, micro-mammals and fish – points to variation in spatial activity (Fig. 15.24).

Overall, the modest quantities of faunal remains recovered from Bestansur to date can be attributed principally to the focus of excavations so far on relatively clean mudbrick buildings and associated external areas with *in situ* evidence for a range of activities, as opposed to rich, stratified midden-type deposits which have not yet been encountered in excavations at the site.

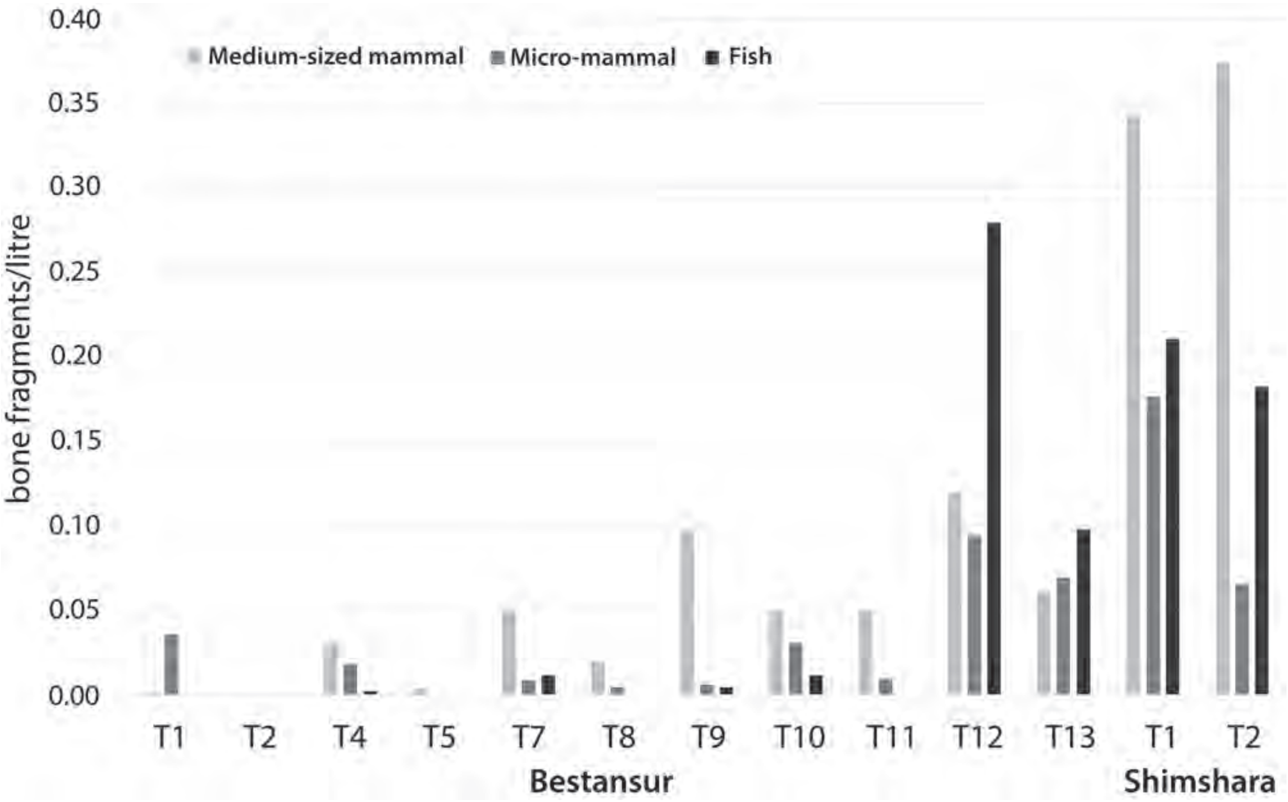


Figure 15.24. Relative densities of bone fragments of medium-sized mammals, micromammals and fish per sampled volume of sediment processed by wet sieving (NISP/litres volume) per trench from Bestansur and Shimshara.

Linked to contextual observations, we may infer domestic areas where we have evidence for food preparation/consumption (fish remains) and 'peripheral' processing areas where the larger taxa (e.g. sheep and pig) are butchered and their bones discarded. High levels of micromammals in Trenches 12 and 13 may be related to commensalism in and around structures, although these trenches are close to the edge of the mound and potentially subject to greater activity by intrusive burrowers.

Discussion

Animal domestication and early husbandry

Of those taxa later to become domestic livestock, the limited metrical evidence suggests that the goats at Bestansur are a managed, early domestic population (Fig. 15.6), whereas the sheep are a hunted wild population (Fig. 15.7) and the pigs are morphologically wild (Fig. 15.10). The absence of metrical and age data pertaining to cattle remains means it is not possible to draw inferences on the status of these animals. They are in very low numbers and there is no evidence to indicate that cattle were managed at this time. This interpretation agrees with the current narrative for the chronology of animal domestication and introduction in the Central Zagros region. Domestic sheep are thought to be introduced to this region in the seventh millennium BC and cattle in the sixth millennium BC (Zeder 2008; Arbuckle *et al*. 2016)

Pigs are relatively abundant at Bestansur and Shimshara, attesting the favourable local environments beside permanent water sources with the potential for some shade-giving flora. The fact that they are morphologically wild, does not necessarily mean that they were not managed. Given the potential zooarchaeological evidence for domestic pigs in the later eighth millennium BC Aceramic Neolithic levels at Jarmo (Price and Arbuckle 2015) and the omnivore coprolite layers at Bestansur post-dating *c*. 7100–7050 BC some of which derive from pig (Chapter 16), future work in this region needs to explore the potential for local domestication processes versus an introduction of livestock from outside the region. In the EFC, the earliest evidence for domestic goats emerges around 8000 BC in the mid-altitude zone of the Central Zagros, in the core area of the preferred natural habitat of wild goats. At Ganj Dareh, the demographic profile indicates a managed, female-dominated, population morphologically unaltered from wild animals (Zeder and Hesse 2000). Subsequently, we see the adoption of goat husbandry during the course of the eighth millennium BC at sites outside this preferred natural upland habitat, first at Bestansur in the western piedmont around 7700 BC, then at

Ali Kosh in the southern Zagros lowlands by 7500 BC and Jarmo in the western piedmont by the later eighth millennium BC (Hole *et al*. 1969; Stampfli 1983; Zeder 2008; Bendrey 2014b).

Compared to Ganj Dareh and Ali Kosh, where goats dominate the assemblages, this animal contributes a relatively minor proportion to the diet and economy at Bestansur (Fig. 15.5). Hunted animals – primarily sheep, pig and red deer – provided the bulk of the consumed food of animal origin, as well as resources such as marrow, bone, leather, and sinew. The goats at Bestansur were clearly eaten by the human community, but their low numbers suggest that the early adoption and use of domestic goats at Bestansur may not have been primarily as a source of dietary meat and fat. The degree to which secondary products such as milk and hair were exploited from the earliest periods of animal husbandry is unknown and the evidence is contested (Orton 2014), but the presence of ruminant dung is well-attested at CZAP excavated sites across the Early Neolithic Central Zagros (Chapters 12 and 16; Matthews *et al*. 2013a). There may have been multiple drivers behind the earliest adoption of domestic livestock, including a complex of social and economic influences. At Bestansur, however, it is notable that there is extensive evidence for the use of herbivore dung as fuel, being identified in all hearths and ashy deposits analysed. Hesse (1984) proposed the use of dung for fuel as a motivator for goat domestication in the context of Ganj Dareh, but it may be unnecessary to invoke fuel as a prime motivator in the context of the Zagros uplands, in the zone above the treeline, where there is abundant evidence for burnt charcoal. Below the treeline, however, the existence of a renewable and controllable source of fuel in the form of animal dung would potentially assume greater significance.

Diet, economy, society and ritual

Similarities in the make-up of the assemblages from both Bestansur and Shimshara identify dietary and economic focus on the large mammals (Figs 15.3 and 15.4), but also exploitation of a broad spectrum of different animals available in the environs of the sites. The high proportion of wild resources, the range of taxa exploited, and the regular grease and fat extraction all point to continuation of hunter-gatherer traditions, with only a relatively minor component of the diet deriving from domestic animals. There is perhaps a greater emphasis on the wild than might be expected when placed into the context of the dominance of managed animals in the economies of sites geographically and temporally surrounding Bestansur and Shimshara, at Ganj Dareh a few centuries earlier and at Ali Kosh and Jarmo a few centuries later (Hole *et al*. 1969; Hesse 1978; Stampfli 1983; Zeder 2008). What we might be detecting, however, especially at Bestansur, is a transitional assemblage, a community in the early phases of adopting animal husbandry as a minor component of their economy, presumably acquired from connections with communities in the high Zagros to the east. Such connections are attested in the occurrences of highland materials such as carnelian in the small finds from Bestansur (Chapter 21).

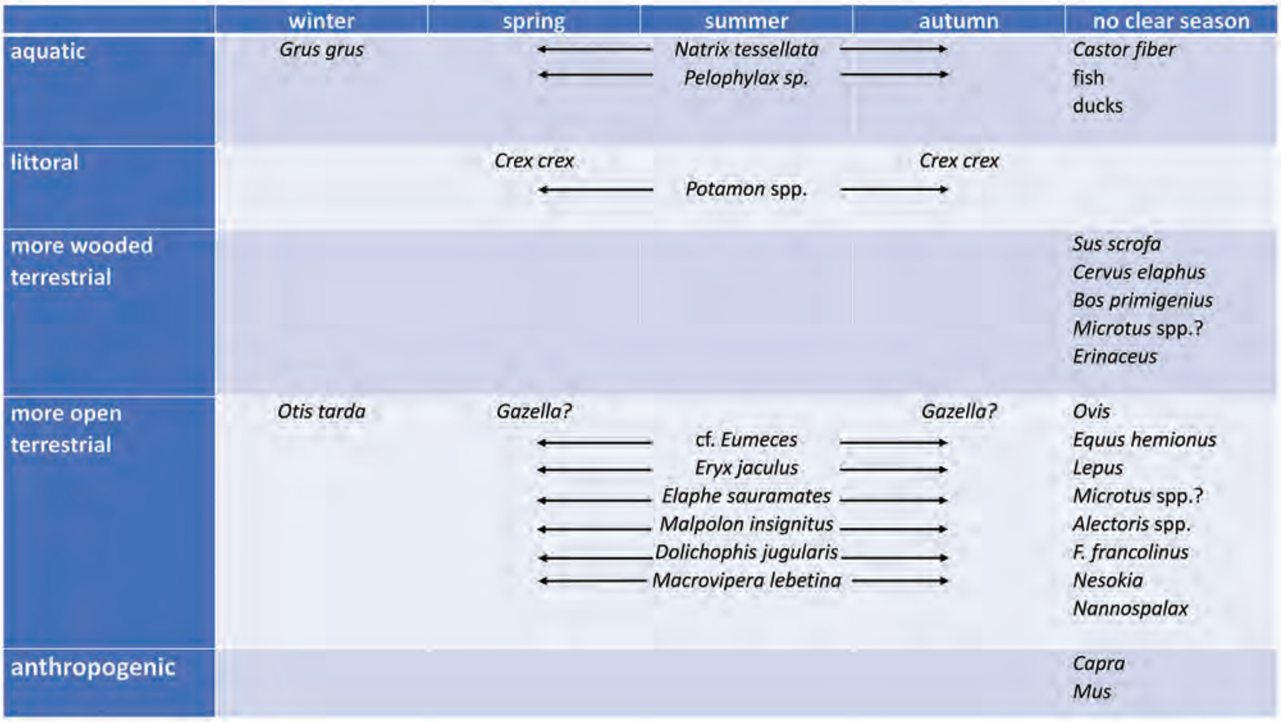
The animal remains from Bestansur and Shimshara can provide insights into the distribution and nature of activities being undertaken across the sites. Assessment of the relative density of bone remains at Bestansur indicates the low density of material recovered, and the relatively higher densities from the two trenches at Shimshara (Table 15.27). At Bestansur, some areas produced material indicative of butchery discard on open surfaces, e.g. Trench 9, but no substantial middens were identified. Trenches 12 and 13 produced some deposits with midden-like character, represented by higher bone densities. Differential bone distribution of animal size categories suggests some areas where there is evidence for food preparation/consumption (fish remains) and more 'peripheral' processing areas where the larger taxa such as sheep and pig were butchered and their bones discarded.

That animals also played an important role in cosmology in Early Neolithic societies in the Central Zagros is interpreted from depositions at a number of regional sites (Smith 1976; Bendrey *et al.* 2013; Bangsgaard *et al*. 2019). At Bestansur, crane bones derive from non-meaty skeletal areas, indicating their use was not primarily for consumption, and while it is not possible to confirm use of feathers from the small assemblage, a calcined crane bone from the fire installation associated with Building 5 may be viewed in the context of wider evidence from Neolithic Southwest Asia (Russell and McGowan 2003) as an association with the spirit world in this mortuary context.

Reconstruction of local and regional environments

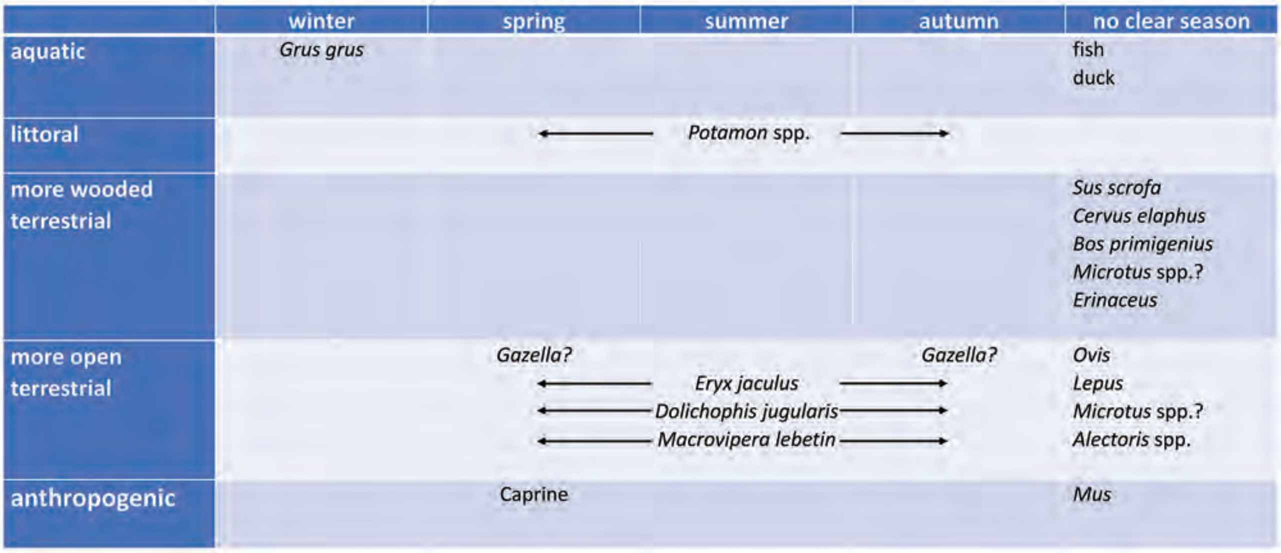
The ability to reconstruct features of the environment from animal remains depends on a number of factors, including the specificity of the ecologies and habitat preferences of the different taxa recovered, the routes whereby they entered the archaeological record, such as anthropogenic versus natural deposition, and the distances at which animals may have been hunted (Reitz and Wing 1999: 85–109).

Perspectives on the more immediate site environment may be offered through consideration of the small vertebrates, with accumulations of their remains reflecting animals that had been living



	winter	spring	summer	autumn	no clear season
aquatic	*Grus grus*		← *Natrix tessellata* → ← *Pelophylax sp.* →		*Castor fiber* fish ducks
littoral		*Crex crex*	← *Potamon* spp. →	*Crex crex*	
more wooded terrestrial					*Sus scrofa* *Cervus elaphus* *Bos primigenius* *Microtus* spp.? *Erinaceus*
more open terrestrial	*Otis tarda*	*Gazella?*	← cf. *Eumeces* → ← *Eryx jaculus* → ← *Elaphe sauramates* → ← *Malpolon insignitus* → ← *Dolichophis jugularis* → ← *Macrovipera lebetina* →	*Gazella?*	*Ovis* *Equus hemionus* *Lepus* *Microtus* spp.? *Alectoris* spp. *F. francolinus* *Nesokia* *Nannospalax*
anthropogenic					*Capra* *Mus*

Figure 15.25. Simplified summary schematic showing interpretations of habitats and seasons represented by the faunal remains at Bestansur.



	winter	spring	summer	autumn	no clear season
aquatic	*Grus grus*				fish duck
littoral			← *Potamon* spp. →		
more wooded terrestrial					*Sus scrofa* *Cervus elaphus* *Bos primigenius* *Microtus* spp.? *Erinaceus*
more open terrestrial		*Gazella?*	← *Eryx jaculus* → ← *Dolichophis jugularis* → ← *Macrovipera lebetin* →	*Gazella?*	*Ovis* *Lepus* *Microtus* spp.? *Alectoris* spp.
anthropogenic		Caprine			*Mus*

Figure 15.26. Simplified summary schematic showing interpretations of habitats and seasons represented by the faunal remains at Shimshara.

on site, such as the house mouse (Table 15.23), or predator accumulations from prey caught in nearby habitats (Andrews 1990). The small mammal assemblage presents a picture at Bestansur of small-scale human habitation, surrounded by open areas with low scrubby vegetation. The small reptiles and amphibians also support a reconstruction of open dry areas, with others – *Pelophylax* and *Natrix tessellata* – indicating a water habitat nearby to the site.

Perspectives on the slightly wider environs may be gleaned from those animals hunted for food from the settlement's surroundings. Local wetlands – presumably the springhead and river – are represented by the fish remains, a reasonable portion of the bird assemblage (especially the ducks), and also a single beaver bone (Figs 15.25 and 15.26). More open terrestrial environments are also indicated by a range of taxa including, in particular, the sheep remains and the ground feeding birds. A range of taxa recovered would have preferred more wooded environments (e.g. pig, aurochs and the deer), but given the fact that animals may have been hunted over some distance, it is unclear to what degree the local environment was wooded. Pigs would have favoured some shade, particularly in the summer months, which could have been supplied by the taller vegetation such as reeds that would have surrounded the springhead and riverbanks. Vegetation around the banks of the river and spring would have been an attraction to all herbivores. In general, we may have a picture of hunting within a largely tree-less piedmont, with local water sources and surrounding stands of vegetation.

There is clearly a patchwork of local ecotopes available around Bestansur and Shimshara (Figs 15.25 and 15.26). Although the wetland resources contributed diversity to the diet, including numerous fish and some of the bird remains, large mammals supplied by far the bulk of the human diet. At Bestansur, the high number of sheep remains within this group suggest a major part of the animal contribution to the diet came from exploitation of the more open environments, including local plains and foothills, and at Shimshara the high representation of morphologically wild pigs likely reflects favourable vegetation/littoral resources along the Lesser Zab River.

Hunting and habitation: seasonal and spatial variations in animal communities

The ecologies of the diverse animal communities can also provide perspectives on the seasonality of settlement use at the sites and the exploitation of local niches (Figs 15.25 and 15.26). At Bestansur, there are positive indicators of seasonal hunting in the bird assemblage in winter (crane) and spring/autumn (corncrake). The few gazelle bones *might* also have migrated through the region in the spring and autumn, in transit between winter and summer pastures, although this is at present speculation. Some of the smaller taxa (reptiles, amphibians, land crabs) are indicative of the warmer months, but it is a little uncertain to what degree all these animals are linked to anthropogenic activity. In the hotter summer months, as the vegetation away from permanent water sources would have become parched (Fig. 15.14), the springhead and river area would have been an attractive location for animals and humans alike. Other possible indicators of warm season settlement at the site might include herbivore dung fuel, which was more likely to be collected in the warmer, drier months (Chapter 16; Anderson and Ertuğ-Yaras 1998; Reddy 1999; Bendrey *et al*. 2016).

At Shimshara, winter occupation is indicated from the remains of common crane (Fig. 15.26). Here, indicators of late winter/early spring activity are also present in terms of a few late-stage foetal sheep/goat remains. Also, as at Bestansur, some of the smaller taxa are indicative of the warmer months, but again it is a little uncertain to what degree all of these are linked to anthropogenic activity.

At both Bestansur and Shimshara, then, there are positive indicators for some activity in the colder months of the year, but also some suggestions for warm season presence too. There is nothing particularly leading in the data-set to argue against permanent, year-round, habitations and presumably both sites would have been rich resource centres in the summer months, with the attraction of wild animals to the permanent water sources and associated vegetation. In the light of this discussion, the house mouse assemblage may also be of interest. It seems likely that some, at least, of the *Mus* assemblage may be Early Neolithic in date and pertain to the origins of settled life, farming and food storage. To validate the origin of this material, however, future work should focus on both direct dating of rodent material and also taphonomic study to identify potential predators and distinguish intrusive specimens (Andrews 1990; Lyman 2017: 336).

Conclusions and future directions

The zooarchaeological assemblages recovered from Early Neolithic Bestansur and Shimshara represent the remains from communities that were in many ways continuing hunter-gatherer traditions while also adopting new systems of food production and exploring new human–animal–environment relationships. These communities drew on animals from a diversity of local ecotopes, incorporating mammals, birds, fish, herpetofauna and crustacea into their diets and their craft activities. The habitat preferences of the diverse taxa recovered from the two sites provide a picture of the local terrestrial environments as one of open areas with grassland, scrub and low or mixed vegetation. Further investigation should be focussed on the taphonomy and dating of the microvertebrate fauna, including the *Mus* remains in particular, to explore their contemporaneity with the Early Neolithic settlement and the factors and agents relating to the accumulation of these remains. Seasonality evidence from the animal species identified positively indicate cold season activity at the sites, although there are no positive indicators for absence of human habitation in the summer months and the permanent water source and associated vegetation would have been an attractive location for both animals and humans. Some taxa active in the warmer months are also present, but it is less clear whether these were deposited by natural or anthropogenic activity.

Results on early animal management indicate an earlier date for the appearance of domestic goats in the western Zagros piedmont than previously known, occurring at least by *c*. 7700 BC. At Bestansur, these animals represent a relatively minor portion of the identified zooarchaeological assemblage, and therefore relatively low likely meat contribution, but occur in a context of regular usage of caprine dung fuel. In the relatively open environments below the treeline, this evidence implies that a renewable and controllable dung fuel source may have played an important role in the early spread and adoption of goat husbandry. The current evidence indicates sheep and pig remains represent hunted wild populations. Pigs, however, are notably well represented at both Shimshara and Bestansur, likely linked to favourable local environments for this taxon. Future work should investigate potential evidence for management of these animals.

16. EARLY NEOLITHIC ANIMAL MANAGEMENT AND ECOLOGY: INTEGRATED ANALYSIS OF FAECAL MATERIAL

Sarah Elliott
with contributions from Wendy Matthews and Ian Bull

Introduction: integrated approaches to animal management and domestication

The domestication of plants and animals is a complex process. Most researchers highlight the local and regional diversity of developments in human, plant and animal relationships in resource management, domestication and agriculture, which spanned several thousands of years, driven by ecological, biological and human cultural factors (Larson *et al.* 2014; Zeder 2015). Human engagement with animals varied at different times, rates and circumstances in multiple centres as a result of regionally specific factors, and for the core selected species resulted in managed and domesticated animals as part of either fully-fledged agricultural or pastoral economies or combinations of these (Abdi 2003; Willcox 2005).

The transition from mobile hunter-gathering to more sedentary farming–herding communities occurred in conjunction with other developments such as the introduction of storage and ground stone technology and architectural innovation (Flannery 1969). The early stages of domestication is an increasingly active area of inter-disciplinary scientific research (Zeder 2015). A further issue, suggested as a consequence of animal management and domestication, is the Secondary Products Revolution related to use of non-meat animal products, such as wool, fibres, dairy, traction, transport and dung (Sherratt 1981; 1983).

In many cases of agricultural emergence there is a delay of up to a thousand years between initial domestication and the development of zooarchaeologically detectable anatomical traits of domestication (Zeder 2011; 2015). Traditional methods of investigation into the domestication of animals are largely based on zooarchaeological data. More recently a range of other approaches has been taken, including genetic, isotopic and bimolecular methodologies (Colledge *et al.* 2013). A relatively recent avenue of research is that of the study of animal dung or faecal material (Olsen 2006; Portillo *et al.* 2012; 2014). Dung studies can be employed to examine animal management and domestication, secondary product use, animal diet, surrounding environment and ecology and the specific identification of animals present that produced dung.

Animal dung has in the past been interpreted from Epipalaeolithic sites in Southwest Asia based on charred assemblages (Miller 1996; Hillman *et al.* 1997) and has recently been directly identified in Epipalaeolithic sites (e.g. Arranz-Otaegui and Richter 2016c; Arranz-Otaegui *et al.* 2017). For the first time in the Neolithic, however, when humans were semi-sedentary and later fully sedentary, animals and their dung were more widely managed and concentrated for longer periods in particular localities. This situation presents a unique opportunity at Neolithic archaeological sites to recover and investigate faecal deposits, as concentrations of dung can be readily detected and analysed. In this chapter we examine the evidence from Neolithic Bestansur and Shimshara using a multi-proxy and multi-scalar approach to identify and analyse faecal material. These sites are located in the 'hilly flanks' of the EFC, a region proposed by Braidwood as a natural area for the domestication of goats (Braidwood and Howe 1960; Braidwood *et al.* 1983). In this study, results from Bestansur and Shimshara in the lower Zagros are compared with evidence from the Iranian Early Neolithic sites of Sheikh-e Abad and Jani in the high Zagros mountains (Matthews *et al.* 2013a; Elliott 2015).

Research context and rationale

The identification of early animal management is a challenge to archaeological research. It is now widely recognised that morphological changes in animal skeletons are not leading-edge indicators of domestication (Zeder 2006). Defining and identifying animal management and domestication in Southwest Asia is a key research issue considered by numerous scholars. Explanations for the domestication process are incomplete because an increase in data has led to greater awareness of inter-regional variability (Conolly *et al.* 2011). Furthermore, many early animal domestication episodes are both archaeologically and genetically poorly documented. A clearer framework for identifying and understanding patterns of animal domestication is increasingly emerging (Larson and Fuller 2014). Few studies, however, have applied analysis of faecal material within wider integrated projects (Portillo *et al.* 2012; Stiner *et al.* 2014). In this chapter a new integrated and multi-methodological approach to dung studies is investigated in order to examine a range of key topics in Neolithic research.

Zeder emphasises that "domestication is a multifaceted relationship involving both biological and cultural processes" between management, domestication and agriculture (Zeder 2015). Therefore, single-factor scenarios should be rejected, and a range of multi-faceted approaches should be considered, such as alternative markers for animal management and domestication in conjunction with zooarchaeological analyses. One developing methodology for the identification of animal management and domestication involves the investigation of herbivore dung by micromorphological analysis, and of compacted laminated layers as indicators of penning. This method has already provided new independent evidence for early animal penning and management from at least *c.* 8000 BC in the Zagros at Sheikh-e Abad (W. Matthews 2010; W. Matthews *et al.* 2013h; Elliott 2015). This chapter focuses on analysis of animal dung as a potential marker of increased animal presence, management, domestication and sedentism.

Research aims and objectives

This research aims first to investigate the potential of animal dung studies as an additional approach to early identification of animal management and domestication. The second aim is to critically examine the concept of a Secondary Products Revolution, which has often been described as a consequence of domestication and a later development, by examining evidence for use of dung in a range of levels at Bestansur and Shimshara. Until recently, archaeobotanical analysis of charred plant remains has been the principal technique for identification of dung as charred pellets or by identification of a range of typical 'dung taxa' (Charles 1998). Charred macrobotanical remains, however, represent only plants that have been exposed to fire and low temperature burning (W. Matthews 2010), and dung deposits are often not recoverable by water-flotation for macrobotanical analyses when not charred. A third aim in this research, therefore, is to develop a methodology that enables detection and examination of both burnt and non-burnt faecal deposits in the field as well as in specialist laboratories. A range of key research questions therefore are examined here to contribute to the overall project objectives:

- How can analysis of faecal matter on archaeological sites be more readily conducted in the field, and how can a multi-proxy approach be effectively applied to identify faecal matter type, content and context?
- Does detected faecal matter represent herbivores or omnivores, including potentially humans? What ranges of animals are represented at the study sites? How does this range inform on local and regional strategies in early animal management and domestication?
- Were animals brought into the built environment and penned? If so, how does this practice inform on early stages of animal management and domestication and interactions with humans?
- How extensively was dung used as a secondary product in the Early Neolithic? Was dung burnt as a fuel and/or used in construction for tempering? Could secondary products, such as dung, have been a driver for domestication as Hesse (1984) suggested?
- What was the diet of animals in the Early Neolithic sites? How can it inform on ecology and environment and the presence of wetland, dryland or woodland resources as well as foddering and grazing/browsing patterns?

Research approaches and methods

We have developed an integrated field and laboratory approach to the location, identification and analysis of faecal material. The field methods consist of identification of elevated phosphorus using portable x-ray fluorescence (pXRF), spot-sampling of selected sediments, in-field microscopic smear-slide analysis and micromorphology soil block sampling. These integrated methods were initially developed at Çatalhöyük (Bull *et al.* 2005; W. Matthews 2005; 2010; Matthews *et al.* 2013f) and in the excavation and post-excavation stages at Sheikh-e Abad and Jani from 2008 (Matthews *et al.* 2013a), while the use of pXRF as a rapid screening method was developed and applied here for the first time in archaeology in an integrated methodology for identification of dung. The laboratory methods include sub-sampling of micromorphological blocks prior to impregnation to obtain high-resolution spot samples for extraction of silica phytoliths for the investigation of animal diet and environment and ecology, and GC-MS analysis for the confirmation of faecal material and identification of faecal origin, as well as *in situ* micromorphological examination and investigation of faecal deposits in large resin-impregnated thin-sections.

Sample selection using pXRF and smear-slide analysis

The aim of using pXRF and smear-slide analysis was to locate, identify and sample dung deposits. The pXRF was used to locate phosphorus rich deposits potentially indicative of animal dung which could then be spot-sampled and further analysed in the field laboratory. The spot-sampling programme and field microscopic smear-slide analysis were employed to identify calcareous spherulites, which are one key indicator of animal dung (Canti 1997; 1998; 1999). The areas for pXRF and spot smear-slide analysis were selected in consultation with the excavators and included a wide range of contexts including internal spaces, external spaces, occupation deposits, floors, surfaces and fire installations, sampled from all trenches during three seasons of excavation.

pXRF

The primary hypothesis and rationale for use of pXRF as a rapid-screening method for detection of dung (Matthews and Matthews 2010), is that elevated levels of phosphorus (P) in archaeological deposits may be one indicator of the presence of animal dung (Proudfoot 1976; Holliday and Gartner 2007), although a wide range of other materials and deposits also contain P.

A standard pXRF procedure applied to archaeological deposits at Bestansur was implemented for *in situ* rapid geochemical analysis, maximising the time available for analysis. The procedure for all pXRF analyses in the field was as follows, using a Niton XL3t GOLDD+ pXRF analyser. Polypropylene film was secured over the nose cone prior to analysis in the field to protect the analysing window from contamination and was changed regularly. A backscatter shield was used to reduce the risk of radiation during analysis. For all samples the analyser was operated in the 'mining mode'. The 'mining mode' allows the analyst to perform tests on soil and other bulk samples without adjusting for a particular matrix which is ideal for finding concentrations elements in rock or soil (Niton 2010). In this mode a total of 34 elements are measured, and elements lighter than magnesium cannot be detected (Niton 2010). Each sample in this research was analysed for a standardised duration which consisted of a 60 second count time with the instrument running for 10 seconds on the main filter, 10 seconds on the low filter, 10 seconds on the high filter, and 30 seconds on the light filter. The light filter measures phosphorus, the targeted element in this research. The limit of detection (LOD) parameter for each element describes the ability of the analyser to identify the absence or presence of an analyte in a sample, calculated using 3 sigma (values lie within three standard deviations of the mean). For each sample analysed, the Niton pXRF analyser records the limit of detection. For the phosphorus values above 4000ppm the values were corrected for instrument calibration/error. The instrument was tested against NIST standard reference materials and the instrument values for phosphorus below 4000ppm were accurate, but above this value the instrument does not have a linear calibration. Therefore a linear regression equation was applied to correct the high phosphorus values, allowing adjustment of high values based on the linear correlation between known and actual values (see Elliott 2015).

Spot sampling and smear-slide analysis

The inclusion of spot sampling and smear-slide analysis in the field is pivotal to this project's methodology. The aim of these rapid and cost-effective field methods was to test whether elevated phosphorus levels relate to the presence of animal dung. This method was conducted by investigating the archaeological deposits to potentially identify faecal spherulites (W. Matthews 1999), which are a strong indicator of animal dung and are formed in the guts of animals during digestion (Canti 1997). The procedure followed for spot sampling was as follows. All the locations analysed by pXRF were labelled during analysis. All *in situ* deposits analysed by pXRF were spot sampled, irrespective of phosphorus content, to create an archive of soil samples from all pXRF locations. Spot samples of approximately 0.5–1.5g were subsequently placed directly into sample bags. The size of the spot sample was based on thickness and extent of the targeted context. All spot sample locations were marked on the appropriate plan or section to record the sampling location.

The procedure for smear-slide analysis of spot samples was as follows: smear-slides were prepared by placing approximately 200–300mg of sediment, *c.* two to three small aggregates/crumbs, onto a 7.6 × 2.6cm microscope slide. Five to six drops of clove oil were added to the sediment and gently mixed with a wooden toothpick to disaggregate the sediment and spread the medium to the approximate area of the coverslip (22 × 22mm). The coverslip was slowly lowered over the medium using the clean end of the wooden toothpick to avoid air bubbles. Immediate assessment of smear-slides was carried out in the field laboratory using a Leica DMEP at a magnification of ×400 in both plain and crossed polarised light (PPL and XPL). Numbers of probable faecal spherulites and types of phytoliths were recorded.

Micromorphology

To investigate the significance and microstratigraphic context of the deposits with elevated phosphorus and faecal spherulites identified in spot samples, micromorphology soil block samples were then selected from key areas in consultation with excavators in the field. These block samples enabled probable faecal deposits to be examined using a wide range of additional integrated analytical methods. Once collected the soil micromorphology blocks were sub-sampled in the laboratory (W. Matthews 2005; 2010). Procedures for micromorphological thin-section preparation in this research were developed by the University of Reading Archaeology Department based on internationally standardised protocols (Courty *et al.* 1989; Goldberg *et al.* 2006; see also Chapter 12).

For each identifiable stratigraphic layer and boundary in thin-section, detailed observation and description was carried out using internationally standardised handbooks (Bullock *et al.* 1985; Courty *et al.* 1989). Observations were conducted in plane polarised and cross polarised light (PPL and XPL) at both low and high magnifications (×40, ×100, ×200 and ×400). The attributes were identified and recorded following standardised published terminology and descriptive criteria (Bullock *et al.* 1985; Courty *et al.* 1989; Stoops 2010). Each identifiable area of faecal material was located and classified within each sample as a 'Faecal Deposit' and given a Faecal Deposit number (e.g. SA350, D1, D2, D3). For each specific Faecal Deposit identified in the microstratigraphic units within the micromorphology samples, 36 characteristics and attributes (where applicable) were documented in order to obtain the maximum information on material origin, deposition and post-depositional alterations. These 36 characteristics follow the standardised published terminology and descriptive criteria usually applied to the microstratigraphic units as a whole (Bullock *et al.* 1985; Courty *et al.* 1989; Stoops 2010). All attributes in this study were applied to the description of identified faecal material instead of the entire microstratigraphic layer, due to the specialist and interdisciplinary focus of this research and time-constraints. The relevance of each of these characteristics to dung studies is detailed in Table 16.1. The identified Faecal Deposits were assigned to 'Faecal Types' which were also classified during analysis (Table 16.2) based on observations during analysis and comparisons with published literature (Brochier *et al.* 1992; Macphail *et al.* 1997b; Anderson and Ertuğ-Yaraş 1998; Canti 1998; 1999; Shahack-Gross *et al.* 2005; Portillo and Albert 2014; Stiner *et al.* 2014).

Phytoliths

Based on the results of the thin-section analysis, specific sub-samples were selected from those samples collected from the soil blocks prior to resin-impregnation. Phytolith assemblages were extracted and analysed from these sub-samples to enable the study of a diverse range of indicators of animal dung, diet and ecology. The aim was to extract silica phytoliths from a range of samples taken directly from significant dung layers or locations and to correlate these results directly related to dung layers identified and analysed using microscopic thin-section analysis. Phytoliths can be located and identified in micromorphological thin-sections and quantified as a percentage of the area or layer within a sample (W. Matthews 2010). In spot samples, extracted phytoliths are statistically quantified by ensuring a minimum count of 200 identifiable phytoliths (Ball *et al.* 1996; 1999; Albert and Weiner 2001; Piperno 2006; Strömberg 2009). Therefore a combination of micromorphology and phytolith analysis enables high-resolution analysis of both the location and context of faecal material as well as statistical quantification of the phytolith assemblage within specific faecal deposits (Shillito *et al.* 2008). The samples for phytolith analyses were subsampled from the micromorphology blocks and then processed at the University of Reading following the protocols developed by Rosen (1999) and as employed in previous CZAP research at Sheikh-e Abad (Shillito and Elliott 2013).

Microscope slides were examined under a Leica DMEP transmitted light microscope at magnifications ranging from ×200 to ×400. Full counts were obtained by counting a minimum of 250 identifiable phytoliths (where applicable). The phytoliths were counted and categorised into types according to the International Code for Phytolith Nomenclature (ICPN) (Madella *et al.* 2005). Phytoliths were further classified as deriving either from woody (dicotyledon) or non-woody (monocotyledon) taxa. Identification of phytoliths was based on pictorial reference guides (Wang and Lyu 1992), University of Reading comparative modern reference collections and online databases (Fuller 2007a; Albert *et al.* 2014).

GC-MS

The GC-MS analysis of the bile acids and coprostanols

Table 16.1. (continued overleaf) Table detailing the relevance of dung characteristics described for all Faecal Deposits identified.

Characteristic	*Example and/or variations*	*Significance for interpreting animal dung deposits*
Dung Classification	e.g. 1.1, 2.2 (see Table AW)	Main Dung Types and Sub-Types
Dung location	e.g. D1, D2, D3	Specific location of dung deposit in samples relating back to dung database and description
Dung 'layer' thickness	applicable only when dung deposits form a layer	Inferences about duration of animal occupation/penning. For example cattle pen occupied for 10–15 years resulted in 20cm of dung after degradation (Shahack-Gross *et al.* 2003), and experimental work has shown that 1m of dung results in a 2–3cm layer (Shahack-Gross *et al.* 2005).
Overall unique diagnostic	e.g. lots of spherulites, dense and compact	Used during analysis to highlight difference in forming dung classifications
Colour	e.g. orangy brown, browny orange, grey	Often indicates a clear distinction between herbivore and omnivore dung
Phytolith %	percentage of deposit	Concentration will vary depending on diet. Herbivores generally have a very high percentages compared with omnivores. Omnivores have a mixed diet compared with herbivores which solely consume on plants
Phytolith type	e.g. monocots, dicots, multicells identified to *genus*	Type will vary according to diet. Therefore phytolith remains are indicative of animal diet, seasonality of grazing, foddering regimes. Grass rich and grass poor diets can be identified.
Phytolith size	e.g. small, medium, large	May reflect taphonomy and preservation
Phytolith articulation (comminution)	e.g. single celled or multicelled/conjoined	May reflect taphonomy and preservation, for example bioturbation. Herbivore dung contains more conjoined phytolith forms in comparison to omnivore dung which contains more single celled forms. Conjouined phytoliths may form a linear/parallel layer in penning contexts.
Phytolith preservation	e.g. pitting, etching, dissolved, burnt, melted	Indication of overall preservation of dung deposit, may be the reason for low percentages in specific deposits. Melted silica could represent dung fuel
Spherulite %	percentage of deposit	High percentage of spherulites produced by Herbivores and low percentage by omnivores. Although absence needs to take into consideration dissolution of spherulites due to high pH (above 6/7) or high temperatures (650–700°C). Spherulite numbers are higher in modern dung samples compared to archaeological deposits (Albert *et al.* 2008).
Spherulite details	e.g. single, grouped, faint	Could indicate preservation, bioturbation, masking by deposits and indicate herbivore vs. omnivore (see above)
Spherulite size	e.g. <5μ, 5μ, 10μ, >10μ	Could potentially link to species. More research needed on spherulite morphology. This parameter could become useful in the future. Generally spherulites are beween 5 and 15 μ
Visibility of spherulites and phytoliths	e.g. masked, clear	Indicates how easily identified dung deposits are. Dung could be present but visible poor to locate
Quick reference matrix details	e.g. dense with planes and laminated or spherulites not within dung matrix	Used during analysis To highlight difference in forming dung classifications. Deposits without dung matrix could indicate mixed deposits or fully combusted dung
Observational visibility-light (PPL/XPL)	e.g. Spherulite outline visible in PPL and cross of extinction visible in XPL	Indicates how easily identified dung deposits are. Dung could be present but visible poor to locate
Microstructure (and voids)	e.g. vughy/spongy, planes/channels/chambers	Size, shape and arrangement of grains/aggregates/voids within dung deposits could vary between dung types and certain voids could indicate trample and compaction during penning (e.g. channels and planes, indicating microlamination from trampling)
Related distribution	e.g. embedded, linked and coated, coated, intergrain aggregate	The relationship between coarse and fine material may represent significant differences between dung types or may represent post depositional alterations such as compaction/trampling
Orientation	e.g. strongly orientated parallel	Inclusions such as phytoliths could be distributed parallel indicating trample and compaction during penning. Microlaminations orientated parallel further indicates trampling. The perpendicular arrangement of inclusions and microlaminations represents the direction of force from above
Distribution	e.g. linear	Inclusions such as phytoliths could be arranged linear to the boundary indicating trample and compaction during penning
Particle size	e.g. silty clay, silt loam	There may be significant variation in particle size between different dung types. Particle size may also reflect the presence of micro-particles and how susceptible these are to movement within a dung deposit or specific micro unit. Also particle size may affect the degree of post-depositional alteration of dung deposits for example by water drainage, or bioturbation by small roots
Coarse/fine ratio	e.g. 10:90	Ratios may differ between types of dung
Coarse/fine ratio limit	e.g. pine particle limit-10 microns, beyond 10 microns=coarse material	Additional details given to coarse/fine ratio

Table 16.1. (continued from previous page) Table detailing the relevance of dung characteristics described for all Faecal Deposits identified.

Characteristic	*Example and/or variations*	*Significance for interpreting animal dung deposits*
Sorting	e.g. well sorted, unsorted	Indicates degree of variability or uniformity within the dung deposit
Fine material (less than 20μ)	e.g. organic or mineral	A higher percentage of organic material is indicative of herbivore dung. Higher mineral content may be indicative of omnivore dung, specifically pig or wild boar which are prone to rooting for food rather than grazing. Alternatively fine mineral material in addition to fine organic material may represent a mixed deposit. A defined dung deposit may contain only organic fine material.
Fine material colour	e.g. brown, orange, grey	Gives the deposit the overall appearance of colour and can generally be related back to species
Birefringence fabric, and minerals	e.g. undifferentiated, crystallitic, isotropic	Omnivore dungs generally have an undifferentiated/isotropic birefringence compared to herbivore dungs which are generally crystallitic
Other plant remains, type	E.g. charred, calcitic ashes	Plant burning at low temperatures (charred plant remains) or high temperatures (calcitic ash). When associated with spherulites indicates use of dung as fuel. Charred plant remains may originate from dung or input of other fuel such as wood.
Other plant remains, %	percentage of deposit	Could distinguish between dung fuel (lower percentage of charred plant remains and higher percentage of ash) and perhaps duel fuel; wood and dung (equal ash to charred plant remains). Also indicative of burning temperatures. Charred plant remains only represent burning at low temperatures
Other plant remains, size	e.g. small, medium, large	Could be indicative of preservation, bioturbation, fragmentation, taphonomy
Other inclusions, type	e.g. bone, molluscs	Presence of bone in dung indicates omnivore dung. Omnivore diet includes meat, bones, carrion etc.
Other inclusions, %	percentage of deposit	Could distinguish between different dung deposits, a large percentage of bone inclusions could represent dog, pig or wild boar as opposed to human
Other inclusions, size	e.g. small, medium, large	Could be indicative of preservation, bioturbation, fragmentation, taphonomy. Small, fragmentary and partially digested bone is indicative of omnivore dung
Microbiological inclusions	e.g. parasites and coprophilous fungi	Could specifically be analysed in the future. The presence of coprophilous fungi, is a further dung indicator-it is known as 'dung-loving' fungi. Specific parasites may be able to be related back to species
Microbiological %	percentage of deposit	A high percentage of parasites in the absence of other dung markers (such as spherulites) could further help identify and confirm dung locations
Post depositional features	e.g. bioturbation, compaction, shrink/swell	Could be factor affecting preservation, mixing of deposits or movement of micro particles such as spherulites and phytoliths. Should be taken into consideration during analysis

Occupation Residues		**Fill**	
Range	0-31250ppm	Range	0-3002ppm
Positive readings	667-31250ppm	Positive readings	817-3002ppm
Maximum reading	31250ppm	Maximum reading	3002ppm
<LOD	59 samples	<LOD	9 samples
667-31250 ppm	84 samples	667-31250 ppm	20 samples
'Natural'		**Feature**	
Range	0-1227ppm	Range	0-2604ppm
Positive readings	841-1227ppm	Positive readings	611-2604ppm
Maximum reading	1227 ppm	Maximum reading	2604ppm
<LOD	2 samples	<LOD	4 samples
667-31250 ppm	2 samples	667-31250 ppm	4 samples
Mixed		**Cluster**	
Range	0-1241ppm	Range	0-1761ppm
Positive readings	700-1241ppm	Positive readings	924-1761ppm
Maximum reading	1241ppm	Maximum reading	1761ppm
<LOD	3 samples	<LOD	12 samples
667-31250 ppm	5 samples	667-31250 ppm	8 samples
Fire Spot		**Surface**	
Range	0-3681ppm	Range	0-2480ppm
Positive readings	867-3681ppm	Positive readings	1494-2480ppm
Maximum reading	3681ppm	Maximum reading	2480ppm
<LOD	7 samples	<LOD	4 samples
667-31250 ppm	8 samples	1323	9 samples
Packing			
Range	n/a		
Positive readings	1323ppm		
Maximum reading	1323ppm		
<LOD	n/a		
1323	1 sample		
Accumulation		**Wall**	
Range	n/a	Range	n/a
Positive readings	n/a	Positive readings	n/a
Maximum reading	0	Maximum reading	0
<LOD	4 samples	<LOD	9 samples

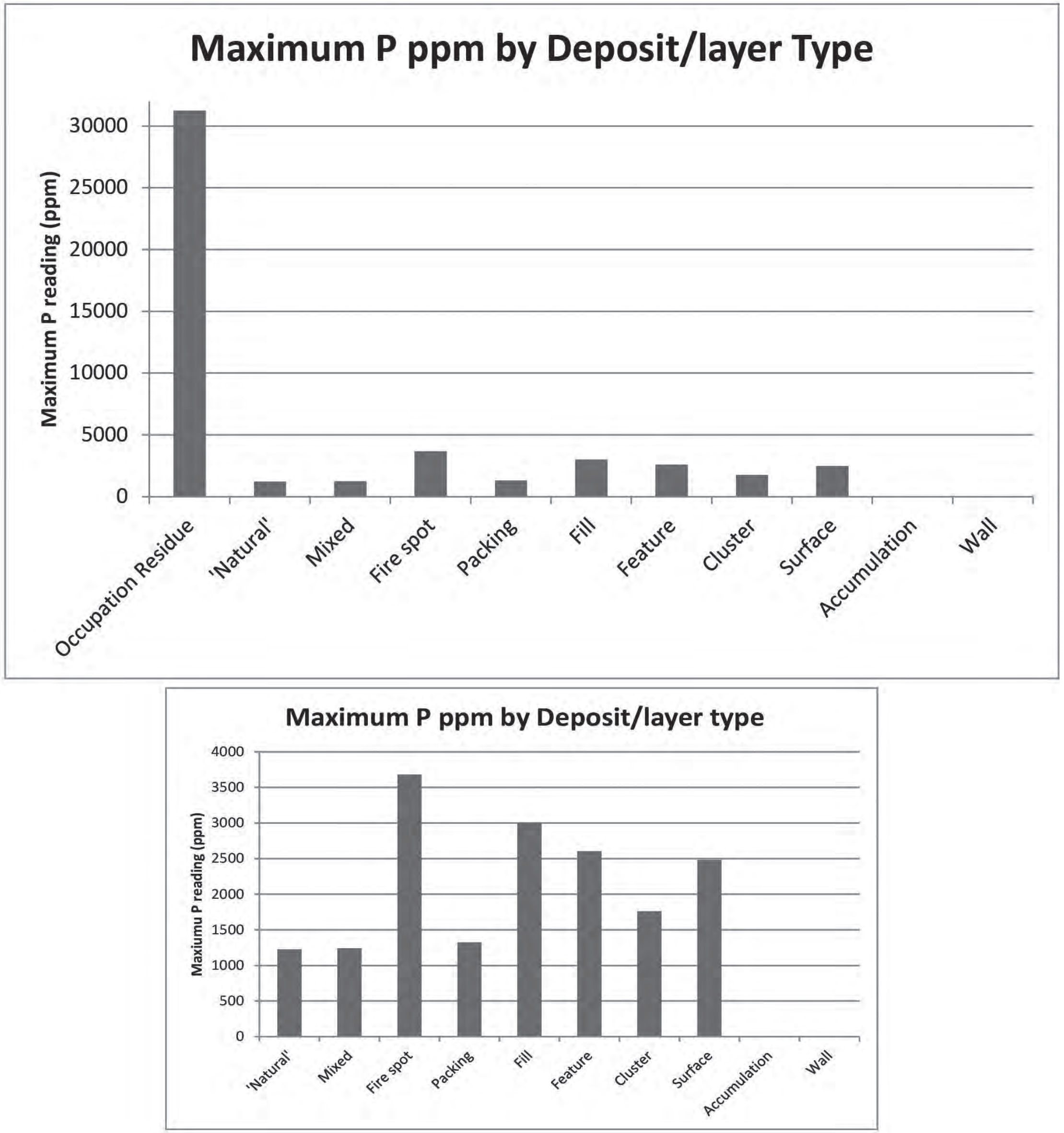


Figure 16.1. Left: Summary table showing the phosphorus readings (in ppm) for all samples from Bestansur, indicating the range, the maximum and minimum positive readings, maximum reading, number of samples <LOD and number of samples with positive readings. Right top: Maximum phosphorus value by Deposit/layer Type for all Deposit/layer types. Right bottom: Same graph with Occupation residues removed to show more clearly the differences between the other categories.

was conducted in order to ascertain firstly, whether biomolecular traces of dung were present and can be used to confirm the microscopic identifications of dung, and secondly, whether these traces may indicate which animal type/genus had produced the dung and or whether some coprolites were human in origin (Bull *et al.* 1999b; 2002). Distinction between ruminant and omnivore coprolites is possible using coprostanols, and further distinction between human and pig faecal material can be achieved by analysis of bile acids (Bull *et al.* 2002). The methodology for the extraction of faecal sterols and bile acid molecules is the standard procedure followed at the LSMSF based on Bull *et al*. (1999a) for sterol biomarkers, and a modified version of the methodology proposed by Elhmmali *et al*. (1997) for bile acids. The GC-MS methodology was consistent with that applied to the samples from Sheikh-e Abad and Jani (Shillito *et al.* 2013c).

Results

The pXRF and spot-smear-slide results are briefly summarised here first, as the focus of the rest of this chapter is on the more specific results from the micromorphology, phytolith and GC-MS analyses. Full results are reported in detail in Elliott (2015).

pXRF and smear-slide analysis results

During three seasons of excavation at Bestansur and a short investigation at Shimshara, a total of 281 pXRF analyses were conducted (Bestansur: 279; Shimshara: 2). A full suite of 34 elements was recorded in each location targeted for analysis. The aim was to recognise elevated levels of phosphorus potentially indicative of faecal deposits. From the 281 pXRF locations a total of 98 spot samples were selected for smear-slide analysis (96 from Bestansur and two from Shimshara). The smear-slides were analysed in the field to identify probable faecal spherulites, which exhibit a distinctive cross of extinction under crossed polarised light.

Bestansur

A range of off-site natural control samples were analysed using pXRF. These samples were collected from areas within the vicinity of the mound with no obvious or significant anthropological input from deposits *c.* 20–30cm below the modern ground surface. These control samples were all below the limit of detection (<LOD) for phosphorus using the pXRF analyser, and the LOD was therefore selected as a baseline from which to measure elevated levels of P. Some of the archaeological deposits from the trenches were described during excavation as 'natural' but two of these deposits allocated to this *Deposit/layer Type* tested with the pXRF analyser were elevated for phosphorus (841–1227ppm P, e.g. Trench 4 C1087) and are likely to have some anthropogenic input.

Of the 279 locations investigated at the Neolithic site of Bestansur by the pXRF analyser, 161 locations indicated elevated phosphorus levels, above the limit of detection >LOD. The elevated phosphorus levels ranged from 612 to 31,250ppm (corrected for instrument calibration/error above 4000ppm). All the results from Bestansur were divided into the ten *Deposit/layer Types* present in the deposits analysed by the pXRF (topsoil excluded). A summary of the range and maximum pXRF reading for phosphorus by *Deposit/layer Type* is presented in Figure 16.1. Two of the types clearly indicate that phosphorus is not elevated within these categories. These types are *Walls* and *Accumulation deposits*. The maximum phosphorus value for each of the *Deposit/layer Type* is presented in Figure 16.1 graphs. *Clustered* deposits, *Mixed* deposits, '*Natural*' deposits and *Packing* contain lower phosphorus levels. *Features, Fills, Fire spots* and *Surfaces* contain higher levels of phosphorus, and the remaining *Deposit/layer Type*, the *Occupation residues* (particularly from the northern area of the site in Trench 12), contain the highest phosphorus levels. *Occupation deposits* include materials such as ash, organics and bone remains.

The remaining 118 samples were below the limit of detection for phosphorus (<LOD) and included some deposits in each of the *Deposit/layer Types*. The two categories with all samples below the limit of detection were *Accumulation* and *Wall* deposits (Fig. 16.1).

Phosphorus is not specific to faecal material and phosphorus levels can also be elevated in other anthropogenic deposits of diverse origin. Phosphorus detection is more generally used for the identification of human occupation and can offer clues regarding type and intensity of human activity (Akyol and Demirce 2005b; Holliday and Gartner 2007). Phosphorus in archaeological deposits can indicate human refuse/waste, human/animal bones, areas of food production or animal dung (Holliday and Gartner 2007; Wilson *et al.* 2008; Shahack-Gross 2011; Lancelotti and Madella 2012). As phosphorus is non-specific to faecal material, samples with elevated phosphorus levels were therefore targeted for smear-slide analysis to identify probable faecal spherulites which can further confirm the presence of faecal material. Smear-slides analysed with elevated phosphorus and from ashy deposits were always identified with probable faecal spherulites. These locations were therefore targeted for sampling of micromorphological soil blocks to examine faecal deposits *in situ* and a range of further microanalyses.

Shimshara

The same research methods were implemented in the field at Shimshara over a short 2 day investigation

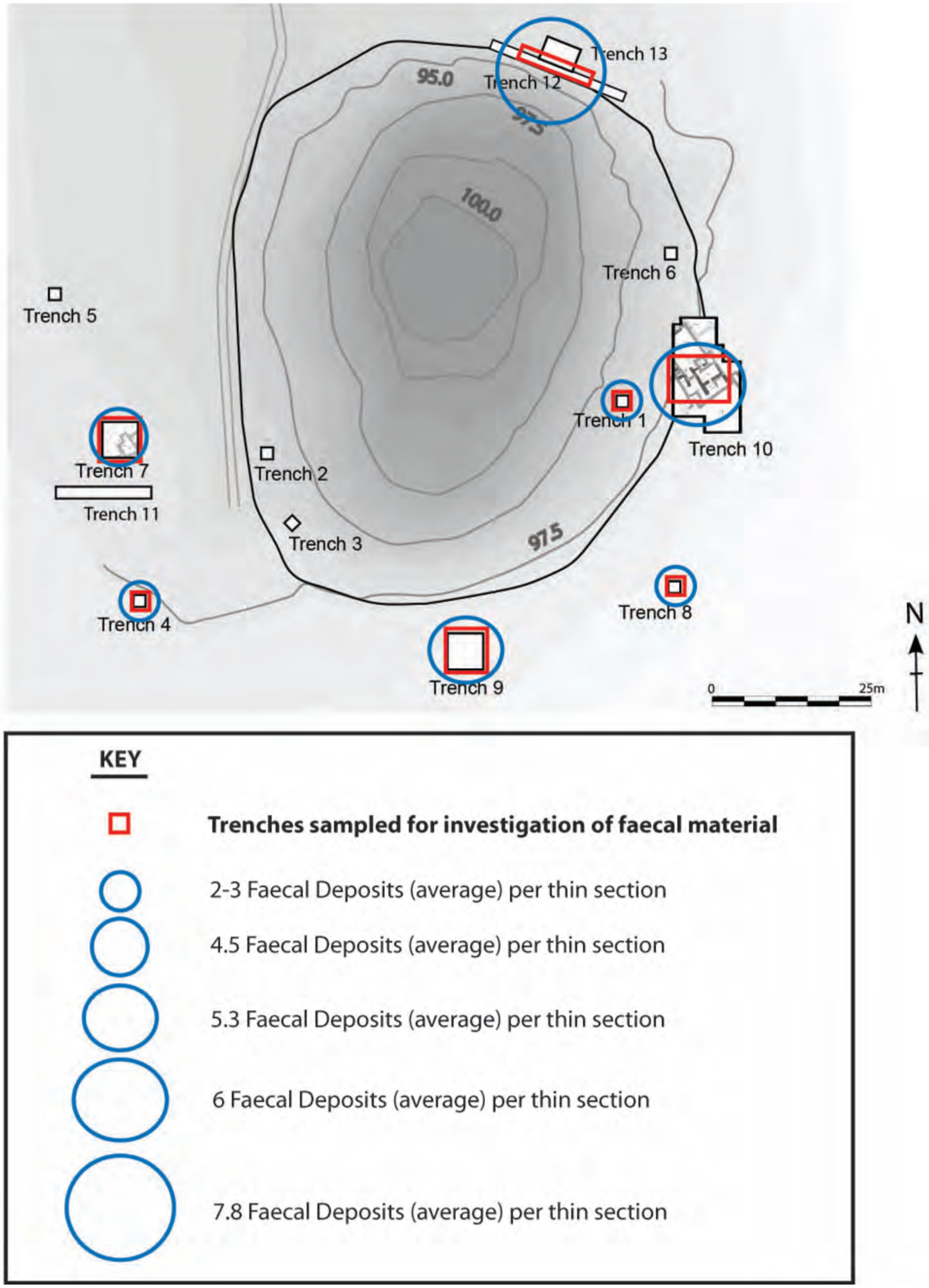


Figure 16.2. Bestansur trenches sampled for investigation of faecal material indicating the average number of Faecal Deposits identified per micromorphological thin-section for each trench analysed.

Table 16.2. Faecal Types detailing Major Faecal Category with sub-category details.

Faecal Type	***Major faecal category**, and sub-category details*
1/ low faecal material/single spherulites/poor preservation:	
1.1	Single spherulite, standard size
1.2	Single spherulite, larger size, no phytoliths
1.3	Single spherulite, none–low phytoliths
1.4	Single spherulite, low–medium phytoliths
1.5	Single spherulite, low phytoliths, charred/burnt material
1.6	Single spherulite, none–high phytoliths, charred
2/ probable herbivore:	
2.1	Low–high (1–40%) spherulites, none–low (<1%) phytoliths, burnt and defined
2.2	Low–high (2–30%) spherulites, none–low phytoliths (0–5%), charred/ash
2.3	Low spherulites (<1–5%), medium–high phytoliths (10–80%), charred/ash
2.4	Medium spherulites (5%), medium–high phytoliths (10–40%), charred material, laminated
2.5	Low (<1–5%) spherulites, none–medium phytoliths (0–5%), charred/ash
2.6	Low–high spherulites (<1–20%), high phytoliths (20–90%), laminated and charred/ash
2.7	Medium–high spherulites (10–40%), medium–high phytoliths (5–30%), laminated, defined
3/ probable omnivore:	
3.1	No spherulites (0%), no phytoliths (0%), bone
3.2	No spherulites (0%), no phytoliths (0%), amorphous, bone
3.3	None–low spherulites (0–1%), low–high phytoliths (<1–50%), charred/ash
3.4	Low spherulites (<1%), no phytoliths (0%), bone, charred material
3.5	Low spherulites (2%), low phytoliths (2%), bone, charred material
3.6	Low–medium spherulites (<1–5%), none–high phytoliths (0–50%)
3.7	Low spherulites (1%), no phytoliths (0%)
3.8	Low–high spherulites (<1–30%), low–high phytoliths (<1–40%), charred material
4/ herbivore:	
4.1	Low–high spherulites (<1–95%), none–medium phytoliths (0–5%), degrading, charred/ash
4.2	Low–high spherulites (1–50%), none–high phytoliths (0–40%), burnt/ash
4.3	Medium–high spherulites (10–95%), none–medium phytoliths (0–10%)
4.4	High spherulites (20–50%), medium–high phytoliths (5–30%)
4.5	High spherulites (20–95%), medium–high phytoliths (10–30%), laminated
4.6	High spherulites (80–95%), low–high phytoliths (1–20%), burnt/ashed
5/ omnivore:	
5.1	Low spherulites(<1–1%), low–high phytoliths (<1–20%), bone

Category	*Overall % range*
No/None	0%
Low	<1–5%
Medium	5–10%
High	20–95%

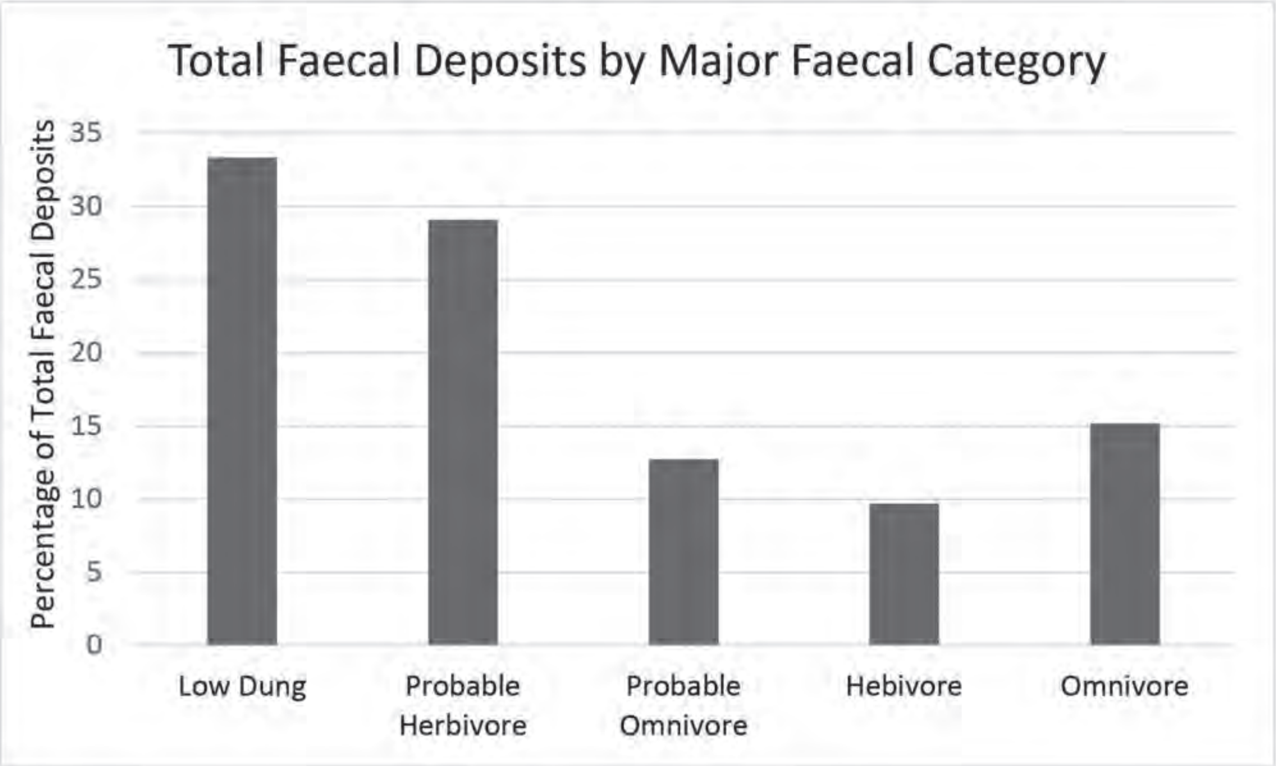
in 2012. The two locations were preliminarily tested by pXRF to look for elevated phosphorus: one from an ashy deposit and the other an orange-brown deposit containing clay aggregates and molluscs. Both samples had elevated phosphorus levels (>LOD) between 2827 and 5017ppm (corrected for instrument calibration/error above 4000ppm). These levels were similar to the higher values at Bestansur (Trench 12). Both locations with elevated phosphorus were analysed by smear-slide analysis and both locations were identified with probable faecal spherulites.

Micromorphology results

A total of 38 micromorphological soil blocks were collected and examined targeting the identification and analysis of Faecal Deposits (33 from Bestansur and five from Shimshara). Sample locations were selected at Bestansur based primarily on the field results that indicated the presence of faecal material (phosphorus and probable faecal spherulites identified using pXRF and smear-slide analysis). The samples from Bestansur were collected from Neolithic contexts in seven trenches in the lower slopes of the Neolithic mound and below in the surrounding fields (Fig. 16.2). At Shimshara, due to time restrictions, the archaeological sediments were assessed visually and areas targeted

Table 16.3. Faecal Types detailing sample numbers, microstratigraphic units and trenches, Bestansur.

Faecal Type	Main Faecal classification, and sub-category details	Samples/units	Trenches
	1/Low dung/single spherulites/poor preservation:		
1.1	Single spherulite, standard size	S285 U1, S350 U2, S352 U1, S354 U1, S449 U2, S651 U1, S652 U2, S675 U1, S678 U1, S818 U1, S967 U1, S969 U2, S1081 U2, S1185 U3	4, 7, 8, 9, 10, 12
1.2	Single spherulite, larger size, no phytoliths	S353 U1	4
1.3	Single spherulite, none–low phytoliths	S353 U2, S359 U1, S360 U3	1, 4, 8
1.4	Single spherulite, medium phytoliths	S325 U3	9
1.5	Single spherulite, medium phytoliths, charred/burnt material	S326 U2	9
1.6	Single spherulite, none–high phytoliths	S326 U2, S352 U2, S657 U1, S679 U1, S818 U1, S968 U1	7, 9
	2/Probable herbivore:		
2.1	None–low spherulites, low–medium phytoliths, burnt and defined	S359 U1	1
2.2	Low spherulites, none–low phytoliths, charred/ash	S967 U1	9
2.3	Medium spherulites, high phytoliths, charred/ash	S968 U1, S1081 U1 & U2	9, 10
2.4	Medium spherulites, medium–high phytoliths, laminated	none	
2.5	Low–high spherulites, none–medium phytoliths	S350 U2 &U3, S356 U1, S449 U2, S651 U1, S652 U2, S656 U1, S657 U1, S673 U1, S675 U1, S678 U1, S679 U1, S967 U1, S968 U1, S969 U2, S1079 U1, S1081 U2	1, 7, 8, 9, 10
2.6	Low–high spherulites, low–high phytoliths, laminated	S1080 U4	10
2.7	High spherulites, medium–high phytoliths, laminated, defined	none	
	3/Probable omnivore:		
3.1	No spherulites, no phytoliths	S678 U1, S1078 U5, S1185 U3, S1186 U5 & U6	7, 12
3.2	No spherulites, none–low phytoliths, bone	none	
3.3	None–low spherulites, low–high phytoliths	S657 U1, S818 U1, S1078 U1 & U3,	7, 12
3.4	Low spherulites, none–low phytoliths, bone, charred material	S656 U1,	7
3.5	Low spherulites, low phytoliths, bone, charred material	none	
3.6	Low–medium spherulites, medium–high phytoliths	S818 U1, S1078 U5,	7, 12
3.7	Medium spherulites, no phytoliths	S1099 U2,	9
3.8	Medium spherulites, low–high phytoliths	S678 U1, S1078 U3 & U5, S1186 U2 & U6,	7, 12
	4/Herbivore:		
4.1	Low–high spherulites, low–medium phytoliths, degrading	S285 U2, S286 U3, S656 U1,	7, 9
4.2	Medium–high spherulites, low phytoliths, burnt/ash	S449 U2, S967 U1, S1099 U2, S1186 U6	9, 12
4.3	High spherulites, none–medium phytoliths	S1099 U3	9
4.4	High spherulites, medium–high phytoliths	S967 U1	9
4.5	High spherulites, low–high phytoliths, laminated	none	
4.6	Very high spherulites, low–high phytoliths, burnt/ash	none	
	5/Omnivore:		
5.1	Low spherulites, low–high phytoliths, bone	S1078 U3, S1080 U2, S1183 U1,U2, U3, U4, U6, U7, U8 & U9, S1184 U2, U3, U5, U6, U7 & U8, S1185 U4 & U5	10, 12



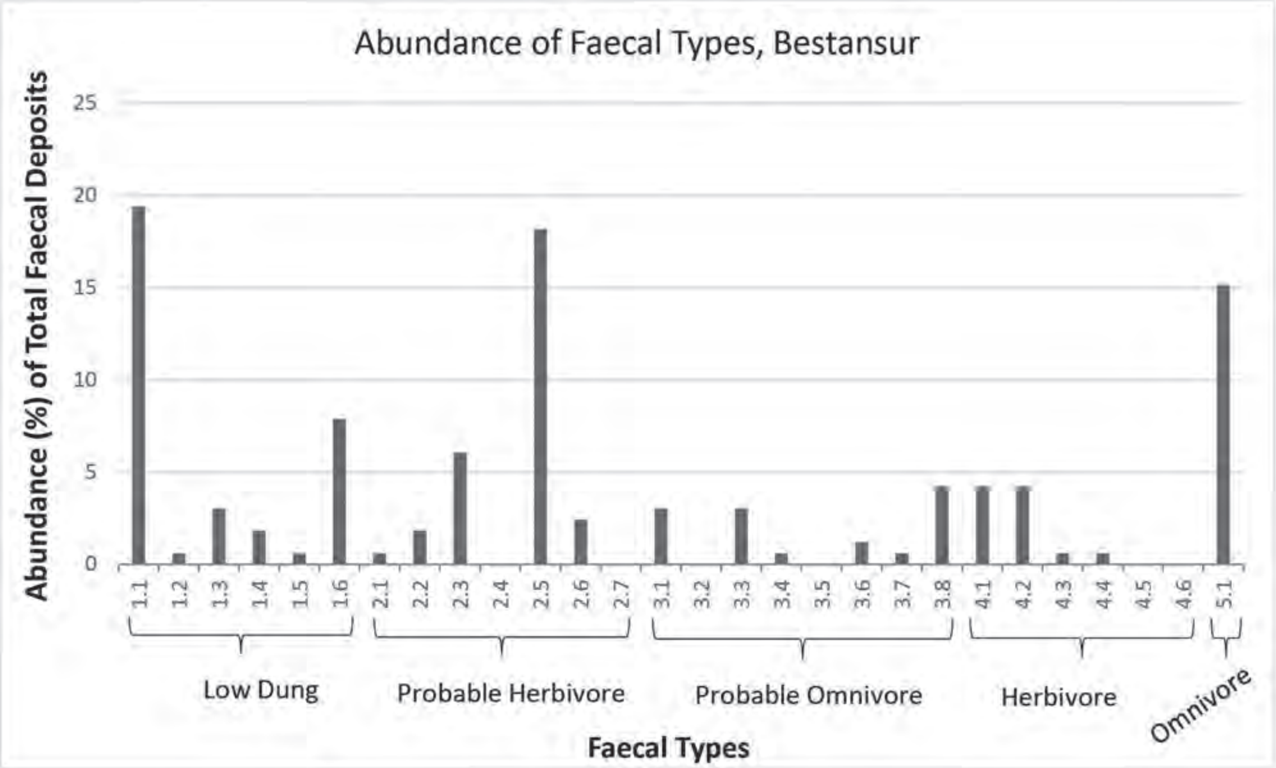


Figure 16.3. Top: Percentage of total Faecal Deposits identified divided by Major Faecal Categories, Bestansur. Bottom: Percentage of total Faecal Deposits identified divided by Faecal Types, Bestansur.

for sampling based on the excavators' and specialists' experience and advice. The results of the analysis of faecal material in the micromorphological thin-sections presented here will focus on the abundance and variation in Faecal Deposits by contextual variation (*Deposit/layer Type*).

Faecal material: attributes, characteristics and classification

Faecal material is often identified in the field macroscopically by criteria such as colour, shape and consistency (Shahack-Gross 2011). Existing published data sets incorporating microscopic animal dung analysis mainly classify faecal deposits based on reported colour, spherulite and phytolith content (Brochier *et al.* 1992; Macphail *et al.* 1997a; W. Matthews 2010). Some studies have included additional details in classifying faecal material such as fine-fabric, orientation and distribution of partially digested remains (Courty *et al.* 1991; Macphail *et al.* 1997a; W. Matthews 2005; 2010). The analysis of faecal material in loose sediment samples alone (for example Portillo *et al.* 2009) does not permit recording of the *in situ* context and characteristics of faecal deposits, as these are disrupted by sample collection. Studies of faecal deposits in micromorphological samples (for example Macphail *et al.* 1997a) by contrast enable analysis of the microstructure and content of faecal material, as well as post-depositional alterations. This research has for the first time focused on in-depth characterisation of individual faecal deposits using the internationally standardised descriptive methodology for each identified faecal deposit (Bullock *et al.* 1985; Courty *et al.* 1989). The significance of the range of characteristics recorded for each Faecal Deposit during analysis of the micromorphological thin-section is summarised and presented in Table 16.1. These characteristics were recorded for each Faecal Deposit and enabled identification of five major 'Faecal Categories'. Within these five categories up to eight sub-types were defined according to specific significant characteristics, including numbers of faecal spherulites, numbers of phytoliths, presence of lamination, presence of bone or presence of burnt or ashy material. Each sub-type is referred to as different Faecal Types and allocated a number, e.g. Faecal Type 1.1, Faecal Type 1.2 etc. The results of the faecal classifications to major Faecal Category and Faecal Types are presented in Table 16.2. The characteristics which define these major Faecal Categories and sub-category details are hereafter referred to by their numerical Faecal Type.

Bestansur

The results of the Faecal Deposits identified in the micromorphological thin-sections are discussed in five different sections. (1) Initially the results are presented by the total faecal deposits identified at Bestansur; this is followed (2) by a presentation of the results by site area. The analysis of the results by site area is sub-divided and focuses on (2a) the frequency of Faecal Deposits in each area of the site in order to investigate which areas of the site have more or less dung, followed by (2b) an analysis of the types of Faecal Deposits by site area to assess which type of dung or faecal material occurs in different areas. This approach might suggest which animals congregated or were corralled in different areas. The faecal results from the micromorphology thin-sections are then presented (3) by the *Deposit/layer Type* allocated during excavation to investigate the range of depositional contexts in which faecal material occurs.

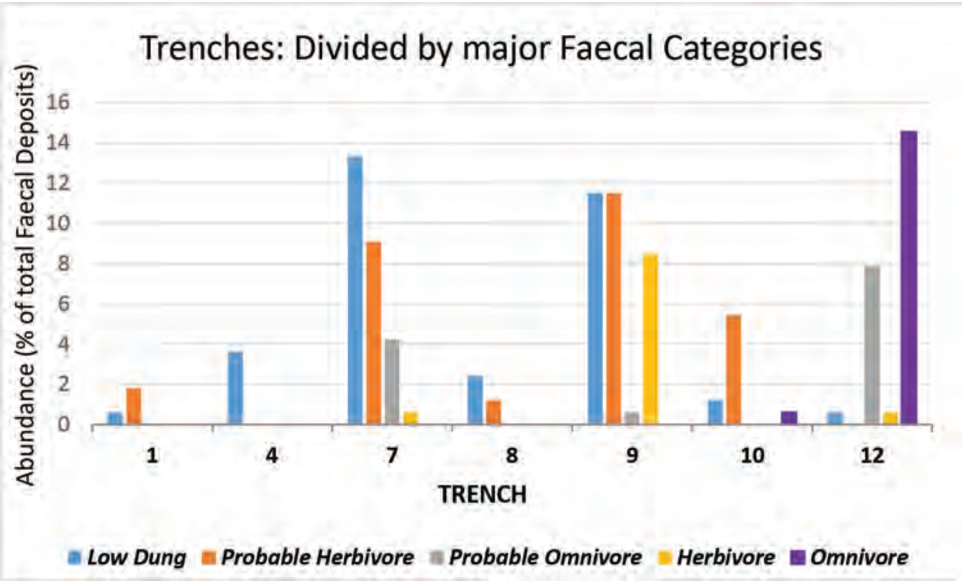


Figure 16.4. Major Faecal Categories identified in all trenches, Bestansur.

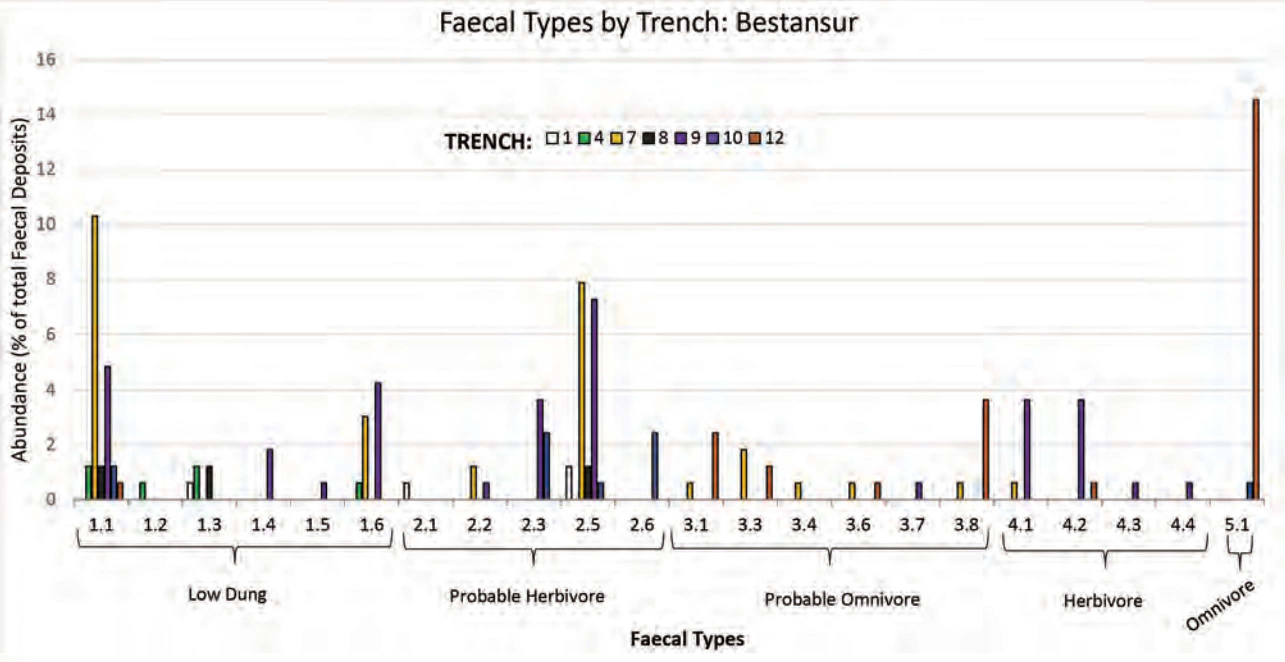


Figure 16.5. Major Faecal Types identified in all trenches, Bestansur.

This step is followed (4) by a correlation of faecal types using a Spearman's Correlation Coefficient to investigate any relationship between the different Faecal Types. Finally (5) the micromorphological results are assessed to identify key contexts for further microanalyses (phytolith and GC-MS).

TOTAL FAECAL DEPOSITS

One hundred and sixty-five Faecal Deposits were identified within the contexts analysed in 33 micromorphological thin-sections from Bestansur. Faecal Deposits were classified according to the five major Faecal Categories, and all five were identified: *Low Dung, Probable Herbivore, Probable Omnivore, Herbivore* and *Omnivore*. A total of 22 Faecal Types were identified within these Faecal Categories from the 165 Faecal Deposits. The following section examines the frequency of faecal deposits in the thin-sections from different areas of the site (see *Frequency of Faecal deposits by site area).* Table 16.3 provides details of where the Faecal Types are located within the samples analysed by Sample/Unit number and Trench number. The relative abundance of each Faecal Category and Faecal Type is presented as a percentage of the total Faecal Deposits identified in Figure 16.3. The highest frequency of faecal material identified at Bestansur is of major Faecal Category *Low Dung* (33%), followed by *Probable Herbivore* faecal material (29%). *Omnivore* faecal material represents 15% of the Faecal Deposits, *Probable Omnivore* 13% and *Herbivore* 10%.

FAECAL DEPOSITS BY SITE AREA (TRENCH)

At Bestansur in order to assess which areas of the site have more or less dung and which type of dung or faecal material occurs in different areas of the site, the Faecal Deposits can also be analysed by trench number (i.e. the different areas of the site where trenches were placed). To evaluate whether there is variation in Faecal Deposits across different areas of the site and whether there is any spatial, contextual and chronological variation in these deposits, all Faecal Deposits were analysed by trench number. Chronological variation can only be evaluated with certainty when comparing the eastern and northern areas of the site (Trenches 10 and 12) where radiocarbon dates have been successfully obtained (Chapter 11).

Frequency of Faecal deposits by site area

The results for the average number of Faecal Deposits within each micromorphological thin-section in the seven areas of the site (trenches) indicate that the northern area of the site (Trench 12) has the highest frequency of Faecal Deposits with an average of 7.8 occurrences in each thin-section (Fig. 16.2). This area is followed by the eastern area of the site (Trench 10) with an average of six Faecal Deposits in each thin-section. In the southernmost extent of the site (Trench 9) there is an average of 5.3 Faecal Deposits and to the west (Trench 7) there is an average of 4.5 Faecal Deposits per thin-section. The south-western and south-eastern areas of the site (Trenches 4 and 8) have low numbers of Faecal Deposits, on average three per micromorphological thin-section. In the lower slopes of the site to the east of the mound (Trench 1) there is the lowest number of Faecal Deposits, with an average of just two Faecal Deposits per thin-section (Fig. 16.2). The average Faecal Deposits per micromorphological thin-section in each trench is used here as a representation of the abundance of Faecal Deposits within each of the areas of the site at Bestansur.

Comparing the number of Faecal Deposits in the eastern area (Trench 10), dated to *c.* 7720–7580 BC, and the northern area (Trench 12) which are *c.* 1m higher and date to *c.* 7070 BC, enables investigation of potential chronological differences in faecal deposition. Based on the average number of Faecal Deposits within each micromorphological thin-section analysed at Bestansur, there are more Faecal Deposits after *c.* 7070 BC in the northern area of the site (Trench 12) with an average of 7.8 Faecal Deposits per sample, in comparison to earlier deposits in the eastern area of the site (Trench 10; *c.* 7720–7580 BC), with an average of six Faecal Deposits per sample (Fig. 16.2). Equally, this variation may relate to differential use of space in the two excavated site areas, as now discussed.

Types of faecal material by site area

In addition to the number of faecal deposits in each area of the site, the type of Faecal Deposits across each area can also be examined using the allocated Faecal Category and Faecal Type in order to assess which animals might have congregated or been corralled in different areas of the site. The Faecal Categories identified within the contexts from each area of the site (trenches) are presented in Figure 16.4 and the specific Faecal Types in each Trench in Figure 16.5. The differences in Faecal Categories and Types in Figures 16.4 and 16.5 indicate a range of significant variations in the different areas of the site investigated (different Trenches) and therefore the different sectors of the settlement. This helps inform on dung distribution, animal intensity, significance and potential use.

In the lower slopes on the eastern edge of the site (Trench 1), *Low Dung* and *Probable Herbivore* Dung Categories were identified (Faecal Types 1.3, 2.1 and 2.5). Similarly, *Low Dung* Faecal Types and *Probable Herbivore* Faecal Types were the most frequent categories identified in the eastern area of the site (Trench 10) and the southeastern area of the site (Trench 8). In the eastern area (Trench 10) the most frequently identified Faecal Types are 2.3 and 2.6, and a low percentage of faecal material allocated to *Omnivore* was also identified here (Faecal Type 5.1). The Faecal Deposits in the southeastern area of the site (Trench 8) were Faecal Types 1.1, 1.3 and 2.5.

In the southern area of the site (Trench 9), as in the western area (Trench 7), both of which include major open areas, a wider range of Faecal Types was identified. The major Faecal Categories identified are: *Low Dung*, *Probable Herbivore*, *Probable Omnivore* and *Herbivore*. The southern area (Trench 9) is dominated

Table 16.4. All Faecal Types identified at Bestansur divided by allocated Deposit/layer Types (x = present).

	Faecal Type																					
	Low dung						*Probable herbivore*					*Probable omnivore*						*Herbivore*				*Omnivore*
Deposit/layer type	*1.1*	*1.2*	*1.3*	*1.4*	*1.5*	*1.6*	*2.1*	*2.2*	*2.3*	*2.5*	*2.6*	*3.1*	*3.3*	*3.4*	*3.6*	*3.7*	*3.8*	*4.1*	*4.2*	*4.3*	*4.4*	*5.1*
Accumulation					☒					☒												
Cluster	☒									☒												
Fill			☒				☒															
Fire spot	☒			☒		☒		☒	☒	☒			☒		☒				☒		☒	
Mixed, occupation residues	☒		☒							☒		☒					☒		☒			☒
Occupation residues	☒		☒			☒		☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒	☒		☒
Occupation residues, accumulation	☒	☒	☒			☒				☒									☒			

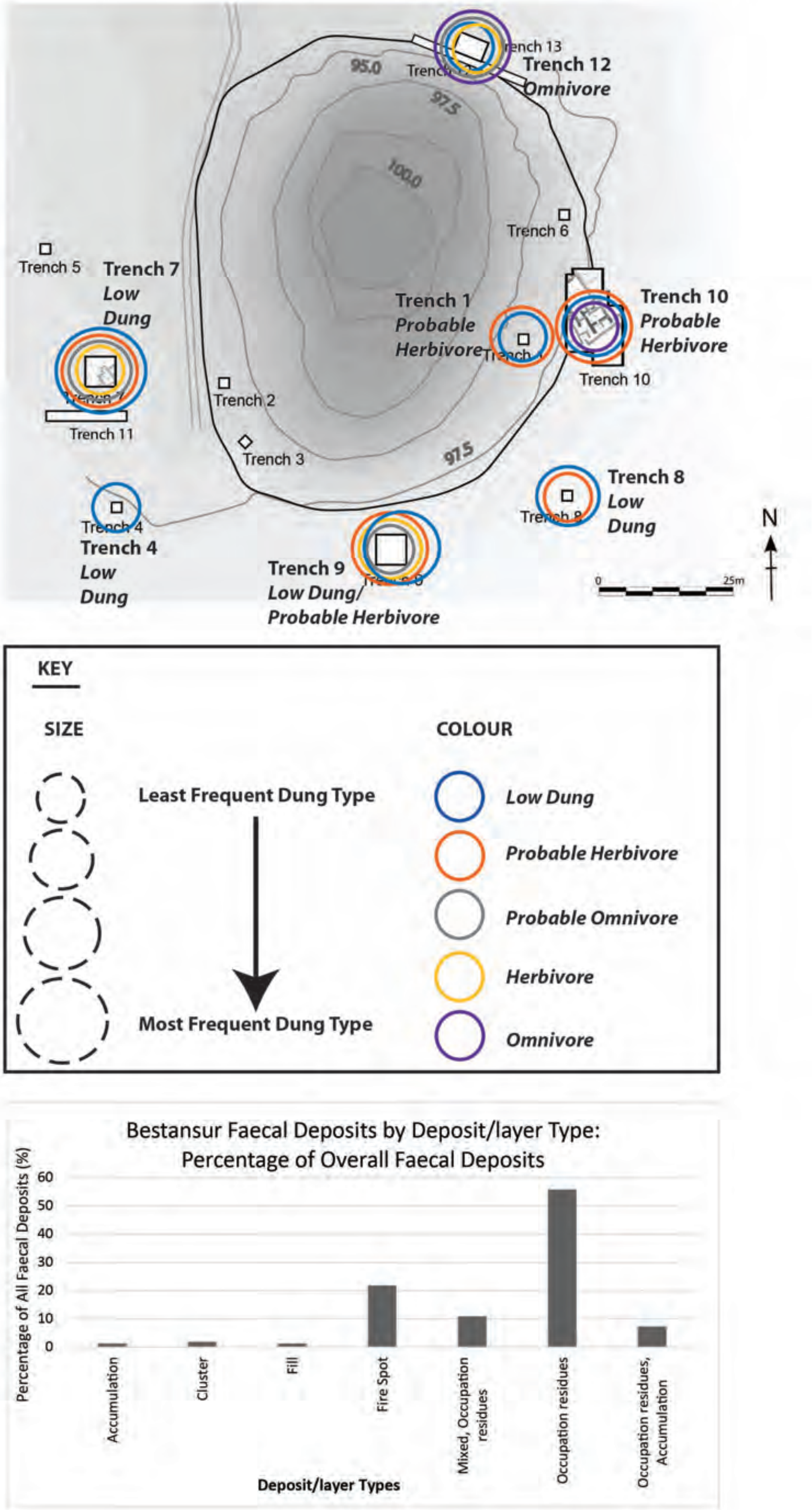


Figure 16.6. a) Diagrammatic depiction of the frequency of Faecal Categories for all trenches analysed at Bestansur; b) Bestansur Faecal Deposits by Deposit/layer Type. Percentage of overall Faecal Deposits identified at Bestansur.

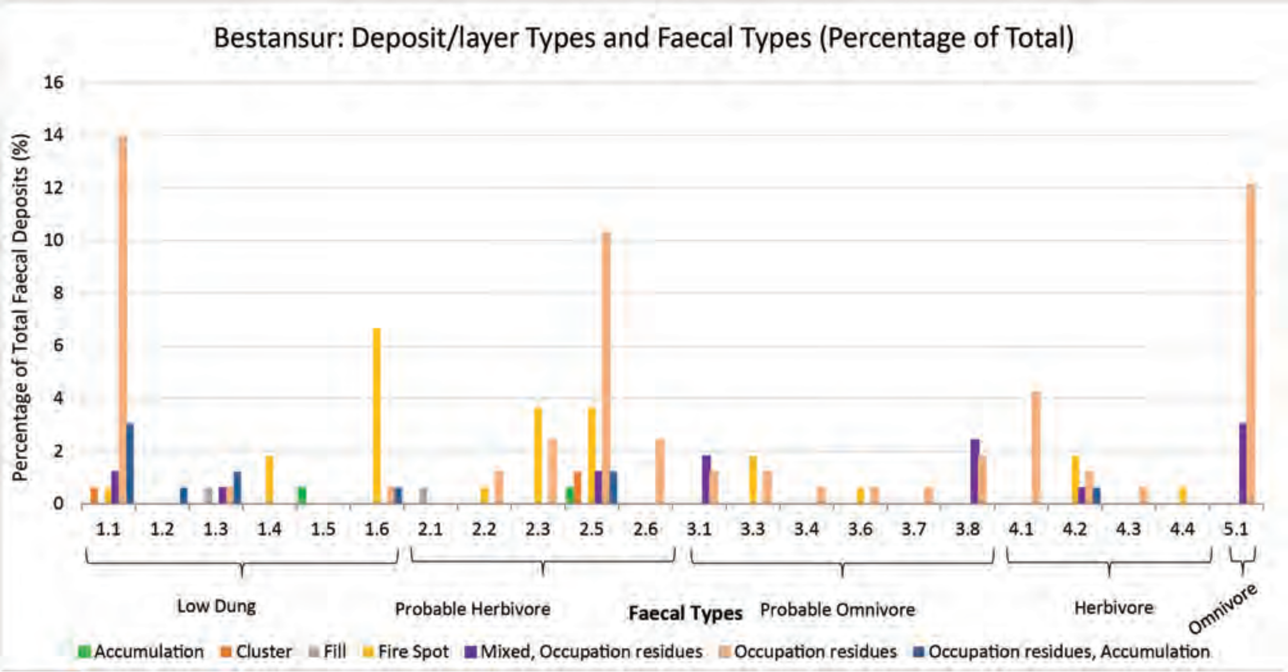


Figure 16.7. Bestansur Faecal Types divided by Deposit/layer Type, percentage of total Faecal Deposits identified from Bestansur.

Table 16.5. Summary of Bestansur results by Deposit/layer Type.

Deposit/layer type	*% of Faecal Deposits*	*Faecal categories*	*Faecal Types*	*Dominant Faecal Types*	*Notes*
Accumulation	1	*Low dung, probable herbivore*	2	N/a	
Cluster	2	*Low dung, probable herbivore*	2	*Probable herbivore* type 2.5	
Fill	1	*Low dung, probable herbivore*	2	N/a	
Fire spot	22	*Low dung, probable herbivore, probable omnivore, herbivore*	10	*Low dung* type 1.6	
Mixed, occupation residues	11	*Low dung, probable herbivore, probable omnivore, herbivore* and *omnivore*	7	*Probable omnivore* type 3.8	
Occupation residues	56	*Low dung, probable herbivore, probable omnivore, herbivore* and *omnivore*	17	*Low dung* type 1.1, *probable herbivore* type 2.5 and *omnivore* type 5.1	Dung types: 1.1, 2.5 and 5.1, with 14%, 10% and 12%
Occupation residues, accumulation	7	*Low dung, probable herbivore, herbivore*	6	*Low dung* type 1.1	

For all Faecal Type descriptions see Table 16.2.

by Faecal Types 1.1, 1.6, 2.3, 2.5, 4.1 and 4.2, and only 0.6% of the Faecal Deposits are identified to *Probable Omnivore* from the southern area of the site (Trench 9) which therefore does not represent a large amount of the faecal material identified. The western area of the site (Trench 7) is dominated by Faecal Types 1.1, 1.6 and 2.5 and only 0.6% of the Faecal Deposits identified in the western area of the site (Trench 7) were from major Faecal Category *Herbivore*. Therefore, the Faecal Deposits from this area (Trench 7) represent low levels of faecal material and the more uncertain Faecal Types.

In the southwestern area of the site (Trench 4) only *Low Dung* Faecal Types were identified; Faecal Types 1.1, 1.2, 1.3 and 1.6. This area clearly contains low abundances of Faecal Deposits based on the

Faecal Types and the overall percentage of faecal material identified (Fig. 16.2), although like the eastern and southern areas of the site (Trench 7 and 9), these deposits are characteristic of an external area (Chapters 9 and 12).

The majority of *Omnivore* faecal material was identified in the northern area of the site (Trench 12) in occupation deposits rich in a range of anthropogenic debris on repeatedly prepared surfaces using plaster/ packing (14.5% of the total Faecal Deposits at Bestansur, Faecal Type 5.1). In this northern area of the site (Trench 12), 8% of the Faecal Deposits were identified as *Probable Omnivore*: Faecal Types 3.1, 3.3, 3.6 and 3.8. There are low percentages of Faecal Deposits in this area (Trench 12) identified to *Low Dung* (0.6%: Faecal Type 1.1) and *Herbivore* (0.6%: Faecal Type 4.1).

Overall, when comparing different areas of the site, the western area (Trench 7) and the southern area (Trench 9) are comparable by the major Faecal Categories in which the Faecal Deposits have been allocated. The values for *Low Dung* and *Probable Herbivore* faecal material are similar. However, to the west (Trench 7) there is a small peak in *Probable Omnivore* faecal material in comparison to the area in the south (Trench 9). In the south (Trench 9) there is also a large peak in *Herbivore* faecal material in comparison to the eastern area (Trench 7).

The other three areas which are similar are the lower slopes on the eastern edge of the site (Trench 1), the eastern area of the site (Trench 10) and the southeastern area of the site (Trench 8) which are all dominated by major Faecal Categories *Low Dung* and *Probable Herbivore*, with one exception of *Omnivore* faecal material identified in the eastern area (Trench 10).

The two areas which are different from the rest are the southwestern area (Trench 4) where only *Low Dung* was identified, and the northern area of the site (Trench 12) which clearly shows a division from the other areas of the site, dominated by *Omnivore* faecal material with a high percentage of material identified in Faecal Category *Probable Omnivore*. There are only very low frequencies of material from Faecal Categories *Low Dung* and *Herbivore*.

A diagrammatic depiction of the frequencies between Faecal Categories and trenches is presented in Figure16.6 to emphasise the variation in identified faecal material by trench. This figure therefore indicates a spatial variation in Faecal Deposits across the settlement at Bestansur. This figure highlights not only the types of faecal material but also shows the frequency, and it is therefore clear that the western, south-western, southern and southeastern areas of the site (Trenches 7, 4, 9 and 8) are areas where *Low Dung* and *Herbivore* Faecal Types are dominant. These areas of the site represent archaeological deposits with a high sedimentological input and lower levels of anthropogenic material, which is particularly correlated with identifications of *Low Dung* and *Herbivore* Faecal Types. This result could suggest a pattern of low-level herbivore animal presence and proximity, or poor preservation of faecal material in these contexts at Bestansur. The anthropogenic input in these deposits is present but limited (e.g. ephemeral external areas or less concentrated activities) and therefore suggests areas of the site that include greater management of residues from human activity and/ or deposits such as packing and building infill. The limited faecal material in conjunction with low-level anthropogenic materials could suggest contexts with overall limited activity residues rather than poor preservation of faecal material, although the high combustion temperatures attested by many fuel rake-outs at the site are likely to have affected the presence of spherulites from dung burnt as fuel, discussed below. These signatures more likely represent areas of limited animal presence in and around the site, a similar signature produced from ethnoarchaeological results (Chapter 7).

DUNG BY DEPOSIT/LAYER TYPES

To investigate the range of depositional contexts in which faecal material occurs, variation in Faecal Deposits and Faecal Types is examined in this section according to macroscopic *Deposit/Layer Types* allocated during excavation. The Faecal Deposits identified from the micromorphological thin-sections from Bestansur were identified in seven main *Deposit/ layer Types* (Table 16.4). The deposits analysed from Bestansur were often allocated numerous *Deposit/ layer Types* during excavation to incorporate all characteristics of each individual archaeological deposit. For comparative analysis within this research the main one or two *Deposit/later Types* were selected for comparison between deposits.

To investigate the abundance of faecal material within different *Deposit/layer Types*, the abundance of Faecal Deposits identified at Bestansur was examined by each of the *Deposit/layer Types* and the value expressed as a percentage of the total Faecal Deposits identified in this study (Fig. 16.6). The Faecal Types identified within each *Deposit/layer Type* are expressed as a percentage of the total Faecal Deposits identified in Figure 16.7. A summary of the results is presented in Table 16.5 and key results are highlighted below.

The majority of the faecal material identified in the deposits from Bestansur occurs in deposits solely or jointly classified as *Occupation residues* (74%) and these types of deposits contain faecal material identified from all major Faecal Categories. Fifty-six percent of the overall Faecal Deposits in *Occupation residues* (which are not classified further) have peaks in *Low Dung* Type 1.1, *Probable Herbivore* Type 2.5, *Herbivore* Type 4.1 and *Omnivore* Type 5.1 (Fig. 16.7). When the *Occupation residues* are *Mixed* (11% of the total) the peaks are in *Probable Omnivore* Type 3.8 and *Omnivore* Type 5.1. When the *Occupation residues* appear *Accumulated* (7% of the total) there is a peak in *Low Dung* Type 1.1 (Fig. 16.7).

Fire spots are the next most prevalent *Deposit/layer Type* with 22% of the Faecal Deposits (Fig. 16.6). The main Faecal Type within *Fire spots* is Faecal Type 1.6 within major Faecal Category *Low Dung*. Faecal remains identified in *Fire spots* could be minimal due to the removal of residual hearth fuel after use. Alternatively, because the *Fire Spots* analysed were located in external areas of the site, perhaps the lack of dung remains resulted from the effects of wind and rain, as lighter material such as dung ash or small remnants of non-burnt dung could be blown or washed away. However, only 8% of the 22% of Faecal Deposits from *Fire spots* are allocated to this major Faecal Category of *Low Dung*. This suggests that the remaining 14% of Faecal Deposits identified in *Fire spots* represents more substantial Faecal Deposits within this *Deposit/layer Type*. This scarcity is also likely to be due to the consistently high temperatures reached in many fire-installations at Bestansur. The presence of abundant calcitic ash and melted silica in micromorphological thin-sections of *in situ* fuel, discussed in Chapter 12, suggests that many fires exceeded 650–850°C, temperatures at which many faecal spherulites are recalcined (Canti 1999; Canti and Nicosia 2018). Other peaks in Dung Types in *Fire spots* are in *Probable Herbivore* Types 2.3 and 2.5 (Fig. 16.7).

Correlation of faecal types

A Spearman's Correlation Coefficient was calculated to investigate relationships between the Faecal Types at Bestansur (see Elliott 2015 for full analysis). Many of the Faecal Deposits occur within inter-related Faecal Types. *Herbivore* Faecal Type 4.4 is positively correlated with *Low Dung* Faecal Types 1.4, 1.5 and 1.6. *Herbivore* Faecal Type 4.4 contains 20–50% faecal spherulites, up to 30% phytoliths and up to 5% charred plant remains. The three *Low Dung* Faecal Types only contain <1–1% faecal spherulites with <1–30% phytoliths and 10–30% charred plant remains. These *Low Dung* Faecal Types could therefore represent poorly preserved or mixed herbivore faecal material which can no longer be identified and allocated specifically to herbivore origin.

Other key positive correlation results occur between *Herbivore* Faecal Types and *Probable Herbivore* Faecal Types. *Probable Herbivore* Faecal Type 2.2 is positively correlated with *Herbivore* Faecal Types 4.1 and 4.2. These three Faecal Types contain moderate to high numbers of spherulites (30%, 50% and 95% respectively) and similar percentages of phytoliths (>5%). They also contain charred plant material and high amounts of ash. The pattern is similar for *Probable Herbivore* Faecal Type 2.3 and *Herbivore* Faecal Types 4.2 and 4.4. Faecal Types 2.4, 4.2 and 4.4 contain variable spherulites with moderate to high phytoliths (respectively 80%, 40% and 30%) with charred plant remains and ash. The occurrence of these Faecal Types together could provide additional information to support the interpretation of this *Probable Herbivore* faecal material as herbivore in origin.

Key contexts identified at Bestansur for additional microanalyses

A range of contexts analysed by micromorphological thin-section were targeted for phytolith and GC-MS analyses. The deposits in a fire-installation (Feature 9) in Trench 9 analysed in SA967 (C1306) were identified as key contexts for further analysis. In SA967, ten Faecal Deposits were identified (Fig. 16.8). Five of these Faecal Deposits were identified as *Probable Herbivore* Faecal Types, a further four were identified as *Herbivore* Faecal Types and the remaining deposit was a *Low Dung* Faecal Type. Also in Trench 9, the deposits in Fire Installation Feature 10 (C1307, SA968) were targeted for further analysis. In SA968, 11 Faecal Deposits were identified (Fig. 16.9): seven of the Faecal Deposits were identified as *Probable Herbivore* Faecal Types and the remaining five were *Low Dung* Faecal Types. Because of the abundance of herbivore Faecal Deposits within these two fire installations these contexts were selected for further microanalysis to confirm herbivore origin of the faecal material and to analyse animal diet.

A substantial ash deposit from Trench 10 was also selected for further microanalysis. This ash deposit C1330 was *c.* 5cm thick and was sampled in thin-sections (SA1080 and SA1081; Figs 16.10 and 16.11). In SA1080 four Faecal Deposits were identified in the ash layer. In this same layer (sampled within a different location in SA1081) six Faecal Deposits were identified. The Faecal Deposits identified in C1330 from Trench 10 were mainly *Probable Herbivore* Faecal Types (nine of the Faecal Deposits), two Faecal Deposits were *Low Dung* Faecal Types and one was an *Omnivore*.

The substantial omnivore Faecal Deposits identified in the northern area of the site in Trench 12 from *External and Open areas* from *Deposit/layer types Occupation residues* and *Mixed, Occupation residues* are significant at Bestansur and were targeted for further investigation from samples: SA1078, SA1183, SA1184, SA1185 and SA1186 (Figs 16.12–16.16). The abundance of omnivore Faecal Deposits within these five samples in Trench 12 led to selection of these for further investigation by micro analysis to confirm the origin of the faecal material and to analyse omnivore diet as a comparison to the herbivore diet in faecal material from Trench 9. See the phytolith and GC-MS sections below for targeted microanalysis results.

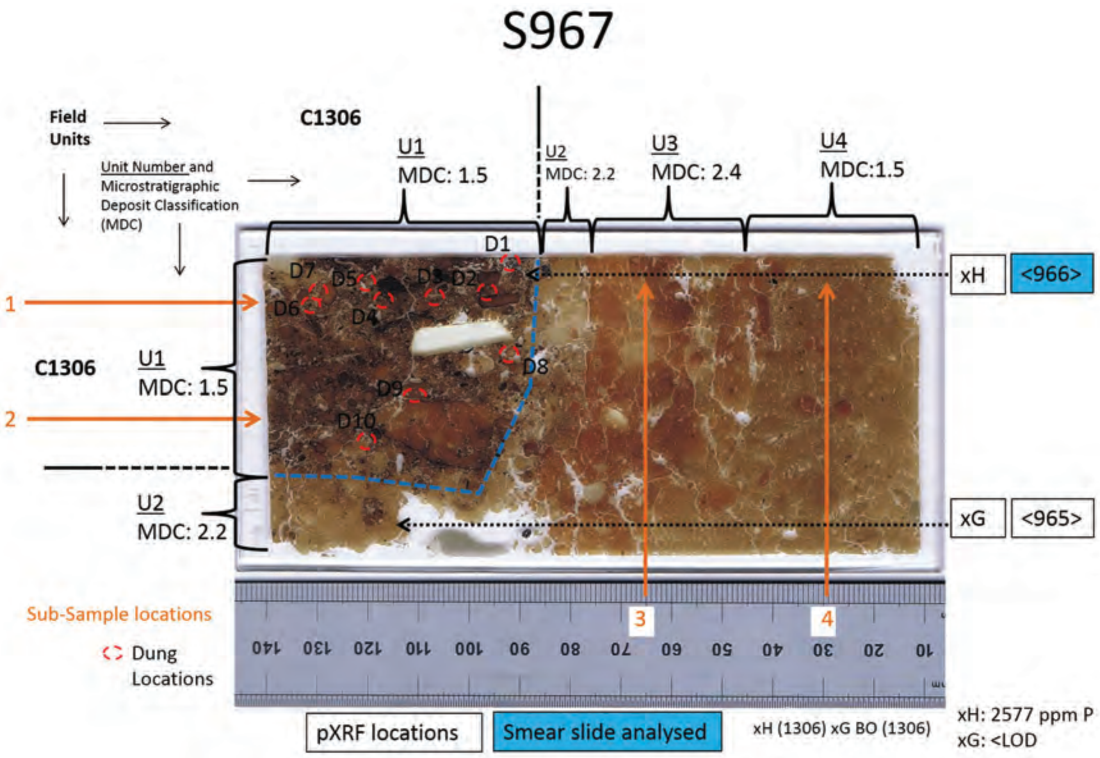


Figure 16.8. SA967, Trench 9, Bestansur. C1306, fire installation F9. Showing dung locations (D1–D10), pXRF location (xH and xG), smear slides analysed and sub-samples taken prior to resin impregnation.

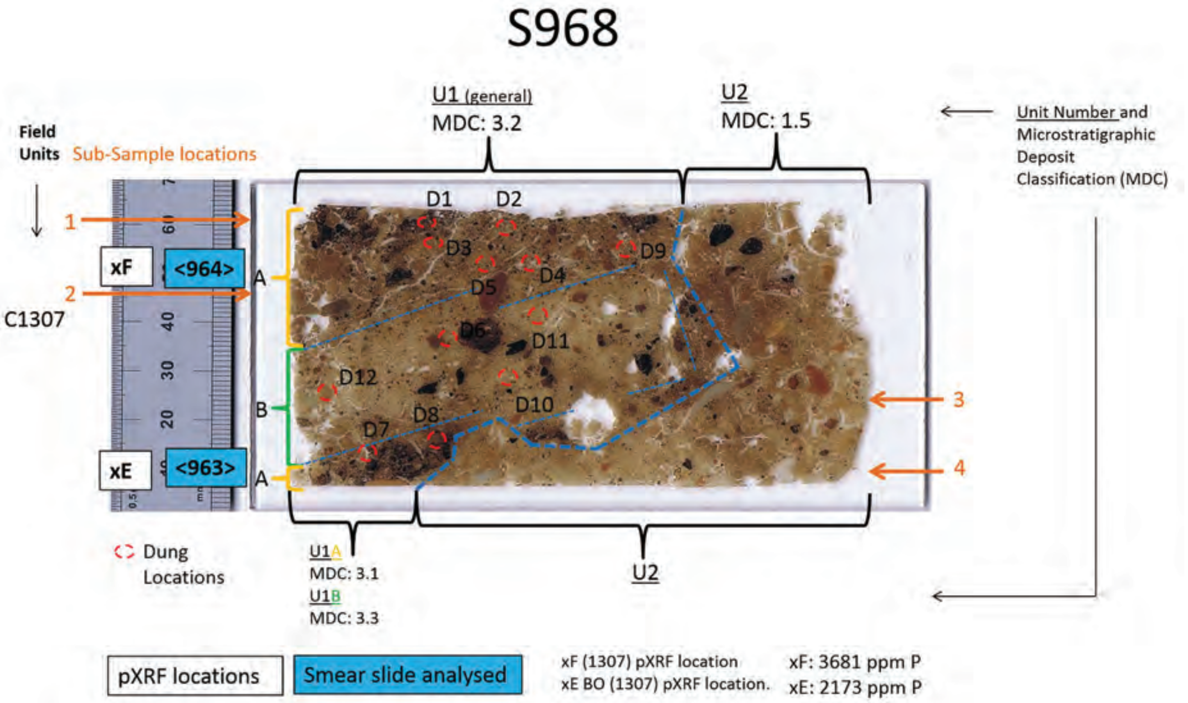


Figure 16.9. SA968, Trench 9, Bestansur. C1307, fire installation F10. Showing dung locations (D1–D12), pXRF location (xF and xE), smear slides analysed and sub-samples taken prior to resin impregnation.

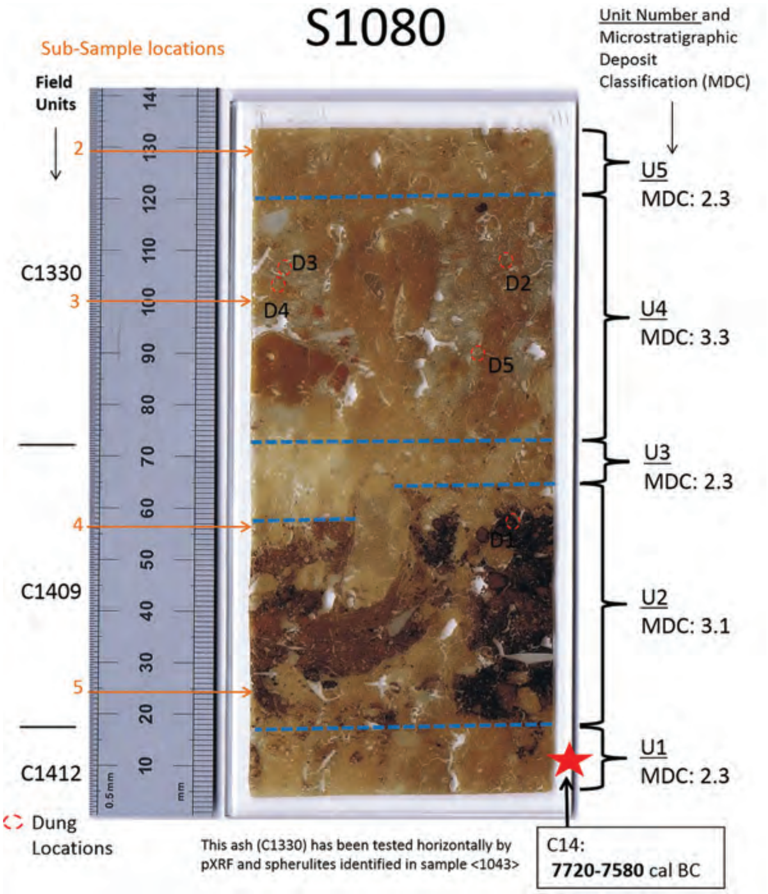


Figure 16.10. SA1080, Trench 10, Bestansur. C1412, C1409 and C1330. Showing dung locations (D1–D5) and sub-samples taken prior to resin impregnation. ^{14}C date obtained from C1412.

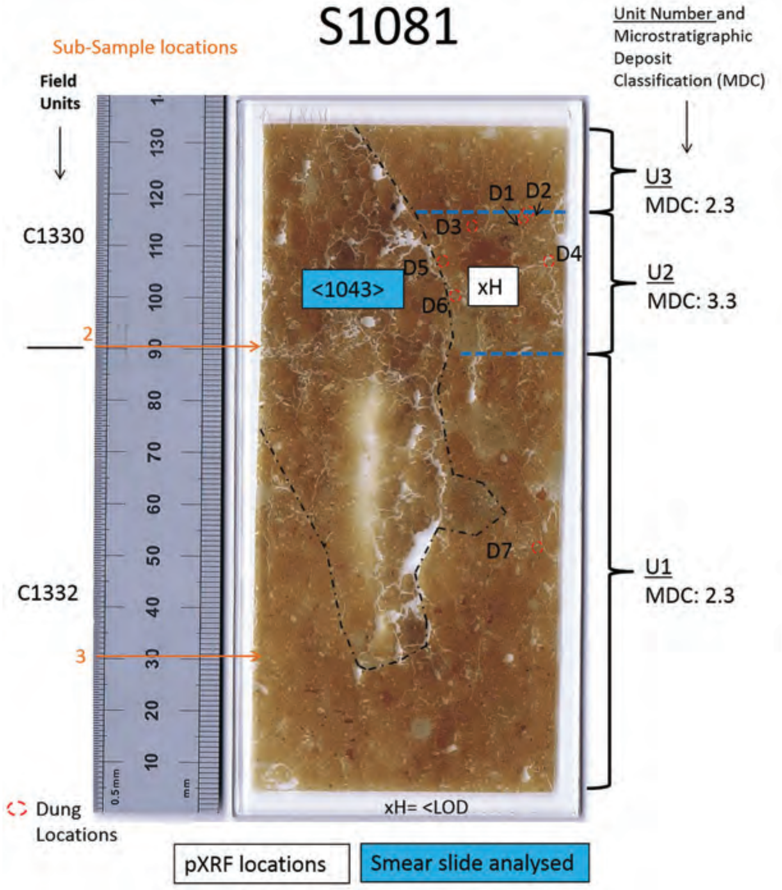


Figure 16.11. SA1081, Trench 10, Bestansur. C1332 and C1330. Showing dung locations (D1–D7), pXRF location (xH), smear slides analysed and sub-samples taken prior to resin impregnation.

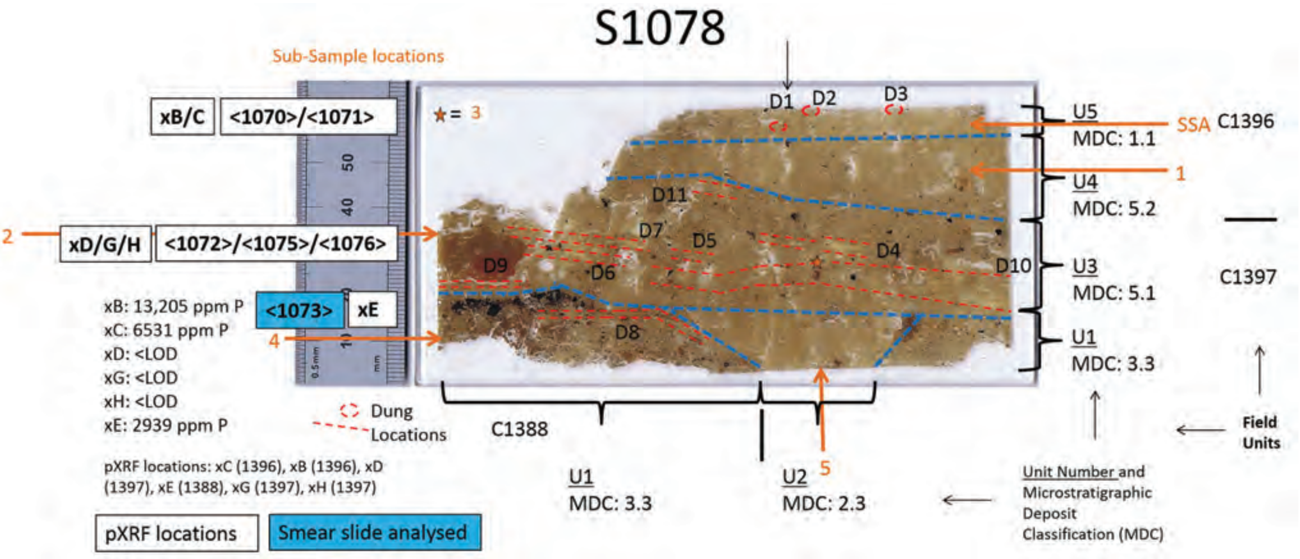


Figure 16.12. SA1078, Trench 12, Bestansur. C1396, C1397 and C1388. Showing dung locations (D1–D11), pXRF location (xB/A, xD/G/H and xE), smear slides analysed and sub-samples taken prior to resin impregnation.

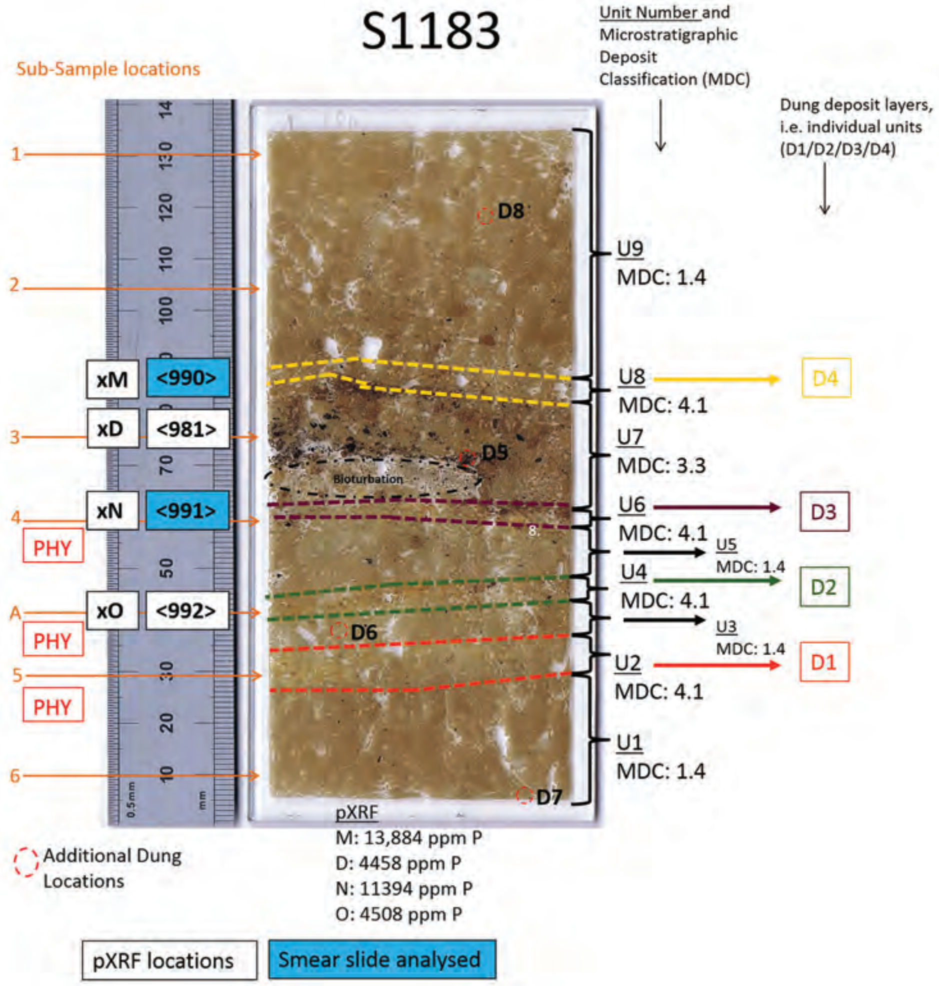


Figure 16.13. SA1183, Trench 12, Bestansur. Showing dung locations (D1–D9), pXRF location (xD, xO, xN and xM), smear slides analysed, sub-samples taken prior to resin impregnation and which sub-samples were selected for phytolith analysis (PHY).

Figure 16.14. SA1184, Trench 12, Bestansur. Showing dung locations (D1–D6), pXRF location (xH, xI, xJ, xK and xL, smear slides analysed, sub-samples taken prior to resin impregnation and which sub-samples were selected for phytolith analysis (PHY).

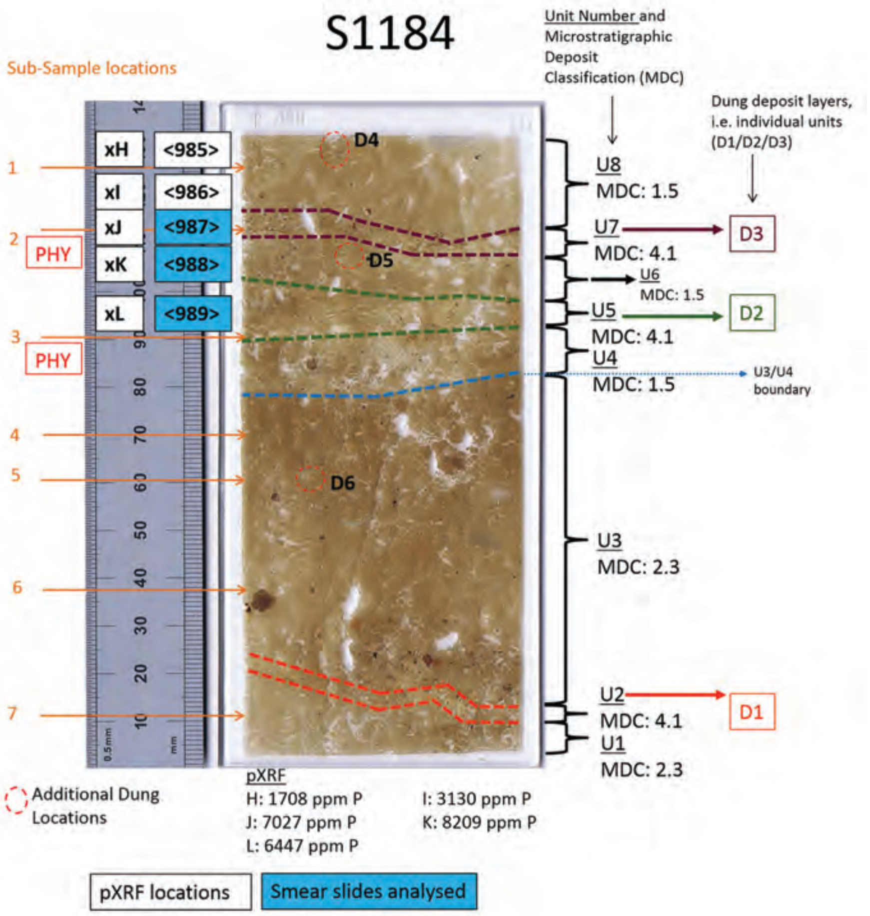
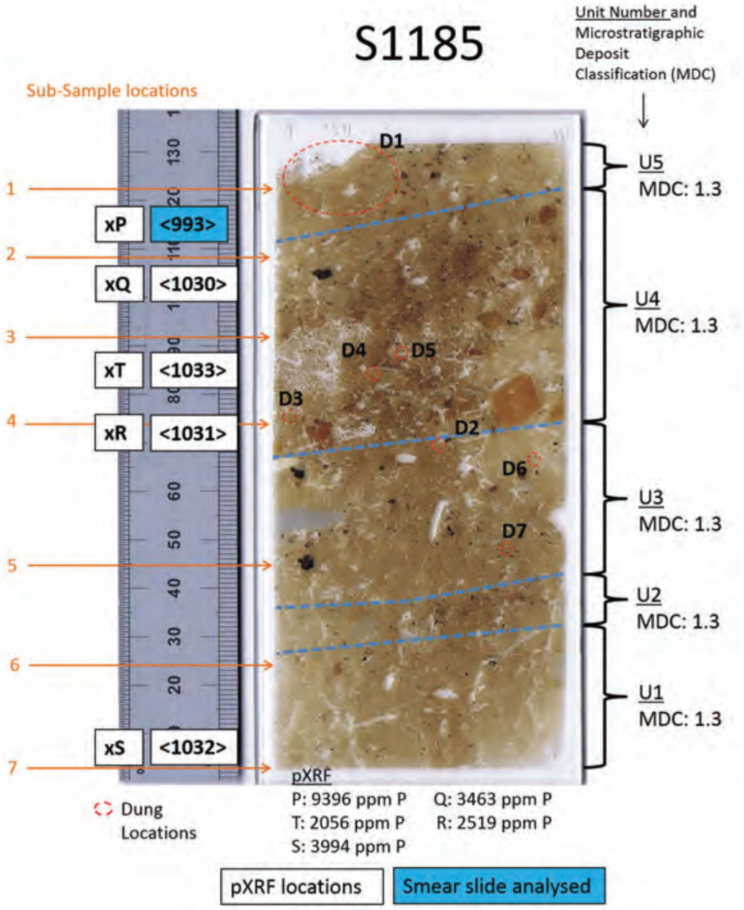


Figure 16.15. SA1185, Trench 12, Bestansur. Showing dung locations (D1–D7), pXRF location (xP, xQ, xT, xR and xS), smear slides analysed and sub-samples taken prior to resin impregnation.



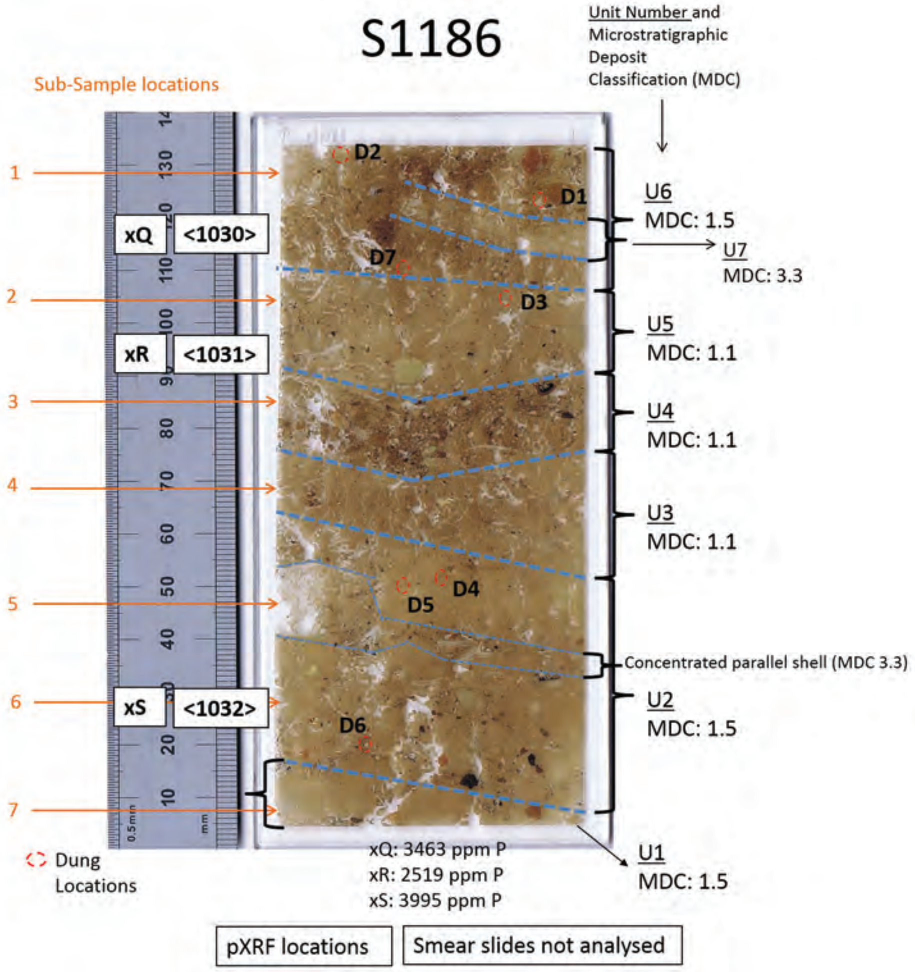


Figure 16.16. SA1186, Trench 12, Bestansur. Showing dung locations (D1–D7), pXRF location (xQ, xR and xS), smear slides locations and sub-samples taken prior to resin impregnation.

Table 16.6. Faecal Types detailing sample numbers, microstratigraphic units and trenches, Shimshara.

Faecal Type	***Main Faecal Classification,** and Sub-category details*	***Samples**/Units*	*Location in Section*
1/ low dung/single spherulites/poor preservation:			
1.1	Single spherulite, standard size	**753** u4, **763** u1	Centre and eastern end
1.4	Single spherulite, medium phytoliths	**758** u2	Western end
1.6	Single spherulite, none–high phytoliths	**757** u2	Centre
2/ probable herbivore:			
2.1	None–low spherulites, low–medium phytoliths, burnt and defined	**763** u2	Eastern end
2.5	Low–high spherulites, none–medium phytoliths	**752** u1	Eastern end
2.6	Low–high spherulites, low–high phytoliths, laminated	**763** u2	Eastern end
2.7	High spherulites, medium–high phytoliths, laminated, defined	**757** u1	Centre
3/ probable omnivore:			
3.3	None–low spherulites, low–high phytoliths	**752** u1, **757** u3	Centre and eastern end
3.6	Low–medium spherulites, medium–high phytoliths	**758** u2, **763** u3	Western end and eastern end
3.8	Medium spherulites, low–high phytoliths	**757** u3, **758** u1	Western end and centre
4/ herbivore:			
4.1	Low–high spherulites, low–medium phytoliths, degrading	**763** u2	Eastern end
4.2	Medium–high spherulites, low phytoliths, burnt/ash	**752** u1, **763** u2	Eastern end
5/ omnivore:			
5.1	Low spherulites, low–high phytoliths, bone	**763** u1	Eastern end

Table 16.7. All Faecal Types identified at Shimshara divided by allocated Deposit/layer Types (x = present).

	Faecal Type											
	Low dung			*Probable herbivore*			*Probable omnivore*			*Herbivore*		*Omnivore*
Deposit/layer type	*1.1*	*1.4*	*1.6*	*2.1*	*2.5*	*2.6*	*3.3*	*3.6*	*3.8*	*4.1*	*4.2*	*5.1*
Occupation residues			☒		☒	☒	☒				☒	
Fire spot				☒				☒		☒	☒	
Mixed, occupation residues	☒						☒		☒			☒
Packing		☒						☒	☒			

Table 16.8. Summary of Shimshara results by Deposit/layer Type.

Deposit/layer type	*% of Faecal Deposits*	*Faecal categories*	*Faecal Type*	*Dominant Faecal Types*
Occupation residues	23	*Low dung, probable herbivore, probable omnivore* and *herbivore*	4	*Probable omnivore* type 3.3, *herbivore* type 4.2
Fire spot	19	*Probable herbivore, probable omnivore* and *herbivore*	5	N/a
Mixed	31	*Low dung, probable herbivore, probable omnivore* and *omnivore*	5	*Probable omnivore* type 3.8
Packing	27	*Low dung* and *probable omnivore*	3	*Probable omnivore* type 3.8

For all Faecal Type descriptions see Table 16.2.

Shimshara

TOTAL FAECAL DEPOSITS

Twenty-three Faecal Deposits were identified within the contexts analysed in five micromorphological thin-sections from Shimshara. Faecal Deposits were classified according to the five major Faecal Categories, and all five were identified: *Low Dung, Probable Herbivore, Probable Omnivore, Herbivore* and *Omnivore*. A total of 13 Faecal Types were identified within these Faecal Categories from the 23 Faecal Deposits. Table 16.6 provides details of where the Faecal Types are located within the samples analysed by Sample/Unit number and the location in the Section. The abundance of each Faecal Category and Faecal Type is presented as a percentage of the total Faecal Deposits identified in Figure 16.17.

Half of the Faecal Deposits (50%) were identified as *Probable Omnivore* (Fig. 16.17). The principle Faecal Type identified is *Probable Omnivore:* Faecal Type 3.8 with 31% of the Faecal Deposits identified in the samples analysed from Shimshara (Fig. 16.17). *Probable Omnivore* Faecal Type 3.8 is orange and yellow with an undifferentiated fabric and up to 30% spherulites, up to 40% phytoliths and up to 10% charred plant remains.

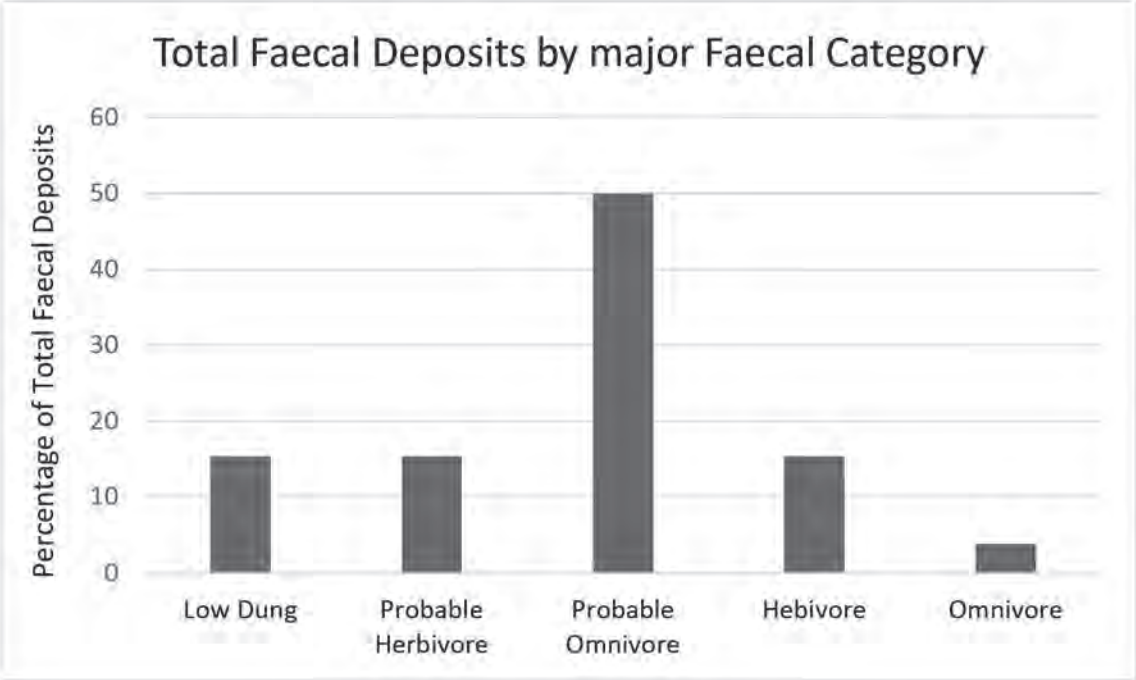
Each of the other main Faecal Categories identified at Shimshara, *Low Dung* (Faecal Types 1.1, 1.4 and 1.6), *Probable Herbivore* (Faecal Types 2.1, 2.5, 2.6 and 2.7) and *Herbivore* (Faecal Types 4.1 and 4.2), were identified with 15.5% of the total Faecal Deposits per category for the contexts analysed. The least abundant major Faecal Category is *Omnivore* with 3.5% of the total Faecal Deposits (Faecal Type 5.1; Fig. 16.17). The Faecal Deposits identified at Shimshara are therefore dominated by omnivore faecal material. Omnivore faeces produced by wild boar and pig cannot be distinguished micromorphologically from human coprolites. The faecal material could therefore represent human faecal material rather than omnivore such as wild boar/pig. This issue was investigated further using GC-MS analysis (see below).

DUNG BY DEPOSIT/LAYER TYPES

To investigate the range of depositional contexts in which faecal material occurs, variation in Faecal Deposits and Faecal Types is examined in this section according to macroscopic *Deposit/Layer Types* allocated during section investigation. The Faecal Deposits identified from the micromorphological thin-sections from Shimshara were identified in four main *Deposit/layer Types* (Table 16.7).

To investigate the abundance of faecal material within different *Deposit/layer Types*, the abundance of Faecal Deposits identified at Shimshara was examined by each of the *Deposit/layer Types* and the value expressed as a percentage of the total Faecal Deposits identified (Fig. 16.18). The Faecal Types identified within each *Deposit/layer Type* are expressed as a percentage of the total Faecal Deposits identified in Fig. 16.19. A summary of the results is presented in Table 16.8 and key results are highlighted below.

The Faecal Deposits identified at Shimshara are fairly evenly distributed across the four Deposit/layer Types (Fig. 16.18). The most abundant Faecal Type identified, *Probable Omnivore* Faecal Type 3.8, was divided over two Deposit/layer Types; 12% of



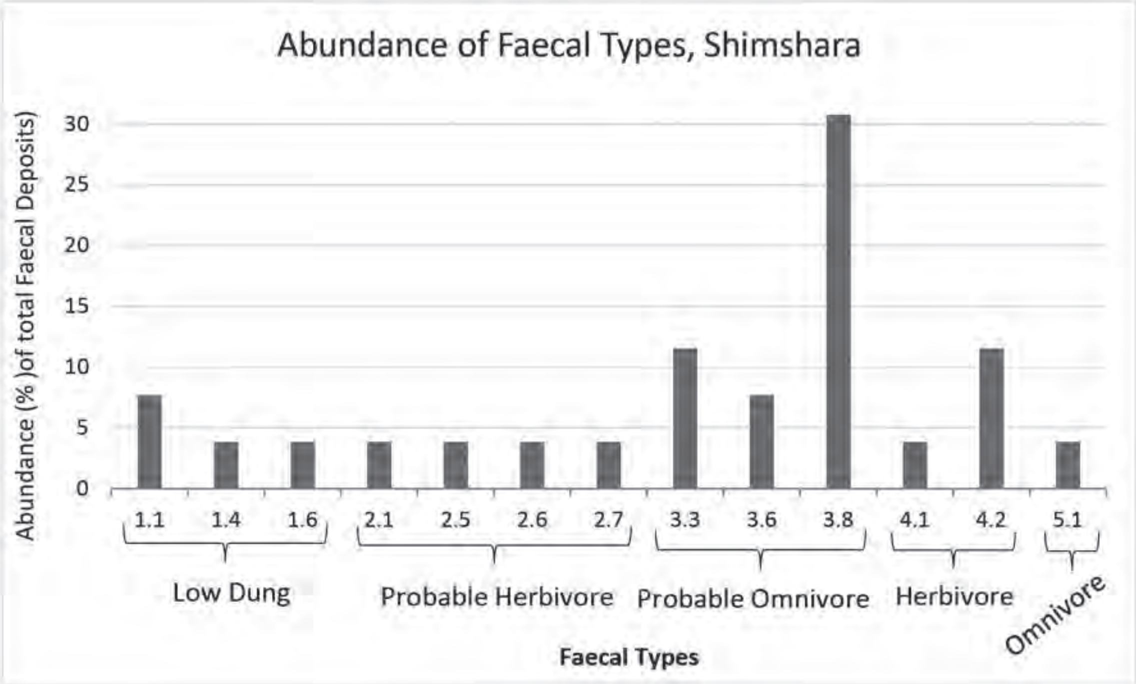


Figure 16.17. Top: Percentage of total Faecal Deposits identified divided by Major Faecal Categories, Shimshara. Bottom: Percentage of total Faecal Deposits identified divided by Faecal Types, Shimshara.

the Faecal Deposits attributed to *Mixed* deposits and 19% to *Packing* deposits (Fig. 16.19). There are no clear identifiable significant patterns between Deposit/layer Types and Faecal Types at Shimshara.

Correlation of faecal types

A Spearman's Correlation Coefficient was calculated to investigate relationships between the Faecal Types at Shimshara (see Elliott 2015 for full analysis). Many of the Faecal Deposits occur within inter-related Faecal Types. Two Faecal Types with perfect positive correlation are *Probable Herbivore* Faecal Type 2.1 and *Herbivore* Faecal Type 4.1. Within deposits where Faecal Type 2.1 has been identified, Faecal Type 4.1 has also been identified. These Faecal Types represent Faecal Deposits of different compositions but occur within the same context sometimes directly adjacent to each other but in other cases within a different area

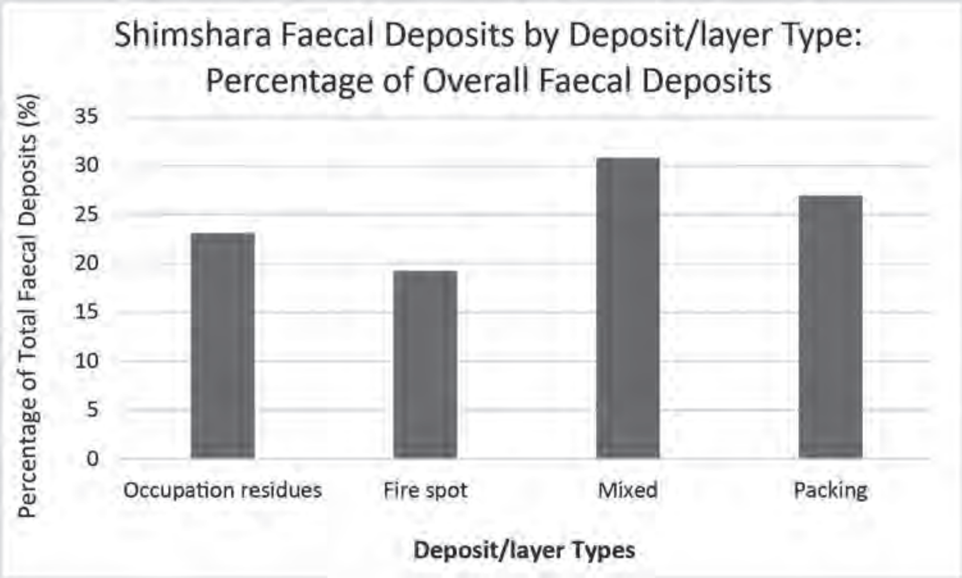


Figure 16.18. Shimshara Faecal Deposits by Deposit/layer type. Percentage of overall Faecal Deposits identified at Shimshara.

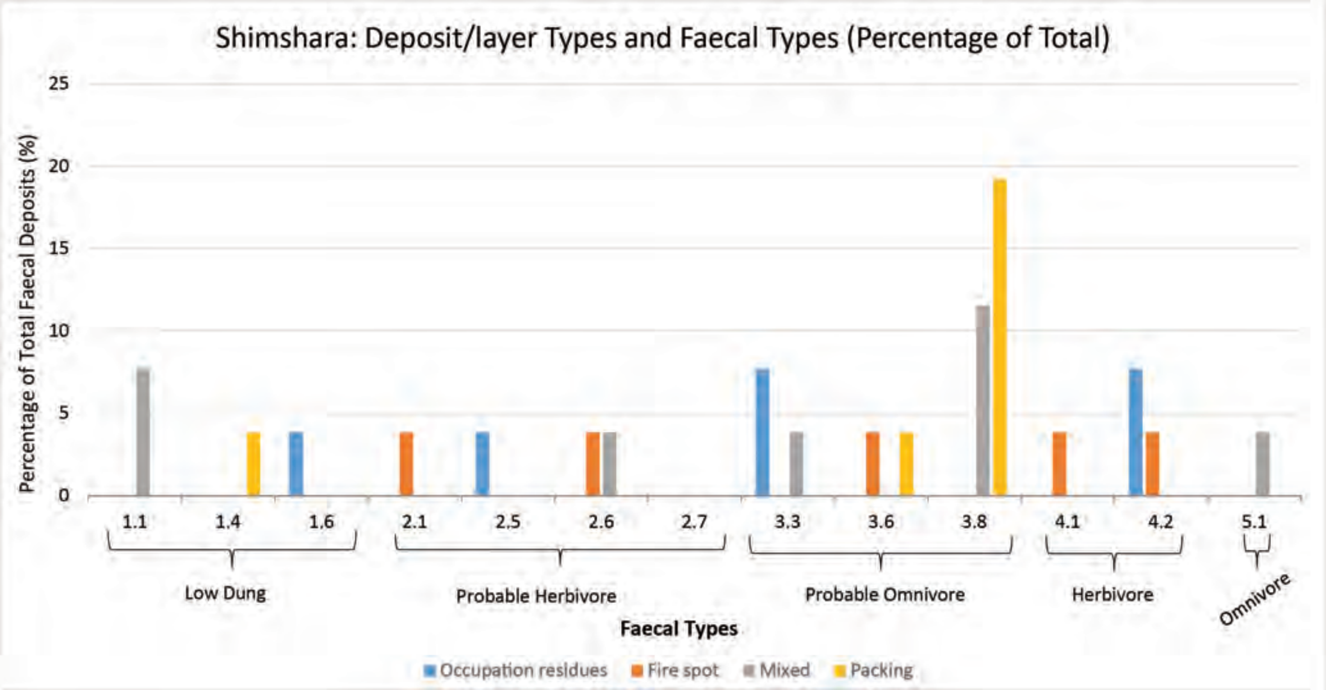


Figure 16.19. Shimshara Faecal Types divided by Deposit/layer type, percentage of total Faecal Deposits identified from Shimshara.

of the same context. The occurrence of these Faecal Types together could provide additional information to support the interpretation of this *Probable Herbivore* faecal material as herbivore in origin. Both Faecal Types are brown in colour with faecal spherulites, phytoliths, charred plant remains and/or ash. These faecal deposits both appear birefringent in crossed polarised light with parallel orientation of phytoliths. In *Herbivore* Faecal Type 4.1 the inclusions identified are up to 95% faecal spherulites, 0–5% phytoliths, 2–5% charred plant remains and 50–70% ash. In comparison in *Probable Herbivore* Faecal Type 2.1 the inclusions identified are only up to 40% faecal spherulites, <1% phytoliths but up to 30% charred plant remains. The reduction in faecal spherulites in *Probable Herbivore* Faecal Type 2.1 in comparison to the confirmed *Herbivore* Faecal Types is one of the factors influencing its placement in Faecal Category *Probable Herbivore* rather than Faecal Category *Herbivore*. However, the greater number of faecal spherulites in

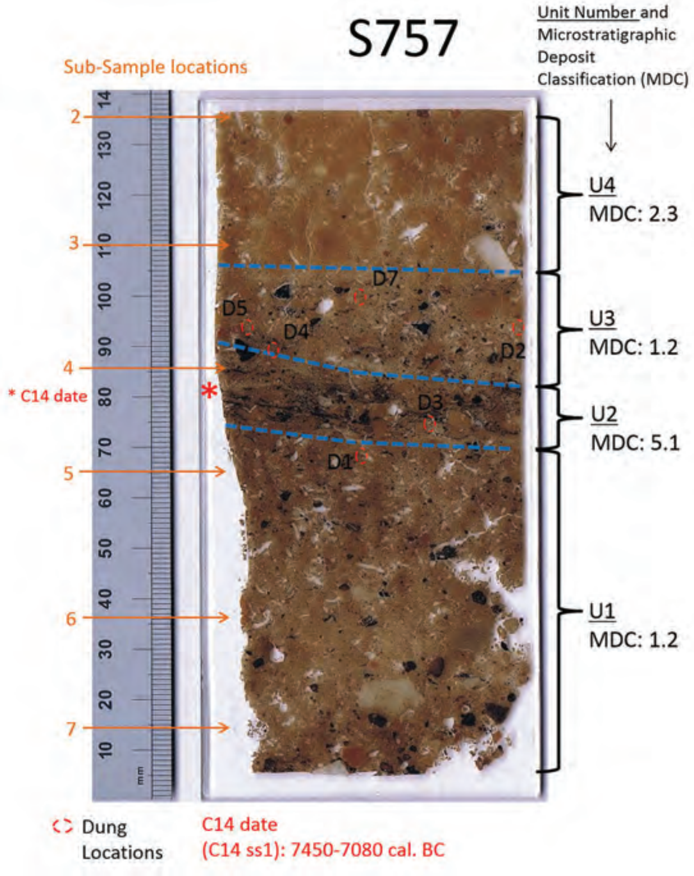


Figure 16.20. SA757, Shimshara. Showing dung locations (D1–D7), sub-samples taken prior to resin impregnation and location of ^{14}C date.

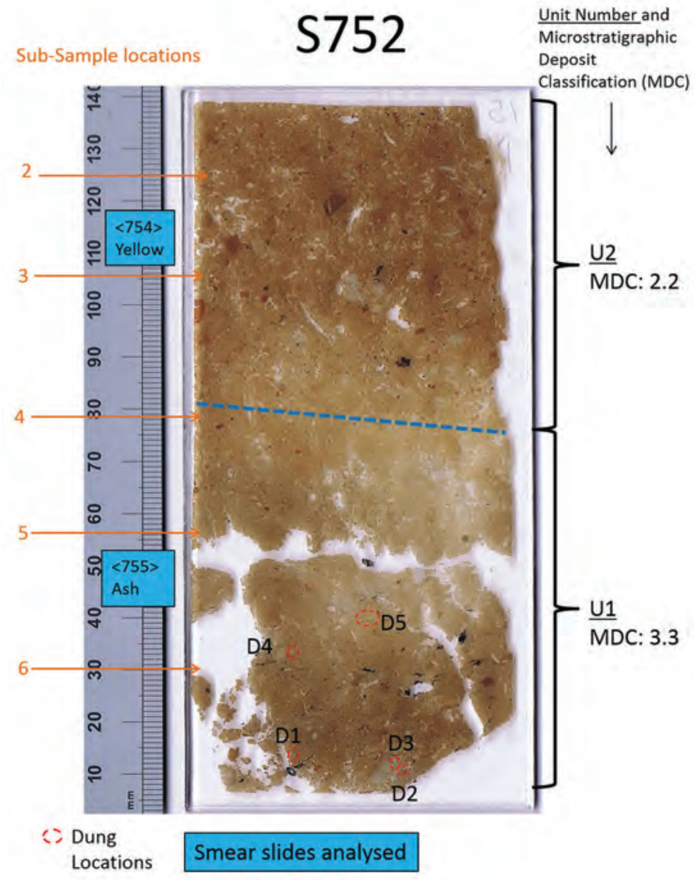


Figure 16.21. SA752, Shimshara. Showing dung locations (D1–D5), smear slides analysed and sub-samples taken prior to resin impregnation.

Faecal Type 4.1 in comparison to Faecal Type 2.1 could result from differential preservation. Faecal Type 2.1 has been identified with charred plant remains (up to 30%) but no ash. In comparison Faecal Type 4.1 was identified with minimal charred plant remains (up to 5%) and a high percentage of ash (50–70%).

The high percentage of ash and the reduced percentage of charred plant remains indicate high temperature burning of these particular Faecal Deposits, above 400–500ºC (Boardman and Jones 1990; W. Matthews *et al.* 1997; 2013h). However, the preservation of spherulites within the ash deposits also suggests a burning temperature of below 650–850°C, after which faecal spherulites are recalcined (Canti 1999; W. Matthews 2010; Canti and Nicosia 2018). Faecal spherulites preserve well in ashy deposits due to the high pH and this could provide one of the main differences between Faecal Type 2.1 (no ash and lower spherulites) in comparison to Faecal Type 4.1 (high ash and high spherulites). These different Faecal Deposits identified within the same contexts but allocated to different Faecal Types could represent varying degrees of burning temperature and faecal spherulite preservation, but both Faecal Types could originate from herbivores. Also, temperature can vary significantly within fires which may affect spherulite preservation (Mallol *et al.* 2013; Canti and Nicosia 2018). Additionally, *Herbivore* Faecal Type 4.1 is positively correlated (positive correlation but not perfect positive correlation) with *Probable Herbivore* Faecal Type 2.6 and *Probable Herbivore* Faecal Types 2.1 and 2.5 are positively correlated with *Herbivore* Faecal Type 4.2. Therefore, the positive correlation between numerous *Probable Herbivore* and *Herbivore* Faecal Types provides supporting evidence to suggest the herbivore origin of Faecal Types 2.1, 2.5 and 2.6 at Shimshara.

There are an additional 12 positive correlations between Faecal Types at Shimshara mainly between Faecal Types from major Faecal Category *Low Dung* and the four remaining Faecal Categories, *Probable Herbivore, Probable Omnivore, Herbivore* and *Omnivore*. The correlation between these *Low Dung* Faecal Types and other Faecal Types could represent the presence of poorly preserved or small fragments of faecal material associated with additional identifiable faecal material. The identification of *Low Dung* Faecal Deposits correlated with other Faecal Deposits could suggest that numerous faecal fragments were perhaps mixed within the contexts resulting in some faecal matter identified as singular faecal spherulites or small deposits of faecal material (*Low Dung*).

Key contexts identified at Shimshara for additional microanalyses

The overall results from the Faecal Deposits identified at Shimshara suggest that there are significant abundant burnt deposits identified with mixed faecal material. A range of these was selected for GC-MS analysis from different contexts with charred plant/faecal material in thin-section SA757 (Fig. 16.20) and ashy/faecal material in thin-section SA752 (Fig. 16.21). Burnt deposits with different Faecal Types were also selected: Faecal Type 3.3 from SA752, Faecal Type 2.7 and 3.8 from SA757. Further GC-MS analysis was implemented to attempt to further identify the omnivore faecal material to distinguish between wild boar/pig dung and human coprolites.

Due to the mixed nature of deposits identified with Faecal Material from Shimshara, no deposits were selected for dietary analysis using silica phytoliths because the phytolith assemblages would represent a dietary signature mixed with background phytoliths.

Phytoliths

Subsamples taken from the micromorphological thin-sections prior to resin impregnation were only selected for phytolith extraction and analysis where faecal material was concentrated, discrete or defined. No samples with these criteria were available from the thin-sections analysed at Shimshara. A total of 13 samples were selected from contexts at Bestansur from Trenches 7 and 12 (Table 16.9).

Weight percent (abundance)

The weight percent of phytoliths produced by each sample was calculated by dividing the weight of the phytoliths recovered after extraction by the original weight of the sediment processed. These values are not 100% accurate due to the presence of other siliceous material such as diatoms and sponge spicules. The weight percent provides a general comparison of the quantity of silica in each sample. However, during analysis only a few diatoms and sponge spicules were observed in all of the samples, and therefore, for these phytolith samples, the weight percent is a reasonably accurate representation of the quantity of phytoliths in each sample.

Figure 16.22 represents the weight percent of the samples analysed at Bestansur from the southern and northern areas of the site (Trenches 9 and 12). Samples were analysed for phytoliths from the southern end of the site (Trench 9) from *External areas* in *Features* (C1306 and C1307) and Deposit/layer type *Fire spot*. The Faecal Types which were analysed from here were identified as *Low Dung, Probable Herbivore* and *Herbivore* types and the samples have an average weight percent of phytoliths of 7.26%. Phytolith samples were also analysed from the northern end of the site (Trench 12) and were also from *External areas* but in this area of the site the deposits were specifically allocated *Open Areas*. These *Deposit/layer types* were *Occupation residues* and the Faecal Types analysed were identified as *Probable Omnivore* and *Omnivore* types and the samples have an average weight percent of phytoliths of 0.34%.

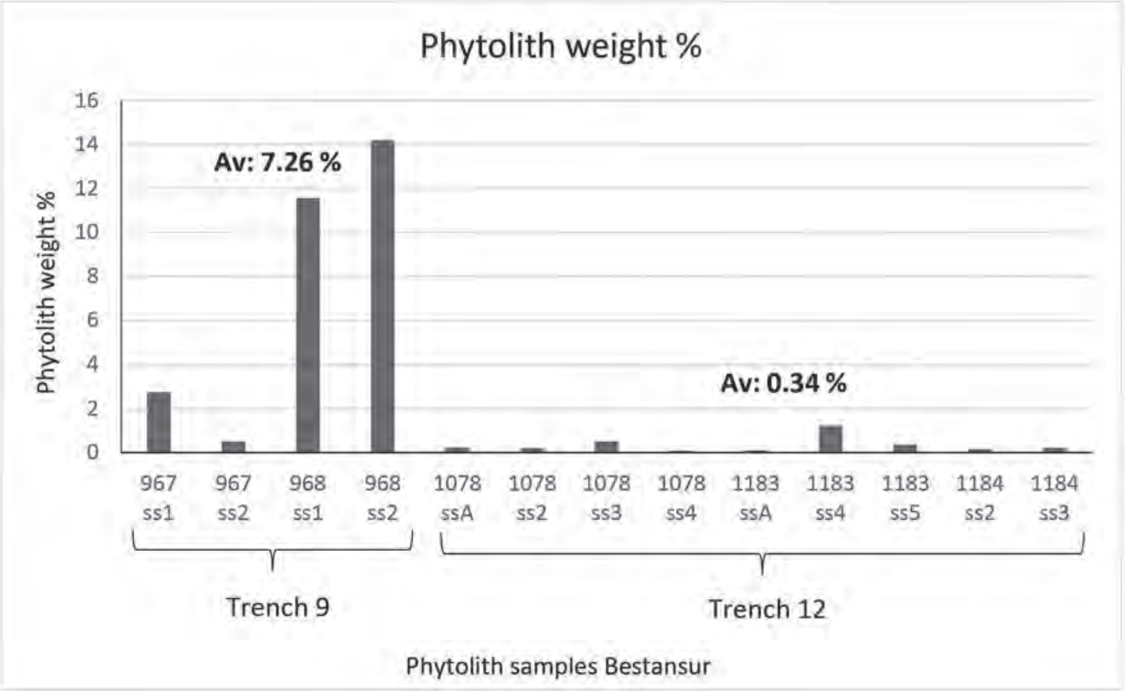


Figure 16.22. Weight percent of phytoliths from sub-samples in Trenches 9 and 12, Bestansur, showing averages for each trench.

Table 16.9. Sub-samples processed for phytolith analysis from micromorphology blocks in Trenches 9 and 12, Bestansur.

Trench	*Thin section*	*Context*	*Sub-sample processed*	*Micro-morphological unit*	*Faecal deposit allocation*	*Faecal Type*	*Main Faecal Type identified*
9	967	1306	Ss1	1	D1-D7	2.2/2.5/4.2/4.4	Probable herbivore/herbivore
9	967	1306	Ss2	1	D8-D10	1.1/2.5	Low dung/probable herbivore
9	968	1307	Ss1	1	D1-D3	1.6	Low dung
9	968	1307	Ss2	1	D4/D5/D9	1.6/2.3	Low dung/probable herbivore
12	1078	1396	Ssa	5	D1-D3	3.1/3.6/3.8	Probable omnivore
12	1078	1397	Ss2	3	D4-D7	3.8/5.1	Probable omnivore/omnivore
12	1078	1397	Ss3	3	D10	5.1	Omnivore
12	1078	1388	Ss4	1	D8	3.3	Probable omnivore
12	1183	N/a	Ss4	6	D3	5.1	Omnivore
12	1183	N/a	Ssa	4	D2	5.1	Omnivore
12	1183	N/a	Ss5	2	D1	5.1	Omnivore
12	1184	N/a	Ss2	7	D3	5.1	Omnivore
12	1184	N/a	Ss3	5	D2	5.1	Omnivore

The weight percent of phytoliths from the samples in the south of the site (Trench 9), which are predominantly identified as herbivore dung (categorised during micromorphological analyses, see Table 16.3) in *Fire spots*, are over 20 times higher than the weight percent of phytoliths from the samples in the north of the trench (Trench 12) from omnivore faecal material identified in *Occupation residues*.

Figure 16.23 compares the normal distribution curves using the mean weight percent and the standard deviation to examine variation within the two data sets. The normal distribution bell-shaped density curves are described by the mean, the peak of each curve, and the standard deviation, the spread either side of the mean along the horizontal axis. There is a larger spread in the weight percent between the samples of herbivore dung in comparison to the omnivore faecal material, as depicted on the X axis (Fig. 16.23). There is a higher mean weight percent in the herbivore dung in comparison to the omnivore faecal material, as plotted on the Y axis (Fig. 16.23). There is limited overlap between the normal distribution curves representing the weight percent of the herbivore dung in comparison to the weight percent of the omnivore faecal material. This overlap helps to determine the probability that the two data sets are from the same distribution. The probability that there is no difference between the data sets increases as the overlap between the distribution

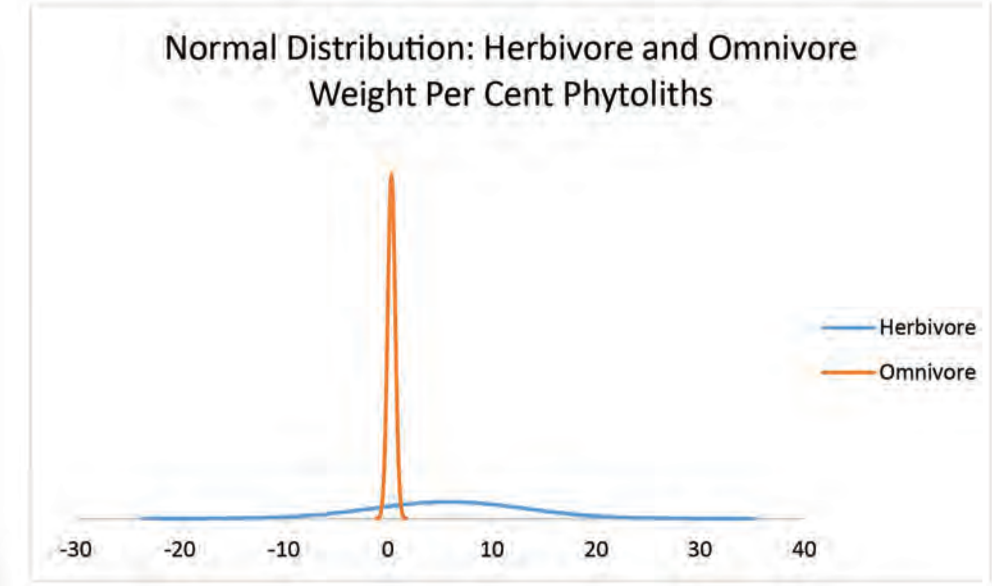


Figure 16.23. Normal distribution curve comparing weight percent of phytoliths from herbivore dung in Trench 9 and omnivore dung in Trench 12. The peaks on the Y axis represent the mean and the spread along the X axis represents the standard deviation.

curves increase. Therefore, the smaller the overlap, the more significant the differences between the data sets. While there is an overlap between these data sets the overall pattern between the two groups is significant, indicating that weight percent of phytoliths can be used to distinguish between herbivore dung and omnivore faecal material. Herbivore dung is identified with high percentages of phytoliths due to a diet of vegetation high in phytoliths such as grasses. Omnivore faecal material examined in this chapter has been identified with low percentages of phytoliths due to a varied diet consisting of vegetation with lower percentages of phytoliths such as roots and tubers in addition to other material such as meat and fish, attested by presence of bone, and some burnt materials. If some of the faecal material identified as omnivore originated from humans, and not pigs, as discussed below and in Chapters 12, 13 and 24, then a lower percentage of phytoliths also could be representative of human diet. Human diet does not include consumption of grass leaves and stems which account for a large percentage of the phytoliths in herbivore dungs.

Assemblages/morphotypes

The phytolith results from the dung samples analysed from Bestansur are presented in Figures 16.24 and 16.25. All samples analysed from Bestansur consist of a mixed monocot and dicot assemblage. A direct comparison between monocots and dicots cannot be conducted because monocots produce between 14 to 20 times as much weight percent of phytoliths in comparison to dicots (Albert *et al.* 2003). All samples from Bestansur are dominated by monocots, and more than half of the samples have <10% dicots (Fig. 16.23). The six samples with >10% dicots all represent main Faecal Type *Omnivore* or *Probable Omnivore* material. This increase in the percentage of dicots is significant, as dicots tend to produce fewer phytoliths than monocots.

The presence of phytoliths from the grass leaf/stems and the inflorescence indicates that the animals were eating material from the complete plant (elongate smooth, sinuate and dendritic, Fig. 16.24). This material could represent either grazed grasses or fodder from two stages of crop processing. The waste material from initial threshing and winnowing removes the leaf/stem material and the subsequent pounding and milling separates the grain and the chaff (Harvey and Fuller 2005). The weight percent of phytoliths produced from the grass inflorescence is higher than the weight percent produced by the grass leaf/stems (Piperno 1988; Tsartsidou *et al.* 2007). The leaf/stem phytoliths (elongate smooth, sinuate, rod and trapeziform) are dominant in all samples from Bestansur compared to the husk phytoliths (elongate dendritic) (Fig. 16.24). Therefore, given that the inflorescence produces more phytoliths than the leaves/stems, the animals' diet for all samples processed from Bestansur is dominated by grass leaf/stems which might be from seasonal grazing (i.e. in the autumn or winter when there are less inflorescence bracts) or foddering using material from the early stages of crop processing (leaf/stems only).

All faecal samples analysed from Bestansur contain phytoliths produced by *Phragmites* (reeds; Fig. 16.25). Single-celled keystone phytoliths are common in, but not restricted to, reeds. Keystones comprise 0.4–12.7% of the single-celled phytolith assemblages identified in the samples analysed from Bestansur (Fig. 16.24).

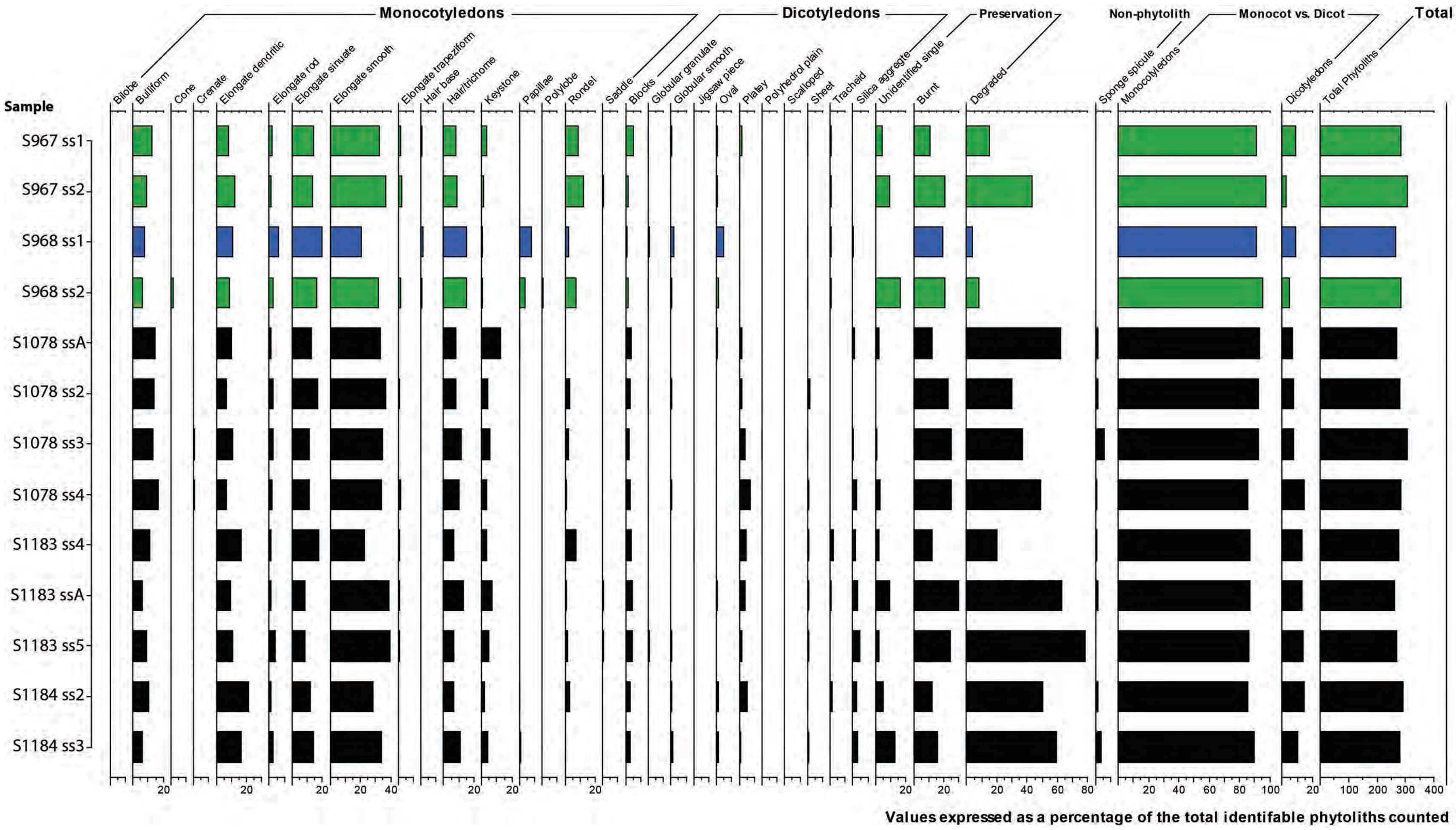


Figure 16.24. Phytolith results for single-celled counts, Bestansur. Values expressed as a percentage of the total single-celled phytoliths identified. Green= Herbivore types; Blue= Indeterminate/Low Dung; Black= Omnivore types.

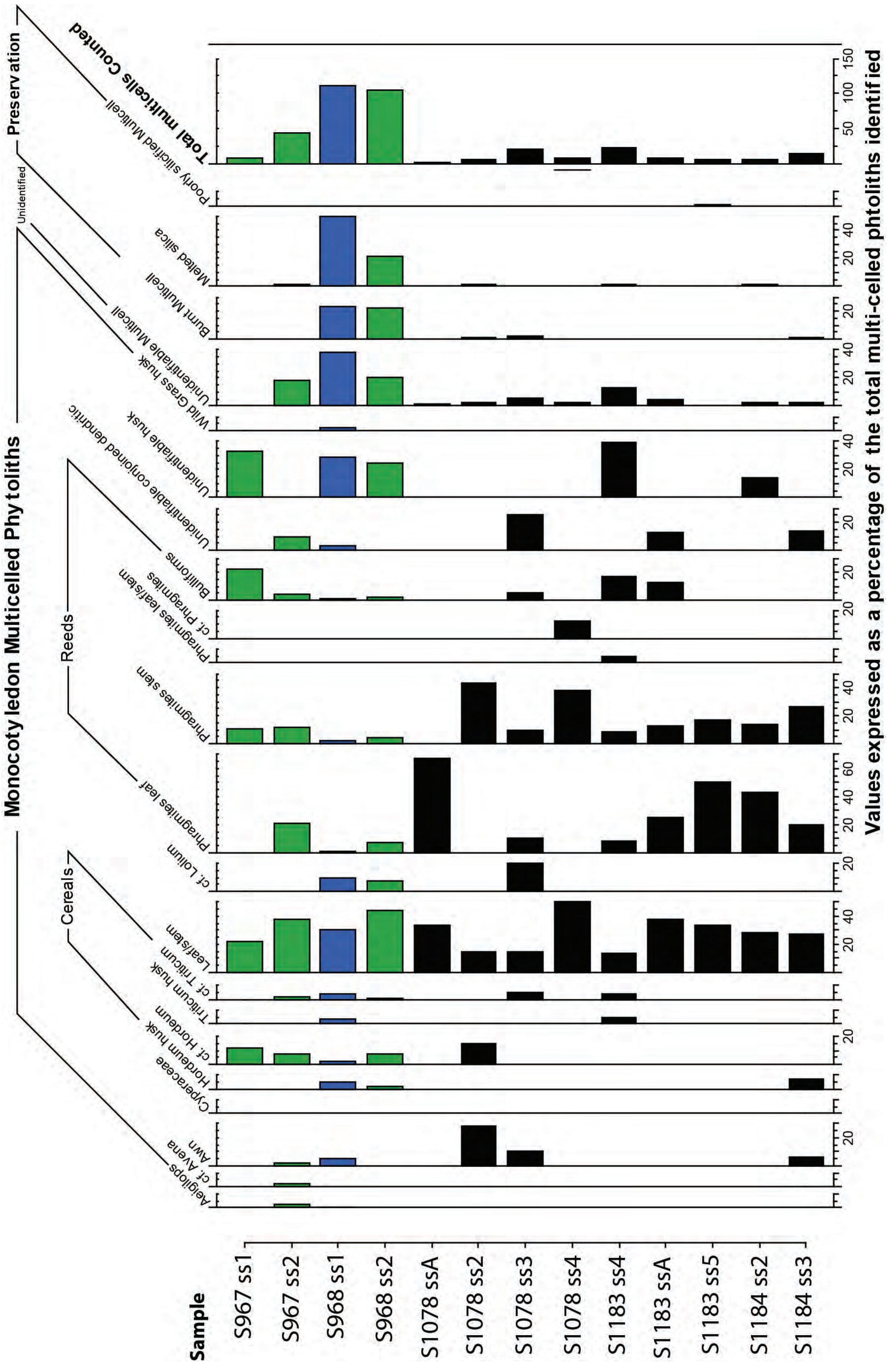


Figure 16.25. Phytolith results for multi-celled counts, Bestansur. Values expressed as a percentage of the total multi-celled phytoliths identified. Green= Herbivore types; Blue= Indeterminate/Low Dung; Black= Omnivore types.

Keystones cannot be used to definitively identify reeds but their presence alongside confirmed multi-celled *Phragmites* phytoliths in all samples suggests a likely origin for these single-celled phytoliths. Multi-celled phytoliths in the form of stacked bulliforms (Fig. 16.25) and other multi-celled varieties identified from reed stems and reed leaves comprise 3.6–66.7% of the identified multi-celled assemblages in the samples from Bestansur (Fig. 16.25). The sample with the lowest percentage of keystones also contains the lowest percentage of multi-celled phytoliths from *Phragmites* and the sample with the highest percentage of keystones also contains the highest percentage of multi-celled phytoliths from *Phragmites* (Figs 16.24 and 16.25, sample SA968 ss1 and SA1078 ssA respectively). Phragmites appear to be in all Faecal Deposits analysed and appear slightly more prevalent in the faecal deposits identified as *Omnivore* (see Fig. 16.24 and 16.25). The site of Bestansur is located next to a spring and reeds were likely to be widespread and available within the vicinity of the site much like today. One of the samples also contained a low percentage of single-celled phytoliths from sedges (*Cyperaceae* cone phytoliths), SA968 ss2. Sedges and reeds are grown in similar environments around springs and rivers in standing water. There could be two possibilities for the presence of reeds and absence of sedges in the majority of the dung. Either the animals graze around the site and consume the reeds but not the sedges out of preference, or the reeds were collected and given to the animals as fodder and the sedges were not. One other possibility is that the quantity of sedges was low in the Neolithic environment.

Eight of the 13 dung samples analysed also contained low numbers of identifiable cereal multi-celled phytoliths, between 6.7% and 14.5% of the overall multi-celled assemblages (Fig. 16.25). Three of these samples contained *Hordeum* (barley), two contained *Triticum* (wheat) and three contained a combination of the two types (Fig. 16.25). Cereals can only be identified by the presence of multi-celled phytoliths from the inflorescence bracts or the chaff. Therefore, in order to positively identify specific cereals in the animals' diet, cereal chaff must constitute part of the animal feed. A diet consisting solely of cereal leaf and stems (e.g. fodder) would therefore not facilitate the identification of cereals (although some small fragments of bract could be incorporated). Three of the 13 samples were identified from the micromorphological analysis as main Faecal Types *Herbivore* or *Probable Herbivore*. All three of these samples contained identifiable cereals (Table 16.9 and Fig. 16.25). In comparison, nine of the dung samples were identified from the micromorphological analysis as main Faecal Types *Omnivore* and *Probable Omnivore* (Table 16.9). Only four of the omnivore samples contained identifiable cereal multi-celled phytoliths (Fig. 16.25). Of the samples identified as omnivore which were tested for bile acids to distinguish human from pig/wild boar origin (five samples tested from Bestansur) four were attributed as human and one as wild boar or pig (see GC-MS results section). Cereals were identified only from the human faecal material, not from the wild boar/pig faecal material. The highest proportion of identifiable cereals from the whole assemblages was in one of the herbivore dung samples, SA968 ss1, C1307 Trench 9 which was from a *Fire installation* in an *External area* (Fig. 16.25). The lowest percentage of identifiable cereals in the faecal samples from Bestansur (apart from the samples without cereals), was in one of the omnivore samples identified as human faeces, SA1184 ss3, Trench 12, from an *External Open area* from *Occupation residues* (Fig. 16.25). Rondel short celled phytoliths are produced in the leaves and stems of C3 pooideae grasses which include the Southwest Asian cereals *Hordeum* and *Triticum* (Twiss 1992). Rondels are present in 12 of the 13 dung samples analysed from Bestansur and comprise 0.4–12.1% of the single celled assemblages in these samples (Fig. 16.24) These short celled rondel phytoliths are present in both herbivore and omnivore faecal material, both in the human faecal material and the wild boar/pig faecal material, but are slightly more prevalent in faecal material identified as herbivore. The presence of these pooideae morphotypes further attests the presence of cereals in the human and animal diet.

Occluded carbon on phytoliths and degraded phytoliths was identified in all 13 phytolith assemblages from the dung samples analysed from Bestansur (Fig. 16.24). Occluded carbon on burnt phytoliths comprises 3.9–11.4% of the single celled phytolith assemblages. Four of these samples were from hearth deposits and the remaining nine were from a dirty area of the site with midden deposits, burnt layers and burnt dung. The degraded forms represent between 1.5% and 29.1% of the overall single celled phytolith assemblages (Fig. 16.24).

Grazing, browsing and foddering signatures

All faecal material analysed for the phytolith assemblages from Bestansur indicate signatures of combined grazing and browsing for herbivores and the one wild boar/pig sample. The three samples confirmed to have a human faecal origin (see GC-MS results section) also suggest that people were consuming both monocotyledonous plants including cereals, but also some dicotyledonous material. Herbivore grazing strategies represent vegetation close to the ground, whilst browsing tends to represent leaves and bark from shrubs and trees. This grazing/browsing signature is represented by the presence of both monocot and dicot phytoliths in the samples. The samples probably represent animals grazing and browsing in and around the cereal fields after harvest, suggested by the low availability of husks. After the harvest there is likely to be low residual husks present in the fields, and the residual material are likely to be dominated by leaves and stems. However, there is also a possibility that the animals were foddered with a mixture of material after crop-processing in the spring, by assemblages dominated mainly by grass leaves and stems. This option is unlikely to have been economically sustainable in the late spring to autumn. The time taken to collect a range of plants for foddering would have greatly outweighed the time needed to take the animals to graze and browse around the village. Fodder could have been collected after the harvest (late spring/early autumn) and stored to provide supplementary food in the winter when grazing and browsing are less fruitful. The low presence of cereal multi-cells identified from the cereal husks in the dung samples indicates that the husks were not widely consumed while grazing, but not that cereals were not a large part of the diet. Cereal leaves and stems are not identifiable from phytolith remains. However, the presence of plants, such as legumes, that do not produce distinctive phytoliths must be considered. Consideration should also be made for the bias in the silicification of single-cells prior to multi-cells. The presence of husks in the diet is attested by single-celled elongate dendritic phytoliths. Therefore, grass husks are a component of the animals' diet, but the specific cereal of origin is not always identifiable because of the lack of identifiable multi-cells. This lack of multi-cells could result from phytolith production and silicification. However, it could also be for a number of other reasons: a consequence of taphonomic breakdown from the passage of phytoliths through the digestive tract, the deposition and compaction of dung deposits, and the effects of *c*. 10,000 years diagenesis resulting from deposition within the archaeological deposits, or the sparsity of cereal use, this latter possibility suggested by both the charred archaeobotanical remains and analyses of micromorphological samples from a wide range of other context and deposit types (Chapters 18 and 12).

The omnivore faecal samples analysed from Bestansur contain more dicots in comparison to the herbivore dung. This could result from dietary preference, grazing/browsing location or perhaps human agency. The phytolith evidence alone cannot provide the reason for this distinction between dietary signatures and dung types. Modern wild boar and pig populations are known to forage or root for food such as bulbs, roots, nuts and tubers as well as seeds and fruits (Cansdale 1970; Challies 1975; Bueno *et al*. 2011). This factor could account for the increased dicot portion of the omnivore diet of pigs/wild boar. The presence of dicot phytoliths in human coprolites from Bestansur adds to the increasing new evidence for the importance of wild foods in human diet in the Neolithic in the EFC and more widely (Chapters 12, 13 and 24).

The phytolith evidence presented in this chapter cannot confirm whether there was anthropogenic influence on animals, or specifically indicate whether these animals were being managed or actively grazed or foddered in Neolithic Bestansur. However, the presence of concentrated dung in fire installations from the southern area of the site in Trench 9 indicates human influence and intervention in the use of dung on site suggesting human management of animals and thereby of animal dung.

Gas chromatography mass spectrometry (GC-MS)

GC-MS analyses of selected sub-samples were conducted to verify the faecal origin of Faecal Deposits identified microscopically in thin-section and to aid identification of producer genus type, by examination of coprostanols and bile acid molecules (Table 16.10). The likely origin of faecal sterols was calculated by identification and comparison of the ratios of these different biomolecular markers (Table 16.11 adapted from Shillito *et al*. 2013c, table 8.2). Sub-samples were selected for GC-MS analysis from the micromorphological thin-section where faecal material was identified during microscopic analysis from 12 deposits at Bestansur and four at Shimshara (Table 16.12).

The coprostanol and bile acid results for the samples from Bestansur and Shimshara are presented in Table 16.13. A summary of the results correlated with micromorphological results is presented in Table 16.14.

Table 16.10. Details of coprostanols and bile acids in ruminant, pig and human faeces.

	Coprostanols	*Bile acids*
Ruminants	High proportions of 5β-campestanol and 5β-stigmastanol	N/a
Humans	Coprostanol is the dominant 5β-stanol	Predominantly hyodeoxycholic acid (3α,6α-dihydroxy-5β-cholanoic acid) with an absence of deoxycholic acid (3α,12α-dihydroxy-5β-cholanoic acid)
Pigs	Coprostanol is the dominant 5β-stanol	Lithocholic acid (3α-hydroxy-5β-cholanoic acid) and is dominated by deoxycholic acid (3α,12α-dihydroxy-5β-cholanoic acid)

Reference: Bull *et al*. 1999: 87–90

Table 16.11. Faecal sterol calculations (adapted from Shillito et al. 2013c, table 8.2).

	Analysis of sterols	
Ratio	*Calculation*	*Interpretation*
1	Coprostanol/ (coprostanol + 5α-cholestanol)	>0.7 = faecal deposit
2	Coprostanol + epicoprostanol/ (coprostanol + epicoprostanol + 5α-cholestanol)	>0.7 = faecal deposit
3	(Coprostanol = epicoprostanol)/ 5β-stigmastanol + 5β-epistigmastanol)	>1 = omnivore, <1 = ruminant

Table 16.12. Samples process for GC-MS analysis from Bestansur and Shimshara.

Trench	*Thin section*	*Context number*	*Sub-sample processed*	*Unit*	*Faecal deposit allocation*	*Faecal Type*	*Main Faecal Type*
Bestansure							
7	651	1093/1252	ss6	1	D1-D5	1.1/2.5	Low dung/ probable herbivore
9	967	1306	ss1	1	D1-D7	2.2/2.5/4.2/4.4	Probable herbivore/ herbivore
9	968	1307	ss2	1	D4/D5/D9	1.6/2.3	Low dung/probable herbivore
12	1078	1397	ss2/3	3	D4-7/D9/D10	3.3/3.8/5.1	Probable omnivore/omnivore
10	1080	1330	ss3	4	D2-D4	2.6	Probable herbivore
12	1183	n/a	ssA	4	D2	5.1	Omnivore
12	1183	n/a	ss5	2	D1	5.1	Omnivore
12	1184	n/a	ss2	7	D3	5.1	Omnivore
12	1184	n/a	ss3	5	D2	5.1	Omnivore
12	1185	n/a	ss3/4	4	D2-D5	5.1	Omnivore
12	1186	n/a	ss5	2	D4/D5	3.8	Probable omnivore
Shimshara							
n/a	752	n/a	ss6	1	D4/D5	3.3	Probable omnivore
n/a	757	n/a	ss4	2	D3/D4	1.6/3.8	Low dung/probable omnivore
n/a	757	n/a	ss5	1	D1	2.7	Probable herbivore
n/a	758	n/a	ss5	1	D1-D4/D7	3.8	Probable herbivore
n/a	763	n/a	ss5	1	D2/D4	1.1/5.1	Low dung/omnivore

In seven of the samples (five from Bestansur and two from Shimshara) no faecal component was evident from the GC-MS results; the remaining nine samples have a definitive faecal origin (ratio 2 is above 0.7; see Table 16.11 and 16.13). Six of the nine samples have a value above 1 for ratio 3 indicating that the samples contain sterols from omnivores and two of the samples have values below 1 indicating that the samples contain sterols from herbivores (Table 16.13). The last sample is indeterminate because the value for ratio 3 is borderline (Table 16.13). The six samples with values from the coprostanol results which indicate an omnivore origin were further tested for bile acids (Table 16.13). Unfortunately, one sample was lost during analysis, but of the remaining five, four were identified as human origin and one as wild boar/pig origin (Table 16.13). All of these samples originated from the same area of the site (Trench 12), and the results suggest that it was used as a human waste/ latrine area, but also at one point has wild boar/pig faecal material in thin compacted horizontal layers, suggesting at least presence of wild boar/pig if not purposeful corralling of wild boar/pig. The animals were likely to be attracted to an area of human waste.

Table 16.14 compares the results from the GC-MS results with the micromorphological analysis and classification of the Faecal Deposits identified in thin-section. A direct comparison cannot be made for five samples from Bestansur and three samples from Shimshara, because seven of the samples contained no biomolecular indicators of faecal matter (five Bestansur and two Shimshara), and in one Shimshara sample the ratio 3 was border-line so distinction between herbivore and omnivore could not be confirmed with GC-MS analysis.

The remaining eight samples were analysed both by micromorphological thin-section and by GC-MS. Five of these samples indicate a full match between the micromorphological and GC-MS identifications and the remaining three show a partial match (see Table 16.14). The definition of a partial match is determined when a mixture of Faecal Types had been identified in micromorphological thin-section. For the GC-MS to be partially matched, initially faecal material would be confirmed from sterol ratio 2 and then confirmation of at least one of the Faecal Types identified microscopically by sterol ratio 3 (see Tables 16.11 and 16.14).

Analysis and discussion

Previous dung studies have highlighted the need for a combination of several techniques to provide the most accurate and robust results for identification

Table 16.13. Top: A summary of the sterol analyses with interpretation; bottom: A summary of the bile acid analyses for samples containing higher than trace amounts of sterol faecal biomarkers.

	Compounds												
Sample ID	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*Interpretation*
651 SS6	Trace	Trace	√	Trace	–	–	√	Trace	√	Trace	√	√	Trace/background faecal component
1186 SS5	–	–	–	–	–	–	–	–	–	–	√	–	No faecal component
757 SS5	√	Trace	√	√	–	–	√	Trace	√	Trace	√	√	Trace/background faecal component
1078 SS2/3	√	Trace	√	√	Trace	–	Trace	–	√	–	√	√	Moderate faecal component, omnivore origin
757 SS4	–	–	–	–	–	–	–	–	–	–	–	–	No faecal component
752 SS6	–	–	√	–	–	–	–	–	–	–	–	–	No faecal component
968 SS2	Trace	–	√	Trace	–	–	√	√	√	√	√	√	Trace/background faecal component
758 SS5	√	Trace	√	√	–	–	–	Trace	√	Trace	√	√	Small faecal component, likely omnivore origin
1183 SS5	√	√	√	√	√	–	–	√	√	√	√	√	Large faecal component, omnivore origin
1183 SS3	√	√	√	√	√	–	–	√	√	√	√	√	Large faecal component, likely omnivore origin
957 SS1	–	–	√	–	–	–	–	–	–	–	–	–	No faecal component
1184 SS2	√	√	√	√	√	–	–	Trace	√	Trace	–	–	Small faecal component, omnivore origin
758 SS5	Trace	–	Trace	Trace	–	–	–	–	Trace	–	Trace	Trace	Trace/background faecal component
1080 SS3	–	–	√	–	–	–	–	–	–	–	–	–	No faecal component
1185 SS3/4	–	–	√	–	√	–	–	–	–	–	–	–	No faecal component
1184 SS3	√	Trace	√	√	–	–	–	√	√	√	–	–	Moderate faecal component, omnivore origin

	Compounds					
Sample ID	*13*	*14*	*15*	*16*	*17*	*Interpretation*
1078 SS2/3	√	√	–	–	–	Human origin
758 SS5	√	√	–	–	–	Human origin
1183 SS5	√	√	Trace	–	–	Human origin
1183 SS3	X	X	X	X	X	Sample lost
1184 SS2	–	–	–	–	–	Omnivore origin
1184 SS3	√	√	–	–	–	Human origin

Table 16.14. GC-MS results from Bestansur and Shimshara compared against micromorphological results.

Trench	*Thin section*	*Context no.*	*Sample processed*	*Ratio 2*	*Ratio 3*	*Sterols Faecal yes/no*	*Herbivore/ omnivore*	*Bile acids Herbivore/wild boar/pig/human*	*Main faecal type identified micromophologically*	*Gc-ms and micromorphological match?*	*Full or partial match*
Bestansur											
7	651	1093/1252	ss6	0.79	0.99	yes	Herbivore	N/a	Low dung/probable herbivore	yes	partial
9	967	1306	ss1	n/a	n/a	no	n/a	N/a	Probable herbivore/ herbivore	n/a	n/a
9	968	1307	ss2	0.56	0.58	yes	Herbivore	N/a	Low dung/probable herbivore	yes	partial
12	1078	1397	ss2/3	0.82	1.26	yes	Omnivore	Human	Probable omnivore/omnivore	yes	full
10	1080	1330	ss3	n/a	n/a	no	n/a	N/a	Probable herbivore	n/a	n/a
12	1183	n/a	ssA	0.97	1.51	yes	Omnivore	Human	Omnivore	yes	full
12	1183	n/a	ss5	0.95	1.01	yes	Omnivore	N/a sample lost	Omnivore	yes	full
12	1184	n/a	ss2	0.93	1.92	yes	Omnivore	Wild boar/pig	Omnivore	yes	full
12	1184	n/a	ss3	n/a	n/a	no	n/a	Human	Omnivore	n/a	n/a
12	1185	n/a	ss3/4	n/a	n/a	no	n/a	N/a	Omnivore	n/a	n/a
12	1186	n/a	ss5	n/a	n/a	no	n/a	N/a	Omnivore	n/a	n/a
Shimshara											
n/a	752	n/a	ss6	n/a	n/a	no	n/a	N/a	Probable omnivore	n/a	n/a
n/a	757	n/a	ss4	0.83	1.02	yes	Indet.(borderline)	N/a	Low dung	n/a	n/a
n/a	757	n/a	ss5	0.81	2.08	yes	Omnivore	N/a	Omnivore	yes	full
n/a	758	n/a	ss5	0.88	1.18	yes	Omnivore	Human	Low dung/ probable omnivore	yes	partial
n/a	763	n/a	ss5	n/a	n/a	no	n/a	N/a	Low dung	n/a	n/a

of faecal remains (Shahack-Gross 2011; Lancelotti and Madella 2012; Portillo *et al.* 2012; 2014). This research has highlighted the value of additional new methodologies in a multi-proxy approach, and has developed stream-lined protocols in the application of these methods, including novel application of pXRF in the field rather than bulk phosphate analyses in the laboratory, and specific in-field microscopic analysis of smear-slides to detect faecal spherulites in addition to standardised laboratory spherulite extractions.

The pXRF and smear-slide field results for Bestansur yielded evidence of areas with elevated phosphorus levels and enabled identification of probable faecal spherulites. These results provided the framework for strategic targeted micromorphological sampling. The use of pXRF to detect phosphorus during excavation as a key indicator of potential faecal material had not been implemented before. This specific methodology was applied in an experimental and developmental approach. As phosphorus may be an indicator of a wide range of materials and activities (Akyol and Demirce 2005a; Holliday and Gartner 2007) in addition to faecal material, deposits with elevated levels of phosphorus detected in the field by pXRF analysis were also tested by microscopic smear-slide analysis of spot samples in the field lab to identify potential faecal spherulites. Field smear-slide analysis of spot samples, mainly collected from areas of elevated phosphorus, facilitated the identification of probable faecal spherulites during excavation and sampling. In addition to identifying faecal spherulites, the presence and preservation of phytoliths was also ascertained in the smear-slide analyses.

Overall patterns of Faecal Deposits, Faecal Categories and Faecal Types

Bestansur

The overall intra-site pattern at Bestansur shows increased numbers of dung deposits identified in the northern, eastern and southern areas of the site (Trenches 12, 10 and 9). There is a dominance of *Omnivore* faecal material to the north of the site in Trench 12, identified in micromorphological thin-section and confirmed by GC-MS analyses. The east area of the site contains a dominance of *Probable Herbivore* faecal material in Trenches 1 and 10. The south of the site (Trench 9) is a combination of *Low Dung* and *Probable Herbivore* dung. The areas to the west, southwest and southeast were identified with *Low Dung* types (Trenches 7, 4 and 8; Fig. 16.6).

An important positive correlation is between *Herbivore* Faecal Types and *Probable Herbivore* Faecal Types at Bestansur. *Probable Herbivore* Faecal Type 2.2 is positively correlated with *Herbivore* Faecal

Types 4.1 and 4.2. Therefore, the identification of *Probable Herbivore* Faecal Type 2.2 correlated with these particular *Herbivore* Faecal Types (4.1 and 4.2) provides supporting evidence for the interpretation of Faecal Type 2.2 as originating from herbivores. The pattern is similar for *Probable Herbivore* Faecal Type 2.3 and *Herbivore* Faecal Types 4.2 and 4.4. The positive correlation between these types also provides supporting evidence for the interpretation of Faecal Type 2.3 as herbivore faecal material.

Significant contexts identified with faecal material at Bestansur are burnt deposits. In total, 22% of Faecal Deposits from Bestansur were identified in *Fire Spots,* suggesting a substantial use of dung as a fuel, providing evidence for secondary product use. Eight percent of the faecal remains identified in *Fire spots* at Bestansur are allocate to *Low Dung* (Faecal Type 1.6), a signature which could indicate the removal of residual hearth fuel after use or poor preservation due to burning above 650–800°C (Canti 1999; Canti and Nicosia 2018). The remaining 14% of Faecal Deposits identified in *Fire spots* represents more substantial Faecal Deposits of mixed herbivore and omnivore origin within this *Deposit/layer Type*.

Faecal Deposits identified in *Fire Spots* are significant for investigating dung used as a fuel (secondary product use). Faecal Deposits are identified within a range of fire installations and substantial ash deposits within external areas at Bestansur, in particular the deposits analysed in Fire Installations, Features 9 and 10, in the southern area of the site (Trench 9). These deposits were predominantly herbivore in origin which was confirmed from Feature 10 by GC-MS analysis. The substantial concentration of faecal material in Fire Installations in Trench 9 allowed for phytolith analysis to investigate animal diet in these herbivore faecal deposits. The herbivore faecal material was identified with substantial phytoliths with an average weight percent of phytoliths of 7.26% which is high compared to the omnivore faecal material (average 0.34%). The herbivore diet represented by the phytoliths indicates a diet mainly consisting of monocotyledonous plants with a small proportion of dicotyledonous material. The dicotyledonous material on average represents 6.35% of the phytolith assemblage from the herbivore faecal material. The grasses which could be further identified to *genus* in the herbivore faecal material include *Phragmites* (reed), *Hordeum* (barley) and *Triticum* (wheat). The cereals were only identified in low numbers due to a low proportion of husk consumption (only husks can be identified to *genus*).

The majority of faecal material being discarded in the northern area of the site is omnivore in type as confirmed by GC-MS analysis. Most of the faecal material tested was identified as human in origin, but one of the samples tested was identified as wild boar/pig. Two of the highest peaks for Faecal Deposits identified in *Fire installations* are from *Probable Herbivore* Faecal Types 2.3 and 2.5. Herbivore faecal material has been confirmed in *Fire Installations* by GC-MS analysis. This pattern of omnivore faecal material dominating discard deposits and herbivore faecal remains in *Fire Installations* further suggests a distinctive pattern of secondary product use of dung as a fuel, and the presence of omnivore faecal matter as discard in selective later areas of the site in particular in the northern area of the site (Trench 12, and Trench 13; Chapter 12). This relationship indicates that herbivore dung may have been selected for use as a fuel and omnivore faecal material may have been discarded, as might be expected. This association is inferred from the dominant Faecal Types, although omnivore faecal remains do occur in lower numbers in the fire installations and herbivore dung in lower numbers in discarded deposits.

In Trench 12, *Omnivore* faecal material has been identified in an *External area* with no clear architecture and this faecal material is not concentrated within features such as fire installations. This faecal material in the northern part of the site (Trench 12) is often interbedded with additional anthropogenic material. All of these layers in Trench 12 represent omnivore faecal remains, which have been confirmed in three contexts using GC-MS analysis. These results are significant because they represent a concentration of omnivore faecal material in Trench 12 (see Fig. 16.6). Some of the Trench 12 faecal remains represent repetitive layering and compaction of both human and wild boar/pig faecal material, which could suggest both the dumping of latrine material (identified in both samples SA1183 and SA1184) but also presence or corralling of either managed wild boar or domesticated pig in sample SA1184 after *c.* 7070 BC (Fig. 16.26). In these two samples seven substantial layers of compacted *Omnivore* faecal material were identified. The other samples in Trench 12 with substantial omnivore deposits are SA1078, SA1185 and SA1186. The concentration of omnivore faecal material identified as both human and wild boar/pig in Trench 12 enabled the analysis of human and wild boar/pig diet from nine samples of identified faecal material. The omnivore faecal material contained enough phytoliths for quantification, but the average weight percent of phytoliths was much lower than the herbivore faecal material analysed from Bestansur (0.34% in omnivore and 7.26% in herbivore). This reduction in phytoliths represents the more varied diet of omnivores in comparison to herbivores. All omnivore faecal samples analysed for their phytolith assemblages were dominated by monocotyledons material, similar to the herbivore faecal material. However, the omnivore samples were identified with a higher percentage of dicotyledons material (11.03% average dicot material compared to 6.35% average from herbivore dungs). *Phragmites* (reeds) were

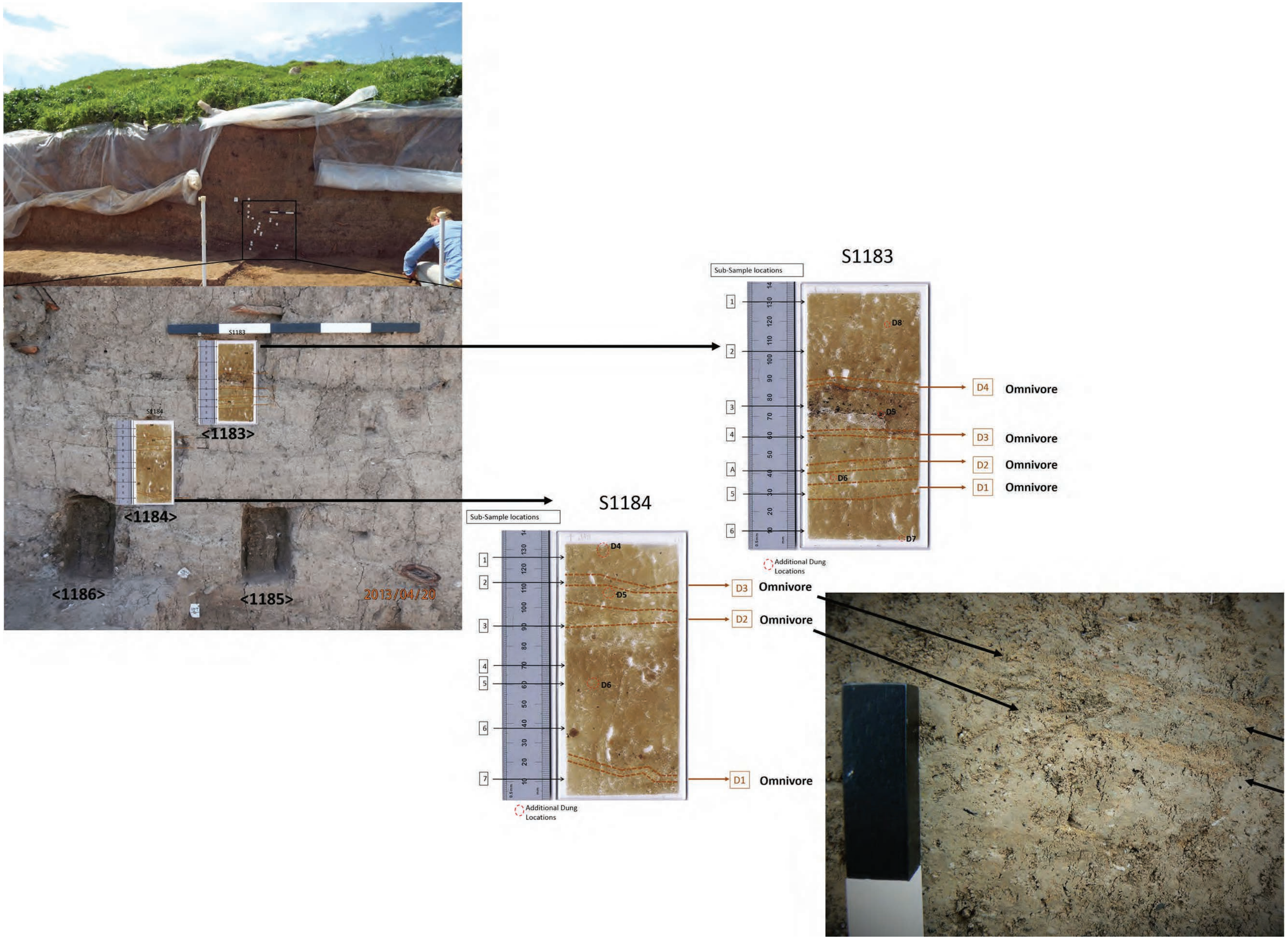


Figure 16.26. Omnivore dung layers identified in Trench 12, Bestansur, from samples SA1183 and SA1184.

identified in all the omnivore faecal material. Cereals were identified in low numbers from only two of the omnivore faecal deposits, one with *Hordeum* (barley) and one with *Triticum* (wheat), both confirmed by GC-MS as human in origin.

The bile acid results from the GC-MS analysis from five of the samples tested suggest that four of these are human in origin and one wild boar/pig, and the dietary analysis from these samples based on the phytolith assemblages suggests a significant dicotyledonous contribution (average 11.03%).

Shimshara

The dominant Deposit/layer Type at Shimshara is *Mixed* with 31% of the Faecal Deposits identified from the contexts analysed suggesting a heterogeneous composition of the contexts identified with faecal material. The *Mixed* deposits are dominated by omnivore faecal material (19.5% *Probable Omnivore/ Omnivore*). However, the Faecal Deposits from Shimshara are fairly evenly spread over the four Deposit/layer Types identified with faecal material. Nineteen percent of the Faecal Deposits identified were allocated specifically to Deposit/layer Type *Fire Spot*, however 42% of the total Faecal Deposits were identified in contexts with a significant proportion of charred plant remains. Burnt contexts at Shimshara that are dominated with charred material indicate a significant burning pattern with dung used as fuel. The identification of the dung in conjunction with charred plant material suggests a mixed fuel source. Furthermore, a further 19% of the Faecal Deposits were identified in contexts identified with significant proportions of ashy material and 8% in association with burnt aggregates. In total, 69% of the Faecal Deposits are within contexts dominated by some form of burnt material. The identification of faecal material in these contexts suggests the use of dung as a secondary product, namely fuel. The most dominant Faecal Types in these contexts are *Probable Herbivore/Herbivore* which suggests the preferential use of herbivore dung as a fuel at Shimshara.

The overall pattern at Shimshara suggests that burnt deposits with Faecal Deposits are dominated by herbivore faecal material and the mixed deposits dominated by omnivore faecal material. Overall the Faecal Deposits identified in contexts at Shimshara suggest mixed fuel, comprising dung in conjunction with wood fuel. Contexts identified with omnivore faecal material could represent burning of either omnivore dung (wild boar or pig) or human coprolites. The presence of faecal material from wild boars, pigs or humans could represent targeted burning of this faecal material. One of the samples from Shimshara was confirmed as human in origin by the bile acid results. Faecal material from herbivores is targeted in modern societies due to the high vegetation content which provides a consistent and lengthy burning temperature. There is no documented evidence of omnivore dung fuel use. Herbivore dung burning has also been identified at numerous other Neolithic sites in Southwest Asia.

In many contexts at Shimshara when *Probable Herbivore* faecal material is identified there is often *Herbivore* faecal material identified based on the perfect positive and positive results of the Spearman's Correlation Coefficient of the Faecal Types. In these contexts at Shimshara it is therefore likely that these Faecal Deposits do represent herbivore dung.

From the five samples analysed at Shimshara by GC-MS only three were confirmed to be faecal in origin. Two of the samples could be identified as omnivore and the third was indeterminate because the value for ratio 3 was borderline. One of these omnivore samples with significant faecal component was further analysed for bile acids and these results confirmed a human faecal origin (Table 16.14). Due to the mixed nature of deposits identified with Faecal Material from Shimshara no deposits were selected for dietary analysis using silica phytoliths.

Faecal Deposit comparison: Bestansur, Shimshara, Sheikh-e Abad and Jani

The average number of Faecal Deposits for micro-morphological thin-sections analysed is higher in the highland Iranian Neolithic archaeological sites of Sheikh-e Abad and Jani (Matthews *et al.* 2013a), in comparison to the piedmont Iraqi archaeological sites of Bestansur and Shimshara. The highland Iranian Neolithic sites have 7.5–8.5 Faecal Deposits on average in each thin-section in comparison to 4.8–5 in the piedmont Iraqi Neolithic sites (Elliott 2015).

At four of the CZAP archaeological sites Faecal Deposits from all five major Faecal Categories were identified: Sheikh-e Abad, Jani, Bestansur and Shimshara (W. Matthews *et al.* 2013h, Shillito *et al.* 2013c, Elliott 2015). The most frequently occurring Faecal Category (the mode) at both Sheikh-e Abad and Jani is *Herbivore.* At Bestansur the modal Faecal Category is *Low Dung*. The modal Faecal Category at Shimshara is *Probable Omnivore* (Elliott 2015). Therefore, the highland Iranian Zagros sites exhibit similarities in the prominent major Faecal Category, indicating a dominance of herbivores. At Bestansur the Faecal Deposits are dominated by low dung signatures. The deposits at Shimshara indicate a dominance of omnivores.

Sheikh-e Abad Faecal Deposits are largely distributed over three of the major Faecal Categories: *Probable Herbivore, Probable Omnivore* and *Omnivore*. This pattern at Sheikh-e Abad contrasts to the pattern of Faecal Deposits identified in Faecal Categories at Jani. At Jani there is a distinct dominance of Faecal Deposits allocated to major Faecal Category *Herbivore.* The pattern at Bestansur indicates an even spread of the Faecal Deposits over the five main Faecal

Categories with the most dominant Faecal Category being *Low Dung*. The Faecal Deposits at Shimshara exhibit a similar pattern to Bestansur but the dominant major Faecal Category is *Probable Omnivore.* Based on the total Faecal Deposits identified at each of the CZAP sites (Elliott 2015), the highest abundance of identified *Low Dung* is from Bestansur, *Probable Herbivore* from Sheikh-e Abad, and *Probable Omnivore* from Shimshara. The highest identified *Herbivore* dung is from Jani and finally the highest identified *Omnivore* faecal material is from Bestansur.

The dominant *Deposit/layer Type* containing Faecal Deposits at Bestansur is *Occupation residues* and at Shimshara *Mixed*. The *Occupation residues* at Bestansur are dominated by Faecal Deposits attributed to *Low Dung* Faecal Types and the *Mixed* deposits at Shimshara are dominated by *Probable Omnivore* Faecal Types. The principle *Deposit/later Type* identified with Faecal Deposits at Sheikh-e Abad is *Surfaces* and at Jani *Floor, Plaster* (Elliott 2015). However, these Deposit/layer Types both represent horizontal defined deposits and therefore exhibit similarities. The *Surfaces* at Sheikh-e Abad which contain faecal material and the *Floor, Plasters* at Jani both represent thin and repetitive contexts within a defined area. Both these *Deposit/layer Types* are dominated by Faecal Deposits attributed to major Faecal Category *Herbivore*.

Conclusions

The results and interpretations presented in this chapter demonstrate the value of an integrated multi-method approach. The combination of the field methods and the micromorphological analysis enables targeted selection of a smaller number of the faecal deposits for further analyses, here of biomolecular analysis by GC-MS and analysis of phytolith microfossils. Once detected, faecal deposits can potentially provide a wealth of information on the identification of animals, human practices pertaining to animal products, animal diet, foddering and grazing/browsing practices, seasonality, surrounding environment and ecology, and early animal management and domestication. Currently there are still few dung studies in the Neolithic in the Fertile Crescent and particularly in the EFC.

Barker stated in 2006 that in order to understand the first agricultural revolution in the Neolithic comparative studies with a range of disciplines are required, utilising research based on anthropology, archaeological science and other relevant disciplines (Barker 2006). The research in this chapter integrates a range of methodologies in order to examine alternative modes of evidence to investigate animal management and domestication and the subsequent consequences of these changes, such as the Secondary Products Revolution, animal diet and animal identification.

The identification of varying abundances of faecal material in a variety of contexts at both Bestansur and Shimshara suggests animal presence and proximity to humans was common in the Zagros in the Early Neolithic. Contexts where animals have been identified within the vicinity of the site, but not specifically within a confined space, provide evidence to suggest herd management or domestication. In fully domesticated animals the most important behavioural response resulting from domestication is the reduced caution and low reactivity to external stimuli (Price 1998; 2002; Zeder 2011). Domesticated animals are more familiar with human occupation and therefore likely to be more comfortable within the confines of human habitation. They may take shelter in and around the village during the day or overnight. In previous studies comparable evidence has been used to suggest similar interpretations. For example, at Ganj Dareh Hesse (1978) interpreted hoof prints in fresh mudbrick as a sign that goats were thoroughly habituated to humans. Zeder (2006) argues that animals were left freely to roam the settlement without the fear of escaping back into the wild. On the other hand, wild animals have increased wariness (Zeder 2011), are less comfortable with human presence, and would probably have tended to avoid the Neolithic settlement. Consequently, the identification of faecal material throughout these two Neolithic settlements is more likely to originate from domesticated, or at least managed, animals.

The evidence of mixed Faecal Types in Spatial Type *Open Area* at Bestansur suggests mixed animal proximity within the Neolithic settlement in non-confined areas that could indicate a transition to animal domestication from animal management. If herds were morphologically wild and in the early stages of management then freedom from animal pens would possibly result in the herds returning to the wild. However, if the herds had been domesticated then it is likely that the animals would be familiar with the Neolithic communities and could co-exist within the village (Price 2002; Zeder 2012b), grazing by themselves in and around the village as observed in modern communities today (Chapter 7). Some dung could also originate from stored/discarded dung at all sites.

The results from Bestansur suggest that herbivore dung was largely used as a fuel in all hearths and was identified in all ashy deposits analysed. Ash deposits with dung fuel in Trench 10 have been dated to *c.* 7700–7600 BC. Furthermore, the identification of low-level background levels of faecal material in all External Areas suggests animal presence or proximity during the Neolithic at Bestansur. The zooarchaeological assemblage from Bestansur suggests a community focused on hunting wild mammals with a small number of domesticated goats, based on metrical assessment of the remains

(Chapter 15). This pattern of a dominance of wild sheep/goat and small numbers of domesticated goat could represent an Early Neolithic community in the process of early management and domestication with animals which are morphologically wild. The quantity of herbivore dung used as a fuel suggests that herbivores could have been managed, possibly to supply dung as fuel, as a secondary product. The omnivore Faecal Deposits identified in the north of the site in Trench 12 which are later than *c*. 7100–7050 BC were identified in repetitive compacted layers and in discard layers that accumulated over a current depth of up to 60cm. These deposits were confirmed as omnivore by the analysis of coprostanols using GC-MS analysis, and five were further tested for bile acids which confirmed four of these to be human in origin and one as wild boar/pig. The pig remains from Bestansur are morphologically wild based on metrical analysis (Chapter 15), and the environment surrounding Bestansur is likely to have been ideal for pigs because of the wet conditions adjacent to the spring, with associated vegetation. The omnivore faecal layer confirmed as wild boar or pig could therefore represent the earliest pig management and/or commensality this far south in the Zagros at *c*. 7100–7050 BC. In the Zagros the earliest definitive evidence for pig domestication is in the Pottery Neolithic *c*. 6000 BC at Jarmo (Price and Arbuckle 2013). The zooarchaeological goat remains from Bestansur also complement the faecal deposits.

The Faecal Deposits at Shimshara are dominated by omnivore faecal material and are identified in a range of contexts *c*. 7400–7000 BC. Shimshara, like Bestansur, is an ideal location for pigs due to the proximity to the river. There is no definitive evidence from the small zooarchaeological assemblage collected from the section investigations at Shimshara, but two thirds of the faunal assemblage is identified as pig/boar (Chapter 15). Further excavation and zooarchaeological analyses need to be conducted at Shimshara. The faecal deposits identified within this research complement the preliminary zooarchaeological assemblages examined at Shimshara.

In the future similar data sets should be produced from other Neolithic sites within the study area to provide comparable results. A range of methods was applied to samples from Bestansur and Shimshara in Iraqi Kurdistan and at Sheikh-e Abad and Jani in Iran. Only one of the four archaeological sites investigated for faecal material in the Zagros Mountains integrated all investigative methods. This research needs expansion across not only the EFC but throughout Southwest Asia from the Neolithic and into later periods. Further similar analyses would enable greater contextualisation within the wider regional study area. All sites analysed in this research should be investigated further to establish whether animal pens can be identified at all sites (thus far only identified at Sheikh-e Abad: W. Matthews *et al.* 2013h), and whether substantial dung fuel use could be recognised. At Jani and Shimshara the archaeological deposits have been investigated for faecal material only from large sections rather than in plan during excavation. At Sheikh-e Abad the earlier levels of the site have been investigated in a small step trench cut into the edge of the mound. By using the full methodology at all the CZAP sites, particularly a substantial programme of pXRF and smear-slide analysis, a wide range of sediments could quickly and easily be analysed to detect probable faecal material for analysis. The results produced for these Early Neolithic sites in the Zagros mountains and foothills are promising, and this new integrated methodology has been successful in identifying and analysing faecal material. In the future, datasets should be expanded and the full methodology utilised at additional Early Neolithic sites, as well as at Epipalaeolithic sites of the region.

17. BESTANSUR MOLLUSCS: REGIONAL CONTEXT AND LOCAL ACTIVITIES

Ingrid Iversen

Introduction

Molluscs are a significant component of the archaeological record at Bestansur, as is the case at a number of sites in the Zagros. Previous studies have highlighted the evidence that molluscs can provide on past environments and diet (Lubell *et al.* 1976; Bar-Yosef Mayer 2005a; Davies 2008; Rizner *et al.* 2009; Lubell and Barton 2011; Bar-Yosef Mayer *et al.* 2012; Thomas 2015a), adornments, possible ritual artefacts and currency (Biggs 1969; Bar-Yosef Mayer 2005b; 2005c: 2–3). Collection and analysis, however, has often been shaped by the particular aims of each study.

Despite their presence in the archaeological material from a number of sites in the Zagros, molluscs are given only a brief mention in many site reports, resulting in a disappointing lack of quantitative and contextual data. To provide a more holistic analysis, this research examines the diverse ecological, economic, social and cultural significance of molluscs and develops a contextual and approach and quantitative methodology (Iversen 2015). This chapter examines first the environmental and ecological context and implications of the presence of land molluscs for biodiversity and dietary breadth and then evaluates how the activities of gathering, preparation, consumption and discard of land snails were organised. Drawing on the spatial patterns of material recovered at Bestansur allows an understanding of how these distinctive activities shaped social interactions. Shells as adornments are discussed in Chapter 21.

Molluscs in the Zagros and beyond

Early Holocene

Land snails are found, often in abundance, at archaeological sites around the Mediterranean from the Late Pleistocene onwards. Many of the early sites with molluscs were caves or rock-shelters. The most "dramatic and convincing evidence for prehistoric land snail consumption" was attested in the Maghreb by large quantities of snails in shell middens characterised as *escargotières* (Lubell 2004b: 78–79). The magnitude of mollusc debris found in association with other food remains such as animal bones, accumulations of ash, fire-cracked stones, charcoal and hearths supports the interpretation of these remains as a food source (Solecki 1963; Lubell *et al.* 1976; Taylor 2014).

Evidence from Zagros sites

In the Zagros, *Helix salomonica* (Naegele 1899) and *Levantina* sp. snails have been found at a number of archaeological sites, both in north Iraq and across the border in western Iran (Fig. 17.1). In a survey of edible land snails, Lubell (2004b: 84) identifies a number of sites "dating just before the appearance of an agricultural economy" where deposits of molluscs can be considered as 'food debris'. These sites include settlements such as Jarmo, Karim Shahir and Tepe Sarab, and a number of caves, including Palegawra and Shanidar. More recently, edible land snails have also been identified at Sheikh-e Abad (Braidwood and Howe 1960; Braidwood *et al.* 1961; Harris 1961; Solecki 1963; Shillito *et al.* 2013d).

Molluscs are generally reported on briefly in most site reports, with a disappointing lack of data on the contexts, quantities and density relative to the volume of deposits. At Jarmo, the molluscs were found in such great numbers that the decision was made to measure them in "number of cubic-foot boxes" (Braidwood and Howe 1960: 48) and it was

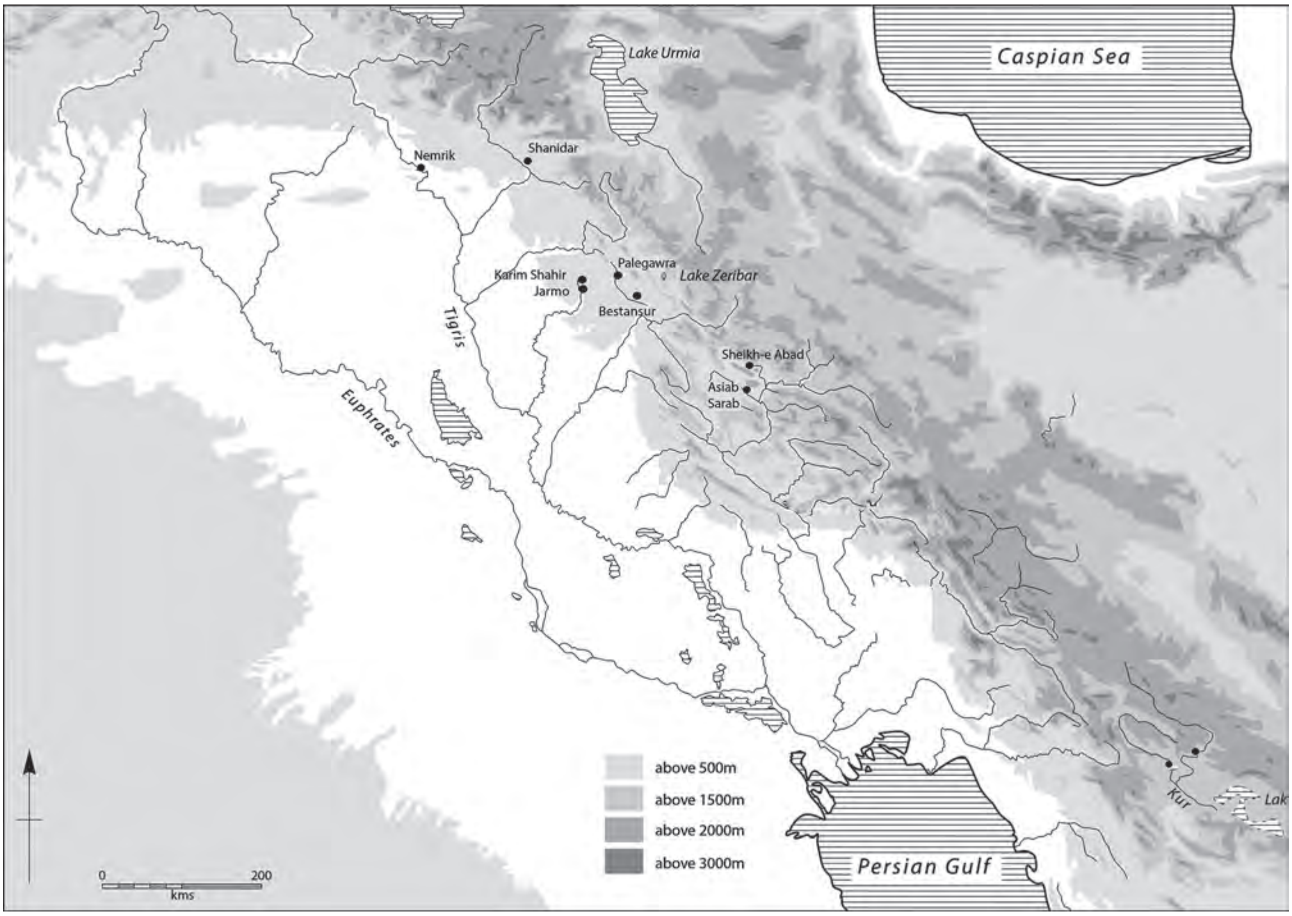


Figure 17.1. Map of Zagros sites with molluscs.

subsequently reported that over three seasons at Jarmo 2m^3 of molluscs were collected (Braidwood *et al.* 1983: 542). The reports from other sites provide even less precise data, noting only that the abundance of molluscs was 'considerable', or in a later report 'moderate', at Karim Shahir (Braidwood and Howe 1960: 53; Howe 1983: 100), and that molluscs were found in 'great quantities' in reference to river clams at Asiab (Braidwood *et al.* 1961: 2008) and 'numerous' at Nemrik (Kozlowski 2002: 92), none of which is supported by more specific quantifications. At Tepe Guran, *Helix salomonica* shells were present throughout the Neolithic levels, typically in clusters of up to 200 shells but it is not possible to assess the relative density as there is no information on the volume of sediment from which they were recovered (Flannery 2014: 104). The paucity of contextual data is in part because the main interest has been the information molluscs provide on past environments and as such the numbers and spatial distributions were considered less important (Iversen 2015).

At Nemrik 9, molluscs were found in significant quantities in the Neolithic levels associated with structures. The *Helix salomonica* recovered at Nemrik are interpreted as sources of food while the river clam, *Unio tigridis* (Bourguignat 1852) was used for making ornaments such as 'circular plaques' and a pendant (Kempisty 1990: 50–51; Kozlowski and Mazurowski 1990: 147–148; Kozlowski 2002: 85). Kozlowski (1990: 211) draws attention to the large deposit of molluscs in a layer covering House 2 and interprets this concentration as evidence of "kitchen-related Early Neolithic activity".

Molluscs as food

At Taforalt in North Africa, middens with high densities of molluscs also contained significant quantities of animal bone and plant material, much of which has been identified as food (Taylor *et al.* 2011: 9). The large quantities of shell in these midden deposits have encouraged the view that molluscs were a staple food, although calculations based on estimates of the quantity of molluscs, their contribution to the diet and assumptions for the group sharing the resource suggest that molluscs were not a major part of the diet (Taylor and Bell 2019: 233–234). Molluscs produce much more waste relative to nutritional value than other food sources, and the resilience of shells and how they are consumed (see *Cooking and eating* below) results in better preservation and visibility than remains of plants and animals (Prummel 2003: 182–183; Lubell 2004b; Taylor 2014: 230–231). At Bestansur, the total weight of molluscs recovered was just over 80kg compared with around 90kg of animal bone but, despite the similar quantities, the molluscs are unlikely to have been a key component of the diet. Rather they should be viewed as adding variety and supplementing other sources of food (Lubell 2004a) and possibly marking special feasting events. The present-day consumption of land snails in parts of the Mediterranean shows them to be associated with festivals at certain times of the year, and as such they may be viewed as a delicacy and a food with 'particular social significance' (Taylor and Bell 2019: 234).

While there is wide acceptance that human food habits and preferences are largely culturally constructed and specific, they are also influenced by environmental and ecological potential and constraints (Hastorf 2016). The "cultural selection of fauna … is obviously dependent upon the existing faunal inventory, which must have first passed through the screen of natural environment" (Solecki 1963: 186–187). At Tepe Asiab, the mollusc of choice was the river clam, *Unio tigridis*, possibly because the site was near a permanent stream making them easier to collect than the *Helix salomonica* which were also found in the vicinity of the site but in lesser numbers (Reed 1962: 10).

Chronologically, there is evidence of *Helix salomonica* at archaeological sites in the Zagros dating from at least 12,000 years ago, with their presence growing in frequency, and probably absolute quantity, across the region during the Early Neolithic before fading from the archaeological record (Reed 1962: 4; Kozlowski 1990: 212). Studies have shown that over-exploitation of marine molluscs can result in a depletion in the resource which may also have occurred with land snails in the Neolithic in the Zagros (Mannino and Thomas 2002). However, the reduction in molluscs may reflect changes in their local availability and in the choice of different food sources. In contrast to some coastal sites where marine molluscs form a key part of the diet, it is likely that molluscs were a supplementary food source and at many sites they were found in levels contemporary with domesticated flora and fauna, for example, at Jarmo and Tepe Sarab (Reed 1962: 10).

Present day surveys of mollusc ecology and use

Research was conducted on modern populations of molluscs and their environmental conditions in 1959–1960, by members of the Iranian Prehistoric Project led by Charles Reed when they explored the area of Kermanshah in west-central Iran to examine issues relating to the 'Ecology-Prehistory-Gastronomy' of molluscs (Reed 1962: 1). The decision was made to concentrate on *Helix salomonica* and *Levantina* sp. as those were the types of molluscs recorded at archaeological sites (Braidwood and Howe 1960; Reed 1962; Braidwood *et al.* 1983).

Two sessions of live snail gathering were undertaken in April 1960 on a rocky slope below a cliff face, close to the archaeological site of Warwasi; the vegetation was low 'thorn-bushes' on a bare hillside. Live *Helix salomonica* were collected from under bushes on the hillside and although the vegetation remained the same, the quantity of snails thinned out further up the slope. *Levantina* sp. were found in the same habitat conditions although they increased further up the slope and were found on the cliff itself (Reed 1962: 11–14). In November 1961, Kent Flannery collected a number of *Helix salomonica* during a survey of the Qaleh Paswah valley, northwest Iran, after a few days of rain. They were found "in great numbers" on the valley floor at a similar altitude, at around 1500m asl, to the earlier samples collected by Reed and his team, but well away from the "nearest hill" (Biggs 1962: 65). Another study of the molluscs in the Zagros has linked the different species to distinct altitudinal ranges, which coincide with rainfall, and shows that *Helix salomonica* and *Levantina* sp. occur in the same zones (Harris 1978). While molluscs can be a good indicator of climatic change, in the Zagros the numbers are skewed by the changes to the environment through the clearing and farming of the land in modern times, and irrigation has allowed some molluscs to survive in areas where they "would not normally occur" (Harris 1961: 108; 1978).

Helix salomonica from the archaeological site of Nemrik were measured and compared with modern populations collected in Iran in the 1960s. They appeared to show that Neolithic snails were significantly larger, encouraging the conclusion that the climate was wetter (Kozlowski 1990: 212–213). However, the samples used for this comparison came from different geographic locations and it was noticeable that the average size varied significantly between the two modern samples, with the Kermanshah population being much smaller than the ones collected on the Mesopotamian plain at Nemrik (Biggs 1962: 65–66). Evans (1969: 172) has argued that local conditions are as important as climate and that the "pattern of molluscan populations at any one time relates to factors of a spatial and historical kind". It is not clear how the modern live snails for this comparison were selected and whether they were selected by size as would have been the case during the Neolithic, and so differences in the average size recorded may reflect different collection strategies as has been found in other studies. Comparing the size of shells collected from archaeological contexts with modern snails in the Iberian peninsula showed a clear difference, with cultural deposits having a significantly larger average size than natural groups (Law 2017: 61).

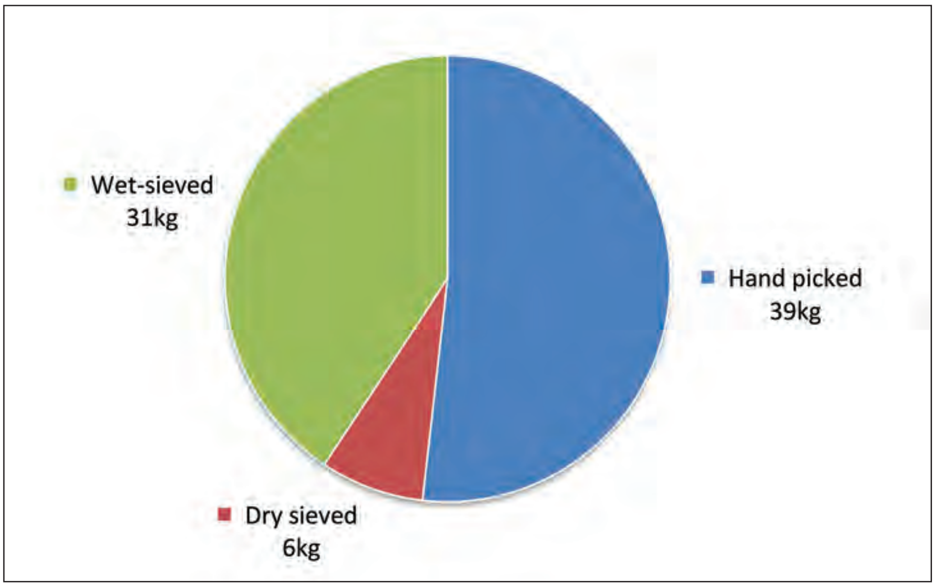


Figure 17.2. Weight of all molluscs by method of recovery.

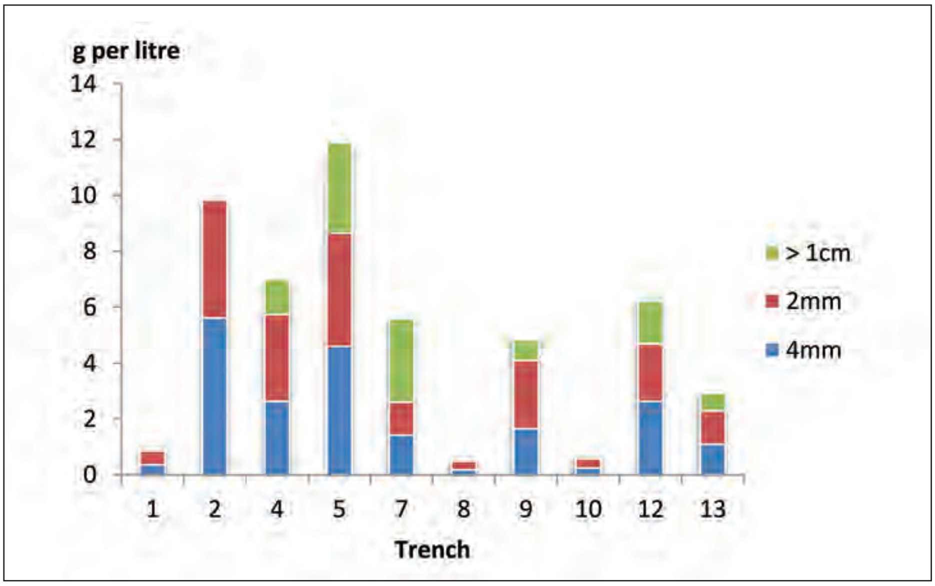


Figure 17.3. Density of molluscs in heavy residue by size fraction.

Recovery methods, quantification and measurement

Recovery

Molluscs were collected from excavated contexts at Bestansur in three different ways: hand-picked during excavation when the sediment was not sent for flotation, collected from dry sieving of bulk samples and collected from heavy residue after flotation (wet-sieving) (Fig. 17.2). In order to use the data to examine spatial variation in the density of molluscs across the site, aggregate numbers have been assessed relative to the volume of sediment excavated or sampled, in terms of grams per litre, thus allowing the comparison of areas and samples of widely differing sizes. However, the densities of hand-picked and dry-sieved molluscs, as measured by weight relative to volume, are not directly comparable to the wet-sieved molluscs where the soil in and around the molluscs is washed away and in the process the weight is reduced.

It was also noticeable that collections of molluscs which had been stored and then revisited for analysis had reduced in weight as the sediment had dried out. The data used to determine the relative density of molluscs are therefore the original weights for all recovery methods. Molluscs from heavy residue are analysed separately. While the total density of molluscs found in heavy residue is of primary interest,

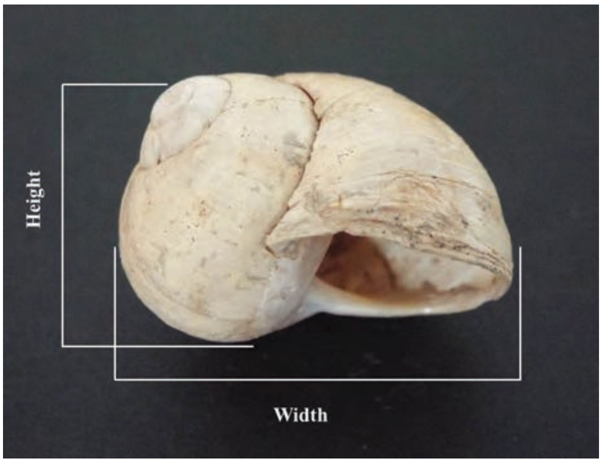


Figure 17.4. Mollusc measurement: height and width.

the density in the different size fractions provides additional information relating to the fragmentation of the material (Fig. 17.3).

Sample selection and recording

Size measurement

In order to assess and evaluate the composition of the mollusc deposits, a total of 21 assemblages of molluscs were examined closely. The samples were selected from a range of different types of Neolithic contexts and weighed 250g or more when first recorded. The minimum size of the selected assemblages was arbitrary but was designed to produce a sufficient number of molluscs to ensure a representative sample; the smallest number of measurable shells in any context was 15. In total, 1430 molluscs were counted using the non-repetitive element of the apex to establish the minimum number of individuals (MNI). To evaluate size, the maximum height and width of 663 complete shells were measured using electronic callipers (Fig. 17.4). Around half of all the shells were measured, as some were damaged and it was not possible to take the appropriate measurement, or in the case of the very large samples a representative fraction of at least 50% was measured.

Density of mollusc debris

The data for the heavy residue from wet-sieved samples provide the most complete picture (see Chapter 14 for description of heavy residue methodology). A total of 457 samples from Neolithic contexts across ten trenches form the basis of this analysis. As noted above, molluscs are ubiquitous across the site but often in low concentrations and so, in looking for areas of focused activities involving molluscs, a number of contexts (45) was identified for further analysis. The average (mean) density of heavy residue samples was calculated and formed the basis for the selection of the contexts: any assemblage with a density of greater than one standard deviation over the average (5.5g per litre) is included. In addition, a number of shell clusters and middens were identified by the excavation records and these were also included.

Bestansur molluscs: the results

The molluscs recovered at Bestansur bear all the hallmarks of cultural accumulations. The relatively uniform sizes of the shells in each sample suggest that they were selected as food rather than occurring naturally, which would result in a greater range of growth stages. In addition, a 'natural death assemblage' is likely to include a wide range of species, many of which would be inedible, which is not the case here (Taylor and Bell 2017: 197). The large number of complete shells indicates human consumption rather than accumulation as a result of actions by other predators, as the latter would have resulted in damaged and fragmented shells (Fernández-López de Pablo *et al.* 2014: 13). In addition, deposits of molluscs were frequently found, both intact and trampled on surfaces, in association with cultural material or features and so have been interpreted as anthropogenic debris, rather than clusters of molluscs in burrows as argued for a number of other sites (Lubell 2004b; Rizner *et al.* 2009; Taylor *et al.* 2011: 11–12; Iversen 2015).

Mollusc typology

Four types of land snail were identified in the recovered material, two of which are probably variations of the same species, *Helix salomonica* (Naegele 1899), and account for 98% in terms of number and close to 100% in terms of weight. The others are tentatively identified as *Xerocrassa* sp. and *Cecilioides jani* (De Betta and Martinati 1855). In addition, fragments of the freshwater mollusc, *Unio tigridis* were recovered. All are molluscs which have been previously identified in the region (Biggs 1959; Harris 1961; 1978). Five dentalium tusk shell beads were recovered and more than 200 perforated freshwater gastropods, possibly *neritidae*, which may have been collected from the river banks and environs (Chapter 21).

One type of *Helix salomonica* is generally larger and more 'squat' than the other and occurs in larger numbers within most assemblages. A comparison of the size of the two variants was made using the largest sample, collected from a mollusc midden in T5 C1078 which was column-sampled (Chapter 9). The 315 measured individuals from a sample of 598 are shown in Figure 17.5. Using just one sample has the advantage of limiting variation chronologically and, although there may have been repeated deposition of shells, the layers are not interspersed with other material (packing or fill), suggesting it occurred over a relatively short period, at most a few consecutive seasons of snail consumption. It is possible that the

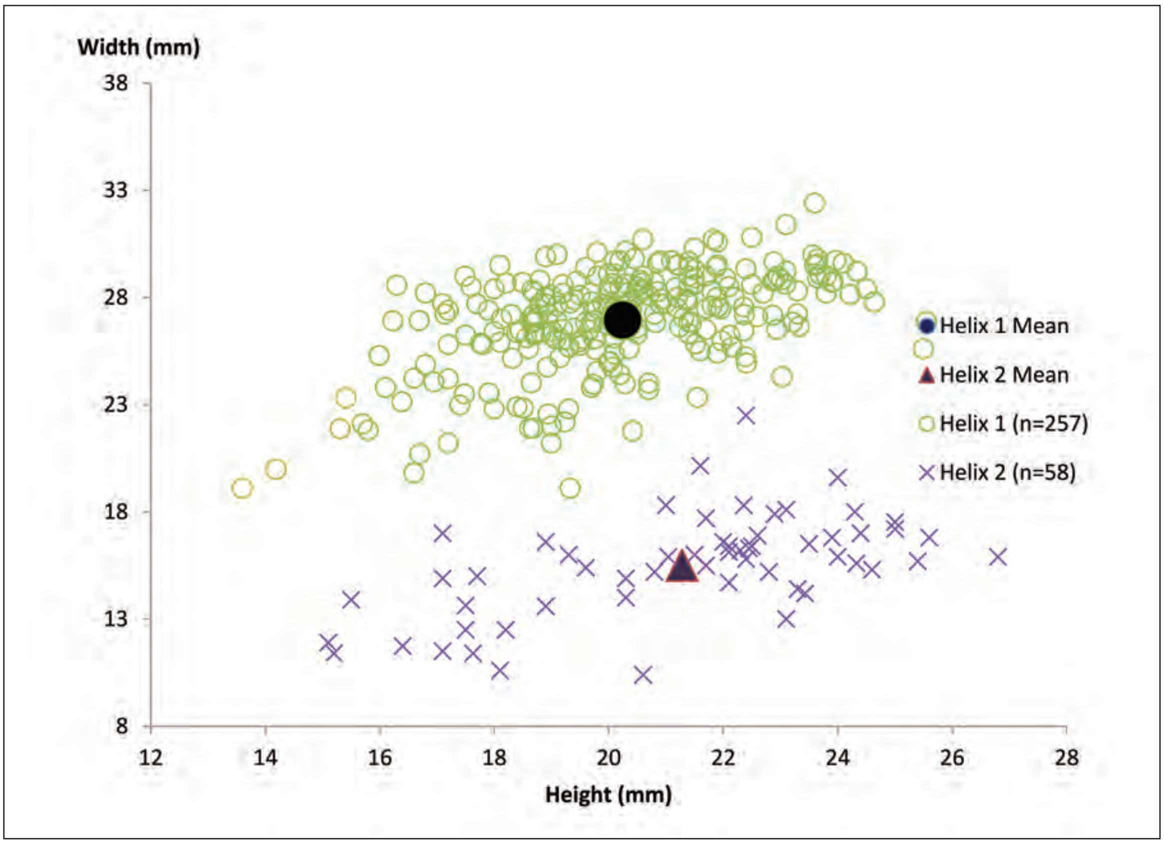


Figure 17.5. Helix salomonica: Height and width measurement of the two variants (Trench 5: C1078).

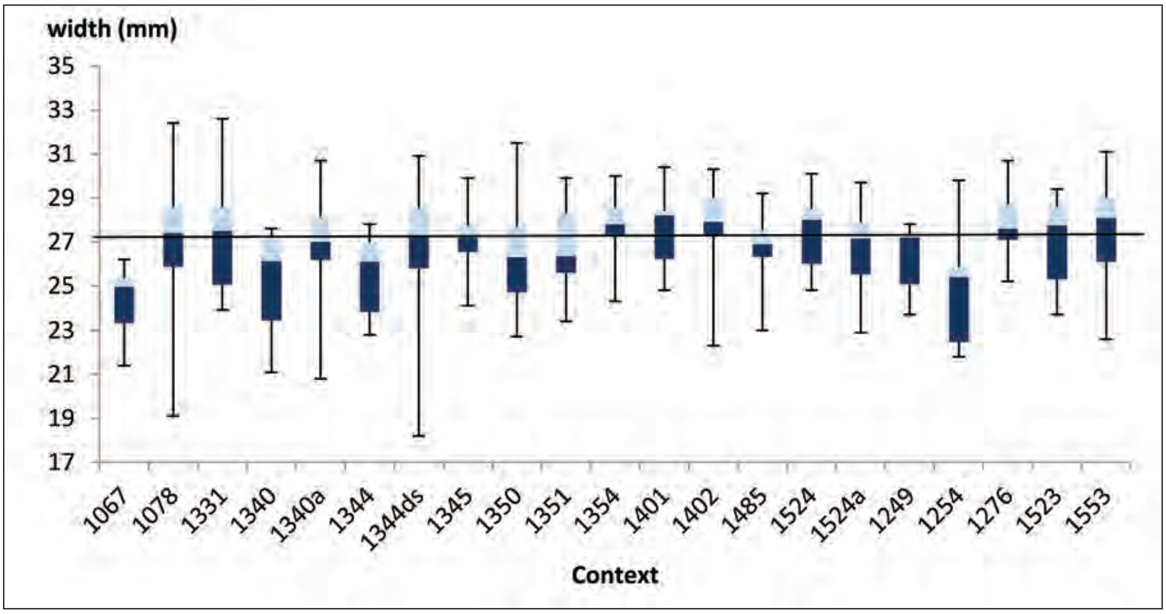


Figure 17.6. Helix salomonica width measurement: box plot showing range, quartiles and average (median) by context. (The overall average is shown by the horizontal line).

two variants represent different ecotypes and were gathered in different habitats. On average, 80% of each sample is made up of the larger type and forms the basis for the numbers and size of molluscs reported on here.

Size selection

The molluscs measured, of the larger variant, fall within a relatively narrow range with an average width of 27mm (±2.2mm) and height 20mm (±2.1mm) (Fig. 17.6), with majority of samples close to the overall average width. The range of mollusc size does vary between the samples but those with the widest range have very few outliers, and only on the smaller end of the size range; for example, C1078 has eight outliers (all at the lower end) in a sample of 257 measured molluscs.

Overall, the results show uniformity in the size of molluscs within each sample, suggesting deliberate selection. A much greater range in sizes would be expected in a natural population, reflecting the age distribution. The samples with smaller snails, that is, C1067 and C1254, could be influenced by local environmental factors, either temporal or spatial, resulting in a reduction in snail size across the whole assemblage (Evans 1969: 171–172).

Evidence for mollusc related activities

In order to ascertain the diversity and context of areas with mollusc-related activities, evidence from the site reports, photographs and the records of all recovered molluscs were examined and three different types of deposit are defined: clusters, middens and areas of discard.

- *Clusters* are identified where more than 250g of shells were recovered from a context, most of the assemblage was comprised of shells with a low level of fragmentation, and there was a high density of shell in any related heavy residue samples. The density of shells in heavy residue is defined as 'high' where it exceeds one standard deviation above the mean, that is, greater than 5.5g per litre. Clusters are interpreted as indicative of areas where molluscs were prepared and eaten.
- Significant accumulations of shells with a low level of fragmentation, which do not include other material in any quantity, are classified as *middens*. The key difference between clusters and middens is in scale, with the latter covering a larger area with multiple layers and with a larger number of number of shells recovered relative to the volume of sediment. Middens are the result of repeated episodes of deposition of shells.
- Areas with a high density of fragmented shells and other rubbish are interpreted as *areas of discard.*

Using the definitions outlined above it is possible to summarise by deposit type at the scale of each trench, and thus to form a picture of the organisation of mollusc related activities across the site. Table 17.1 illustrates that, while there is evidence for many areas of discard across the site, there are only a few clear midden deposits.

Clusters

Shell clusters were present in external areas, typically associated with other activities. There were clusters in trenches T2, T4, T7, T9 and T10, suggesting that the consumption of molluscs took place across the site (see Fig. 17.7). Trench 4 produced the most molluscs of any of the 2 × 2m trenches excavated in the first season and this, combined with the excavator's observation of thick mollusc lenses covering a large area, supports the interpretation of the preparation and consumption of molluscs here (W. Matthews and Ahmed 2012).

Other material found in association with the molluscs points to variation in the eating event. In T7 molluscs were found in distinct clusters but with little animal bone, whereas in T9 the mollusc clusters were associated with high absolute amounts and density

Table 17.1. Summary and interpretation of results.

Trench	*Results*	*Deposit type* *Cluster*	 *Area of discard*	 *Midden*
2	High density in heavy residue: 10g per litre		✓	
4	High density in heavy residue in 6 of 9 contexts: 8g per litre		✓	
	Large number of shells with low fragmentation; MNI=88	✓		
5	Large accumulation of shells with visible layering; 7cm in depth; MNI =598			✓
7	High density in samples from 2 contexts: 10g and 18g per litre per litre associated with clusters			
	Clay lined pit with shells	✓		
	Accumulation of shells			✓
9	Visible clusters of shells mixed with other material recorded; MNI=374	✓		
	High density in heavy residue in 9 of 56 contexts; average 10g per litre		✓	
10	High density in heavy residue from 1 context coinciding with cluster; 12g per litre; MNI=112	✓		
12	High density in heavy residue in 4 of 8 contexts; 20g per litre			
	Large number of shells with low fragmentation; MNI=127			✓
13	High density in heavy residue in 3 of 36 contexts; 9g per litre		✓	

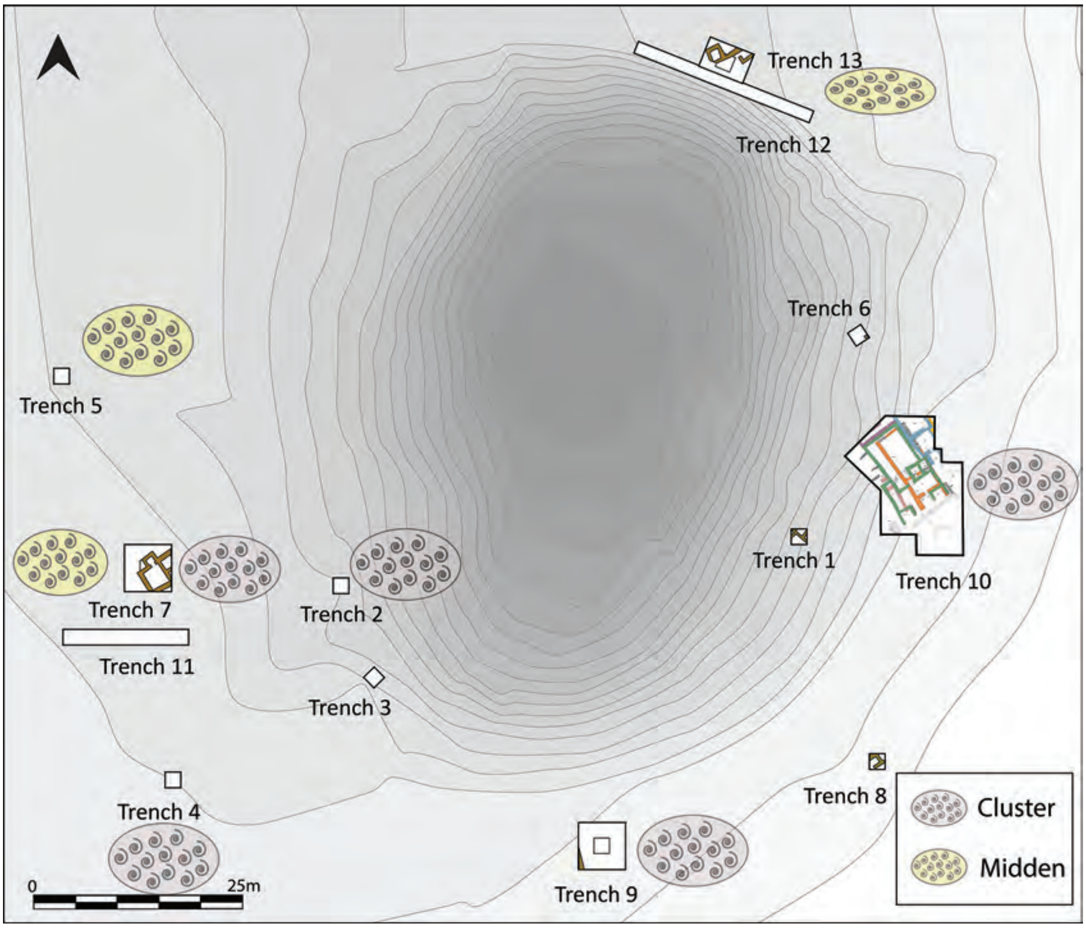


Figure 17.7. Location of mollusc clusters and mollusc middens.

of animal bone, suggesting that this area of the site was used for butchery and initial food processing (Bendrey 2013).

In the western half of T7, after the original trench was expanded to 6 × 6m, an extensive open area with surfaces with discrete clusters of shells, stones and chipped stone was sampled systematically (Matthews *et al.* 2013b). The samples collected from the areas in the immediate vicinity of the shell clusters had a density well above the average but in the surrounding spaces the density fell sharply. It appears the consumption and discard of molluscs was contained within small areas.

Trench 7 also produced some tantalising indications of how the molluscs may have been cooked, as a cut into underlying deposits had been made in order to situate a small pit, *c.* 50 × 40cm, lined on the base and sides with clay which was fire-hardened (Fig. 17.8). Fill within the pit comprised a dense cluster of land snail shells, cooked within the pit through heating by fired stones, as well as broken chert tools, including a serrated blade (Matthews *et al.* 2013b: 13).

Middens

In T5, an area dense with molluscs was discovered and interpreted as a mollusc midden. The mollusc deposit was column-sampled at its maximum depth with an area of 50x50cm and depth of 4cm collected (Figs 17.9 and 17.10).

Chipped stone tools have been found in a number of shell deposits. Often the tool is a blade with a curve which would have been ideal for extracting the snail from the shell (Chapter 20). An obsidian blade was found between the two spits of the column-sample and combined with other such tools suggests the consumption of the land snails within the vicinity of the midden (Fig. 17.11). The visible layering of the shells is indicative of multiple events, possibly a season of consumption.

A mollusc deposit in T7, albeit much smaller, could also be a midden or maybe a large cluster (Fig. 17.12). A deposit in T12 has clear 'layering' of shells, although here the deposit is mixed with other material. It appears that after eating, the shells were collected and deposited in one area and that these areas were used repeatedly for some time, hence the build-up. It is unlikely, given the layering reported and the quantity of shells, that the middens were the result of just one session of consumption.

Figure 17.8. Trench 7: Small fire installation with fired clay lining and molluscs and denticulated blade in fill. Looking south, scale = 25cm.

Figure 17.9. Trench 5: Context 1078 after removal of 50cm column sample. Looking north, scale = 50cm.

Discard

Molluscs also appear in high densities in deposits in locations across the site in the microdebris collected from heavy residue and could be the result of clearing up the remains of the molluscs after cooking and eating. Some of the areas of high density of shell in heavy residue coincide with higher than average density of other 'rubbish', notably in trenches T4, T9 and T12 (Chapter 14). The heavy residue from the flotation samples collected in T12 have among the highest density of molluscs anywhere on the site (excluding the column sample collected in T5) and, combined with the results for other microartefacts, suggest that this was an area where activity debris, including food processing waste, was periodically discarded and sealed by layers of thin packing and plasters. T7, T10 and T13 have far fewer contexts with above average density of molluscs in heavy residue, except where the samples are directly associated with the mollusc clusters.

Figure 17.10. Molluscs collected from C1078 T5.

Figure 17.11. Trench 5: Obsidian blade found in mollusc midden.

Figure 17.12. Trench 7: Mollusc deposit C1098. Looking north, scale = 50cm.

Discussion: the sequence of activities

The procurement, preparation and consumption of food form a key part of the daily activities of a community. The sequence of actions, or *chaîne opératoire,* involves both practical knowledge and an understanding of social rules and practices (Skibo and Schiffer 2008).

Gathering at Bestansur

In order to understand better the human exploitation of *Helix salomonica* at Bestansur, attempts were made to find living molluscs around the site. Although there was no visible evidence in the areas immediately adjacent to the site, based on guidance from local residents, we were encouraged to look for *Helix salomonica* a little way away from the site beside the river towards the springhead. The search involved checking under stones alongside the stream, paying special attention to areas with lush vegetation but not in running water. The edges of the fields had areas with a number of stones and wild thistle plants and these were checked as well.

No *Helix salomonica* were found and it was concluded that a living population no longer exists in the vicinity of the site, or that they survive in very small numbers. The exercise was met with some bemusement by the locals over our interest in what they call 'devil's eggs' (*helke Šaitan*).

It is difficult to determine where the molluscs were collected in the Early Neolithic. The land surrounding the mound, now rendered inhospitable to molluscs by cultivation, may have provided the ideal habitat. Live *Helix salomonica* snails were found on hillsides with scrubby bushes during a survey in Kermanshah, Iran in 1960 (Reed 1962) and it is possible that the hills close to Bestansur (around 2km away), which are now bare, provided this environment in the Early Neolithic. The two different ecotypes found in the archaeological assemblage may indicate that a range of habitats was exploited in the collection of snails.

Similar questions were asked at Jarmo in the 1950s, with the conclusion that while *Helix salomonica* was "obviously abundant when the village was occupied, [it] is extremely rare in the area today" (Braidwood and Howe 1960: 172). The few examples found there were under rocks and in crevices in the soil, and much more common were the *Levantina* sp., found feeding in the same terrain as *Helix salomonica* during the day but retired to rocky ledges at night. *Levantina* sp. has not been identified among the shells recovered at Bestansur, although one was found in the spoil heap (dead) and so it is not clear whether it is present day or archaeological. Another *Levantina* sp. snail was picked up alive from a rocky ledge while on a walk in the Qara Dagh mountains and identified using the illustration in Reed (1962) (Fig. 17.13), before being returned to its hillside.

Cooking

The snails were cooked before eating as the shells are still whole and any attempt to extract the meat otherwise would be very difficult and would break the shell (Rizner *et al.* 2009). How they were cooked is not clear. With few signs of burning on the recovered shells, it is unlikely they were cooked directly on the fire and so other methods of cooking need to be considered. Experiments by Reed and his team, with the molluscs collected in the Iranian Zagros, involved boiling the snails and the results were deemed to be 'acceptable' but left the question of how they were prepared in the Neolithic unanswered (Reed 1962: 15–18). Without pottery it is difficult to boil water and as there was no evidence of burning on the shells, as is the case at other Zagros sites including Bestansur, it is unlikely they were placed directly onto fire (Reed 1962; Kozlowski 1990). The molluscs found in Pre-Pottery Neolithic levels at Jericho also showed no signs of burning, which again raised the question of how they were cooked (Biggs 1960: 380). Stone hearths found in proto-Neolithic levels at Shanidar cave in association with large numbers of land snails have been interpreted as being used to cook the molluscs (Solecki 1963; Lubell 2004b: 85).

Similar questions faced a team working on the snails from a Mesolithic cave site in Croatia and they conducted a number of experiments using modern molluscs. First, they extracted live snails but discovered that this broke the shell and, as the Mesolithic shells were whole, they were able to rule this out as a method. They then boiled the molluscs which worked well, but with no evidence for vessels this is unlikely to have been the method used and so, based on local customs, they tried to roast the snails by throwing them into the embers of a fire. The key to cooking them this way was to limit the roasting time to 5–8 minutes after which "delicious snails ... were easily extracted from the shell" (Rizner *et al.* 2009: 530). In addition, the signs of burning were very limited which, combined with the location of a large number of shells next to a hearth, encouraged the conclusion that this was the most likely method of cooking.

The experiments with cooking molluscs in the embers of a fire are persuasive as this method generally leaves the shell unmarked. Some indication of methods employed at Bestansur comes from the pit with fire hardened clay and stones in T7 with intact molluscs, suggesting that they may have been cooked using hot stones. It is also possible that some material, of plant or animal origin, was used between the stones and the molluscs allowing them to be 'steamed'. Clusters of heat-fractured stones have been found across the site providing evidence that this was a method of heating and cooking being employed. A range of technologies for boiling water are also known ethnographically and from archaeological

Figure 17.13. Modern Levantina sp., photographed against the illustration of Levantina sp. (Reed 1962: 12).

examples including: woven baskets, many of which are water-proof; or hot-rock and skin technologies (Hastorf 2017: 299).

Eating

The molluscs would have been eaten after cooking by prising the snail from its shell with appropriate tools. Chipped stone blades have been recovered at Bestansur, some in association with shell clusters, which would have been ideal for the task. In their 'gastronomic experiments' in Iran, the Oriental Institute of Chicago team used microliths from Sarab as 'snail-picks' to experiment with and demonstrate how the snails may have been consumed (Reed 1962: 16). The smaller type of *Helix salomonica* found at Bestansur were all broken around the aperture while many of the larger type remained intact, suggesting that either the size of the shell or its shape made the former harder to extract. This may also be the reason for their lower frequency in samples.

Some shells, although not all, were broken in more-or-less the same place suggesting a deliberate action to help in extracting the meat (Fig. 17.14). Shells with deliberate perforations have been found at a number of Neolithic sites in Morocco; the holes have been interpreted as being made intentionally as they are very neat and are found in the same part of the shell. Experiments with modern molluscs showed that perforating the shell of a cooked mollusc breaks the vacuum that is created as it cools, and so makes it easier to extract the meat. The snail could then be sucked out through the aperture. Chipped stone tools have been found associated with the molluscs which would have been ideal for the task, for example, at Neolithic sites in Morocco (Hutterer *et al.* 2014). It is possible that a similar technique was used at Bestansur as indicated by the perforated molluscs and the presence of chipped stone tools associated with mollusc clusters and middens (Fig. 17.14).

Discard

Once eaten, the shells were discarded, in large accumulations in a midden, as in T5, or in smaller amounts mixed with other rubbish as in T12. These

Figure 17.14. Helix salomonica with evidence of possible perforation.

different types of mollusc discard appear to have been organised spatially. The effort of disposing of rubbish is often balanced against the nuisance of leaving it where it is (Hayden and Cannon 1983); applying this principle to the discarded molluscs, allows them to be interpreted as rubbish as they do not appear to have any re-use value and would have posed a hindrance if left in areas used for activities (Chapter 14).

Conclusions: the social dimension

The procurement, preparation and consumption of food form a key part of the daily activities of a community and these activities (*practice*) are important in structuring and reproducing the social structure (Bourdieu 1977; Giddens 1984). The archaeological evidence for the consumption of molluscs indicates that this was a significant activity at the site. Molluscs have been recovered in all Neolithic contexts; fragments of shell occur in 99% of all flotation samples in the heavy residue while large numbers of complete shells have been recovered through hand-picking and dry-sieving. Molluscs have been found in high concentrations in some areas, in 'middens', and in association with features and other artefacts. The quantity of shell recovered, and frequent spatial distribution across surfaces, points to their anthropogenic origin and so they can be considered as deliberately collected rather than naturally occurring.

By examining the spatial organisation of repetitive practices, such as those related to the consumption of land snails, it is possible to gain a greater understanding of interactions and thus the social structure and relationships within the community more generally. It is likely that many individuals were involved in the gathering, preparing and eating of molluscs.

The collection of molluscs would have been a comparatively easy task and, especially if it happened close to the site, could have included children as well as adults. Ethnographic studies and observations have reported that children are often included in this activity. Knowledge of the behaviour of the snails would have shaped the collection strategies, whether during wet periods or during the time the snails were aestivating and so aggregated in predictable locations (Hunt *et al.* 2011; Taylor 2014: 194; 221–223). If snails were gathered further afield, this may have been combined with other activities such as gathering of other food only available at a distance from the site.

The preparation, eating and discard of molluscs took place in distinct areas and it is possible to discern where from the archaeological record. The spatial pattern of the activities has been mapped, with evidence for the cooking and eating of the snails taking place across the site, and evidence of discard only in external areas, suggesting that the preparation and discard of snails, and probably their consumption, was most likely a shared social activity (Fig. 17.7). In some parts of the site, the areas where the molluscs were eaten also show evidence of other activities, further supporting the view that this was a communal event (Chapter 14).

Some molluscs were discarded in a more limited number of areas with at least one, but possibly two or three, significant accumulations to the west of the mound, comprising layers of whole molluscs suggesting repeated events of deposition after eating. Areas with a high density of fragmented molluscs were found in trenches T9, T12 and T13 at the north and south of the mound indicating the clear-up and dumping of mollusc debris.

The examination of the spatial organisation of mollusc-related activities at Bestansur indicates a set of actions which are likely to have involved, and to have been understood by, the whole community, and as such would have played a role in shaping practices and social interactions.

Future research on the molluscs from Bestansur and from other Early Neolithic sites of the EFC will benefit from increasingly refined techniques of isotope analysis (Thomas 2015b; Leng and Lewis 2016). Study of mollusc oxygen isotopes can yield vital new information on the Neolithic environment, seasonal and annual climate, and on seasonal timing of mollusc collection, for example. We plan to conduct such studies in the next phase of CZAP researches.

18. THE CHARRED PLANT REMAINS FROM EARLY NEOLITHIC LEVELS AT BESTANSUR AND SHIMSHARA

Jade Whitlam, Charlotte Diffey, Amy Bogaard and Mike Charles

Introduction

The following chapter presents the results of archaeobotanical investigations carried out at Bestansur and Shimshara by the Central Zagros Archaeological Project (CZAP) between 2012 and 2014. Analyses have focused on charred plant remains recovered from Early Neolithic levels at both sites, where occupation is broadly contemporaneous with the Levantine Pre-Pottery Neolithic B (PPNB, *c.* 8700–7000 BC). The Early Neolithic levels at Bestansur span 7700–7000 BC, and at Shimshara 7300–6000 BC (Chapter 11). Material from these sites is of particular interest as few early farming settlements have been excavated in northern Iraq to date, and little is known about how local communities managed and consumed plants across the agricultural transition. Archaeobotanical evidence from Bestansur and Shimshara has the potential to elucidate key aspects of the emergence of farming in this region, including documenting the range of crops grown, how they were cultivated and the role that wild plants played within these early farming economies.

Research context

The emergence of farming in Southwest Asia was a protracted process that saw different plants brought into cultivation and domesticated independently in multiple regions of the Fertile Crescent (Fuller *et al.* 2012; Willcox 2013). These developments took place within the context of widespread experiments in plant use during the Early Neolithic (10000–7000 BC), as increasingly sedentary communities explored new ways of managing wild plant species. Supporting this model is a growing body of archaeobotanical evidence that documents regional diversity in pre-agricultural plant management and the appearance of locally distinct crop ‘packages’ at early farming settlements (Weiss *et al.* 2006; Asouti and Fuller 2012; Willcox 2013; Arranz-Otaegui *et al.* 2016; Weide *et al.* 2018; Whitlam *et al.* 2018). Of particular importance is new evidence from the eastern Fertile Crescent (EFC), a region that until recently was under-represented in models of agricultural origins. Key archaeobotanical datasets to have emerged out of renewed archaeological enquiries here come from sites in the Iranian Zagros, such as Sheikh-e Abad (Matthews *et al.* 2013a; Whitlam *et al.* 2018) and Chogha Golan (Riehl *et al.* 2013) where occupation spans the agricultural transition.

However, despite this increased attention on the EFC, there remains little archaeobotanical evidence available for tracing the emergence of farming in northern Iraq – especially in and around the foothills of the Zagros Mountains in present-day Iraqi Kurdistan. Archaeobotanical remains have been recovered from sites further west in the moister steppe, for example Nemrik, M’lefaat, Qermez Dere and Maghzaliyeh (Nesbitt 1992; Savard *et al.* 2006; Willcox n.d.) but apart from Jarmo, which lies *c.* 65km northwest of Bestansur and *c.* 73km southwest of Shimshara, no sites corresponding to the Early Neolithic period have been identified and excavated in Iraqi Kurdistan to date (Altaweel *et al.* 2012).

Results from our analyses of charred plant remains from Bestansur and Shimshara are presented and discussed below, at a site level and in relation to archaeobotanical data from contemporary settlements in the EFC. Where possible we draw on evidence from the analysis of micromorphological thin-sections (Chapter 12), recognising that charred plant remains represent only a subset of the plants and plant parts that potentially survive on archaeological sites (van der Veen 2007; W. Matthews 2010; 2016; Colledge and

Conolly 2014). As part of this study we also present the results of an ongoing programme of radiocarbon dating on charred plant remains recovered from Bestansur. Previous radiocarbon dates obtained by CZAP indicate that at least some of the charred plant remains within Early Neolithic deposits are intrusive from later periods of occupation (Chapter 11). To explore this issue further, additional samples of charred plant material were sent for dating at the Oxford Radiocarbon Accelerator Unit (ORAU) supported by a NERC/AHRC grant (NF/2016/2/5). The new dates are reported below and discussed in terms of their implications for interpreting Early Neolithic plant use at the site. Finally, we briefly consider to what extent post-depositional processes at Bestansur may have shaped the charred plant assemblage using the presence of non-archaeobotanical flot components in samples, for example modern roots, burrowing snails and modern seeds, as proxies for bioturbation at the site.

Methods

On-site sampling

Samples of archaeological deposits were collected systematically from all archaeological units excavated at Bestansur and Shimshara, including from ashy/blackened layers, floor deposits in architectural structures, open area deposits, deposition within pits and fire installations. Bulk samples of 20–50 litres were collected as standard from each archaeological context, with contexts less than this sampled in their entirety. Floors and fills of rooms were further sampled by gridding these into multiple contexts to account for potential spatial variation in the distribution of plant remains.

At Bestansur, in addition to systematic sampling, strategic sampling was undertaken where a concentration of charred plant remains was clearly defined within a deposit and/or when potentially significant spatial variation was identified across a single archaeological context. This form of sampling was closely linked to the on-site microarchaeology sampling strategy (see Chapter 14). Strategic samples were typically small (*c.* 0.5–10 litres) and taken in addition to a bulk sample for each unit, or in conjunction with additional strategic samples that when combined would allow a larger sample to be reconstructed.

Processing of deposit samples

Samples were processed by machine-assisted water flotation using a variant on the Ankara Machine-style (French 1971). Small samples (typically less than one litre in volume) were processed manually by bucket flotation. In both cases the light fractions (floating material) were collected in a mesh with an aperture of *c.* 250μm, while the heavy residues (non-floating material) were collected in an internal mesh with an aperture of 1mm. After flotation, light fractions (flots) were air-dried in the shade and the heavy residues were passed along to the microarchaeology team for further processing. Any charred plant remains, including wood charcoal, which had failed to float were recovered from heavy residues and studied alongside their corresponding flot. Very few charred plant remains were recovered via this route and they are not discussed separately within this report.

Once dry, each flot was fractioned using a stack of nested Endecotts sieves with mesh sizes of 4mm, 2mm, 1mm and 0.3mm. Small flots were left unsieved. For samples recovered from Bestansur during the summer 2013 and spring 2014 seasons, a 0.5mm sieve was used in place of the 0.3mm sieve. This increased the efficiency with which non-archaeobotanical material, such as silt and fine root fragments could be removed from samples, without losing the smallest identifiable macrobotanical remains. All material that passed through the 0.3/0.5mm sieve was retained for future study.

Post-excavation analysis

Scanning of samples

Samples collected from Bestansur were initially scanned to evaluate their richness and botanical composition. During scanning each flot was inspected under a low-powered microscope, so that the number of charred plant remains within each sample and the presence of different taxa and types could be assessed according to broad categories (see Table 18.1). The presence of non-archaeobotanical flot components, including modern roots, burrowing snails and modern seeds, grain and chaff were also recorded. Given the large number of samples recovered from Bestansur and the low quantities of charred plant remains these produced (see results below), scanning formed the primary method of analysis at the site. Only a limited subset of samples

Table 18.1. Categories recorded during scanning of flots from Bestansur.

Feature of flot	*Categories for scoring*
Number of charred plant remains	0, 1–10, 11–25, 26–50, 51–100, >100
Botanical taxa/types	Cereal grain, cereal chaff, lentil, pulse indeterminate, nut/fruit, wild/weed, culm, potentially identifiable plant material
Non-archaeobotanical flot components	Small/medium-sized modern roots, large modern roots, burrowing snails, modern cereal grain, modern cereal chaff, modern wild/weed seeds

underwent further sorting and identification. This strategy allowed the maximum number of samples to be characterised without spending time on further analysis that would have provided little additional information. This method of description is similar to semi-quantitative methods described elsewhere (Toll 1988). At Shimshara, where fewer samples were available for study, these were sorted without first being scanned.

Sorting and identification

During sorting, flots were examined under a stereo-microscope (Leica model EZ4HD or a CETI varizoom) at magnifications of ×6–40 so that each fragment was inspected individually. Identifiable botanical remains including caryopses, chaff and pericarp fragments were removed at this stage. Identifications were made according to morphological characteristics, surface texture, size and where visible internal structure. Identifications were refined with the aid of reference texts (Townsend *et al.* 1966; Jacomet, 2006; Cappers *et al.* 2012; 2006) and through comparison with modern reference material at the School of Archaeology, University of Oxford. Where identifications are not definitive – usually due to poor preservation or distortion – the term 'cf.' has been used to denote this uncertainty.

Quantification

Charred plant remains identified during sorting were quantified following the principle of recording the 'minimum number of individuals' (MNI) (*sensu* Jones 1991). Counts of MNI were made by counting unique features relevant to each taxa/type to reduce the chance of a seed or plant part being recorded more than once. For cereal grains, embryo and apical end fragments were both scored, and whichever category produced the highest count this value was taken and added to the number of whole grains to give the MNI. For glume wheat chaff, glume bases were counted as single units with whole spikelet forks (a pair of glume bases) assigned a count of two. For barley the upper 'nodal' parts of the rachis segments were used. Large-seeded legumes (pulses) were quantified based on counts of radicles and by visual inspection. Other wild plant taxa were quantified based on embryo ends or equivalent 'diagnostic zones' and/or by visual inspection with comparison to whole individuals. Fragmented nutshell, kernel and pod material were also treated in this manner. At Shimshara wood charcoal greater than 2mm (typically considered the minimum size for identification) was quantified by volume (ml). At Bestansur, the majority of wood charcoal fragments were less than 2mm in size and difficult to distinguish from other poorly preserved charred plant remains during scanning. Thus, no assessment of the wood charcoal remains from Bestansur was undertaken for this study.

Selection of charred plant remains for radiocarbon dating

At Bestansur, some charred plant remains were selected for radiocarbon dating by the archaeobotanical team from samples that had been fully sorted (see results section below). As only lentils (*Lens* sp.) had previously been directly dated from the site it was decided to select other taxa where possible. We also aimed to date material from the deepest archaeological deposits available, on the basis that these were less likely to be disturbed as a result of any surface activity. Ultimately however, it was archaeobotanical preservation that drove selection, with a minimum weight of plant material required for processing. This also necessitated that, as with previous samples sent for dating by CZAP, multiple seeds were combined to make up a single sample. The potential issues associated with this approach are discussed in Chapter 11. Charred plant remains selected for dating were photographed before being sent to the Oxford Radiocarbon Accelerator Unit (ORAU) for processing (see Table 18.5).

Results from Bestansur

A total of 647 samples (representing 17,524 litres of deposits) were recovered from 366 archaeological contexts and 14 trenches over the course of the first five field seasons at Bestansur. For the purposes of this study only samples corresponding to secure Early Neolithic levels at Bestansur have been considered. Samples from disturbed, post-Neolithic and topsoil contexts have been omitted. This includes all samples recovered from C1254 and C1262 in T7 and C1388 in T12/13, where some charred plant remains have been demonstrated to be intrusive on the basis of radiocarbon dating (see Chapter 11). Furthermore, given the potential for small strategic samples to be misleading these have either been excluded – in cases where a bulk sample was present for a context – or amalgamated with other strategic samples from the same context. In both cases scanning data was first consulted to make sure that no potentially meaningful spatial variation or analytical information was lost. Full details of sample eliminations and amalgamations are provided in the CZAP database. After these exclusions 511 samples with a total volume of 14,181 litres of deposits, corresponding to 291 contexts and ten trenches remained.

Table 18.2 provides a breakdown of the 511 samples by trench. Trenches 1, 2, 4, 5, 8 and 11 were all excavated over a single season and are represented by the smallest number of samples (2–9) and volumes of deposits (93–483 litres). Trenches 7, 9 and 12/13, which were all excavated over two field seasons, are represented by 85 samples (2492 litres), 48 samples (1524 litres) and 81 samples (2399 litres)

Table 18.2. Number of samples, contexts and volume of deposits (to nearest whole number) corresponding to Neolithic levels by trench studied at Bestansur.

Trench	*No. of samples*	*No. of contexts*	*Vol. of deposit (litres)*
1	8	7	366
2	3	3	146
4	9	8	483
5	5	4	245
7	85	53	2,492
8	9	7	318
9	48	38	1524
10	261	111	6115
11	2	2	93
12–13	81	58	2399

respectively. The greater number of samples and volume of deposits representing T7 is due to a more intensive focus in this area during the summer 2012 season, while for T12/13 this partly reflects its origin as two separate trenches (Chapter 9). T10, which was excavated over three seasons, is represented by the largest number of samples (261) and greatest volume of sampled deposits (6115 litres).

Results of scanning assessment

Full scanning data for the 511 samples examined is presented in the CZAP database along with estimated densities (items per litre of deposits) of charred plant remains for each sample. Densities have been calculated based on the maximum possible number of charred plant remains within each sample, so that for samples containing 1–10 items a figure of ten was used, while for samples containing 11–25 items a figure of 25 was used and so forth. In this way the densities reported here should be considered overestimates.

Numbers and density of charred plant remains

Figure 18.1 summarises the results of scanning in terms of the number of charred plant remains present in samples across the site (see Table 18.1 for categories). Individual results are provided for the major trenches (Trenches 7, 9, 10 and 12/13) but not for the remaining trenches, where the small number of samples (fewer than ten) makes results potentially misleading. While *c.* 80% of samples assessed contained some charred plant remains, these were mostly at low densities, with *c.* 64% of samples containing just 1–10 items (Fig. 18.1a). This is a pattern that is consistent across the site except for T12/13 where the samples were a little more productive (Fig. 18.1e). Indeed, most samples that contained more than 50 charred plant remains (10 out of 14 samples) were recovered from deposits in T12/13. However, it should be noted that these still account for only 12.4% of the samples from this area, with more than four times as many (*c.* 50%) producing 1–10 items or no identifiable charred plant remains whatsoever.

Sample densities across Bestansur ranged from 0 to 50 items per litre of deposits, although the majority of samples produced low densities of charred plant remains (0.79 items per litre on average; Fig. 18.1a). As observed when considering numbers of charred plant remains, T12/13 is the most productive area based on density calculations, with an average sample density of 2.39 items per litre (Fig. 18.1e). The remaining trenches all recorded average densities of less than one item per litre of deposits, and especially low densities (less than 0.5 items per litre) were attested across T7 and T10 (Fig. 18.1b, d).

Botanical composition of scanned samples

Figure 18.2 illustrates the ubiquity of different botanical taxa and types at Bestansur and within major trenches (see Table 18.1 for categories). Figure 18.2 demonstrates that across the site as a whole, no taxon or type was found in more than 35% of samples. However, these low ubiquities can be partly explained by the lack of charred plant remains in *c.* 20% of the samples (Fig. 18.1a). Cereals were relatively common at the site with cereal grain (32.2%) occurring more frequently than chaff (29.9%). As the majority of these remains were observed to be highly fragmented and poorly preserved (see Fig. 18.3a–b) no attempt was made to identify them further during scanning. Pulses were also recorded, although at slightly lower ubiquities. Only lentils (21.7%), could be confidently identified to type, while the remainder of pulse material (24.7%) was highly fragmented and indeterminate (Fig. 18.3c, d). In contrast to the pattern documented across the site, and within T7, T9 and T10 (Fig. 18.2a–d), crop remains were produced by the majority of samples in T12/13 (Fig. 18.2e). Cereal grain and chaff were present in 65.4% and 72.6% of T12/13 samples respectively, while lentils were recorded from 59.3% and indeterminate pulses from 45.7% of samples. Thus, crops were roughly twice as ubiquitous within T12/13 than across the site as a whole.

Also recorded during scanning were wild/weed taxa. These were found in a similar proportion of samples overall as crops (26.8%; Fig. 18.2a) but were particularly common in T7 where they occurred in the majority of samples (52.9%; Fig. 18.2b). In contrast, nut/fruit remains (13.7%) represented by small fragments of charred nutshell, along with culm fragments (2.3%) were both rare; within individual trenches and across the site (Fig. 18.3). It should be noted that culm fragments were not found outside the major trenches shown in Fig. 18.2. Finally, more than a third of samples (34.1%; Fig. 18.2a) produced potentially identifiable plant material. The ubiquity of

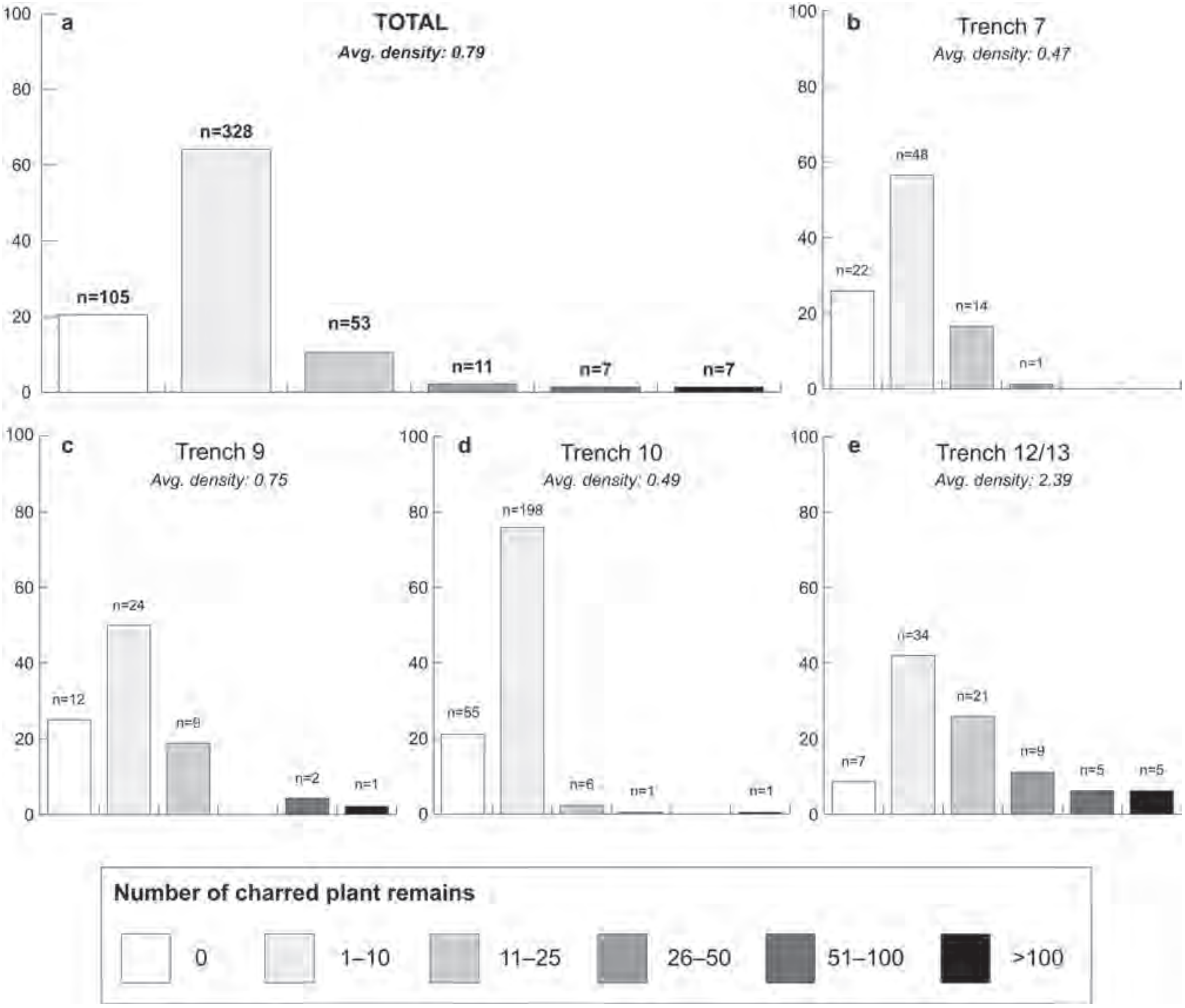


Figure 18.1. Number of samples corresponding to each category of 'number of charred plant remains' recorded during scanning at Bestansur (see Table 18.1) across: a) all 511 samples studied across ten trenches; b) 85 samples studied across Trench 7; c) 48 samples studied across Trench 9; d) 261 samples studied across Trench 10; e) 81 samples studied across Trench 12/13. Absolute number (n) of samples reported above each bar with ubiquity recorded on vertical (y) axis as % of total samples. Average density of charred macrobotanical remains within each trench (items per litre of deposits) also reported.

this category reflects the poor preservation of charred plant remains at Bestansur where many specimens are devoid of any obvious identifying features.

Non-archaeobotanical flot components

Figure 18.4 illustrates the ubiquity of non-archaeobotanical flot components across samples at Bestansur and within major trenches (see Table 18.1 for categories). This demonstrates that, in marked contrast to charred plant remains, non-archaeobotanical flot components are highly ubiquitous across the site and within individual trenches. This is especially true of small/medium-sized modern roots, which correspond to the roots of cereals (Fig. 18.5a). These were present in 90% of samples and at ubiquities of more than 80% within T7, T9, T10 and T12/13. Moreover, these small/medium-sized modern roots made up the physical bulk of the majority of flot samples by volume (personal observation). The other type of modern root material recorded in samples were fragments of large modern roots - corresponding to the roots of perennial shrubs and trees (Fig. 18.5b). Present in 30.9% of samples across the site these were less ubiquitous than their small/medium-sized counterparts, except in T12/13 where they were present in 88.9% of samples (Fig. 18.4e). Their ubiquity in T12/13 can be explained by the fact that, until 2012, this area was the location of tree plantation (see Chapter 9).

Other non-archaeobotanical flot components recorded in samples at Bestansur included burrowing snails. These occurred in 77.9% of samples overall and at ubiquities of between 54.1% and 90.8% in the

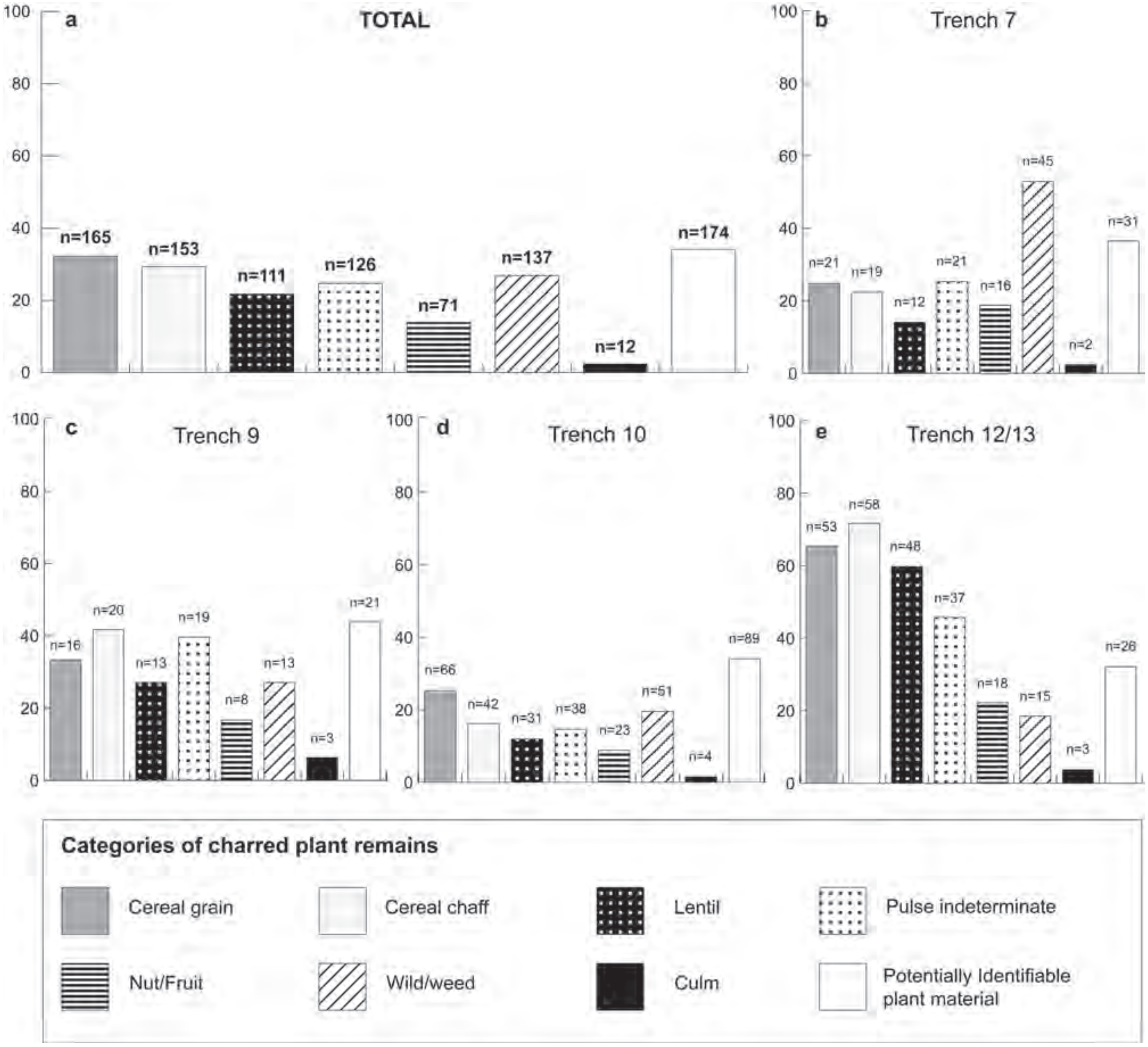


Figure 18.2. Botanical taxa and types recorded during scanning at Bestansur (see Table 18.1) across: a) all 511 samples studied across ten trenches; b) 85 samples studied across Trench 7; c) 48 samples studied across Trench 9; d) 261 samples studied across Trench 10; e) 81 samples studied across Trench 12/13. Absolute number (n) of samples reported above each bar with ubiquity this represents recorded on vertical (y) axis as % of total samples.

major trenches (Fig. 18.4b–e). Further work is needed to establish the origin and date of these snails that may be contemporary with the Early Neolithic deposits or may have burrowed down into these at a later date. Also recorded from *c.* 50% of samples across the site are modern seeds. A distinction was made during scanning between these seeds, which corresponded to wild/weed taxa and the grain of modern cereals, which was relatively rare (2.9%). Modern cereal grain, along with modern cereal chaff (24.5%) were observed to be partially charred in some cases. It should be noted that modern chaff was especially common in T7, where it was recorded in 63.5% of samples (Fig. 18.4b). This likely reflects the fact that the majority of excavations in T7 took place in summer 2012, in the months immediately following the cereal harvest. At this time of year, the fields surrounding the mound are covered with the remnants of the cereal crop (personal observation), which becomes easily incorporated into samples during their collection due to wind, as opposed to representing the movement of these components through archaeological deposits.

Results of sorting

Thirty-five samples, corresponding to 25 discrete archaeological units and 1223 litres of deposits, were selected for further sorting from T10 and T12/13 at Bestansur (Table 18.3). Thirteen samples (413 litres) were recovered from the lower levels of T10, including

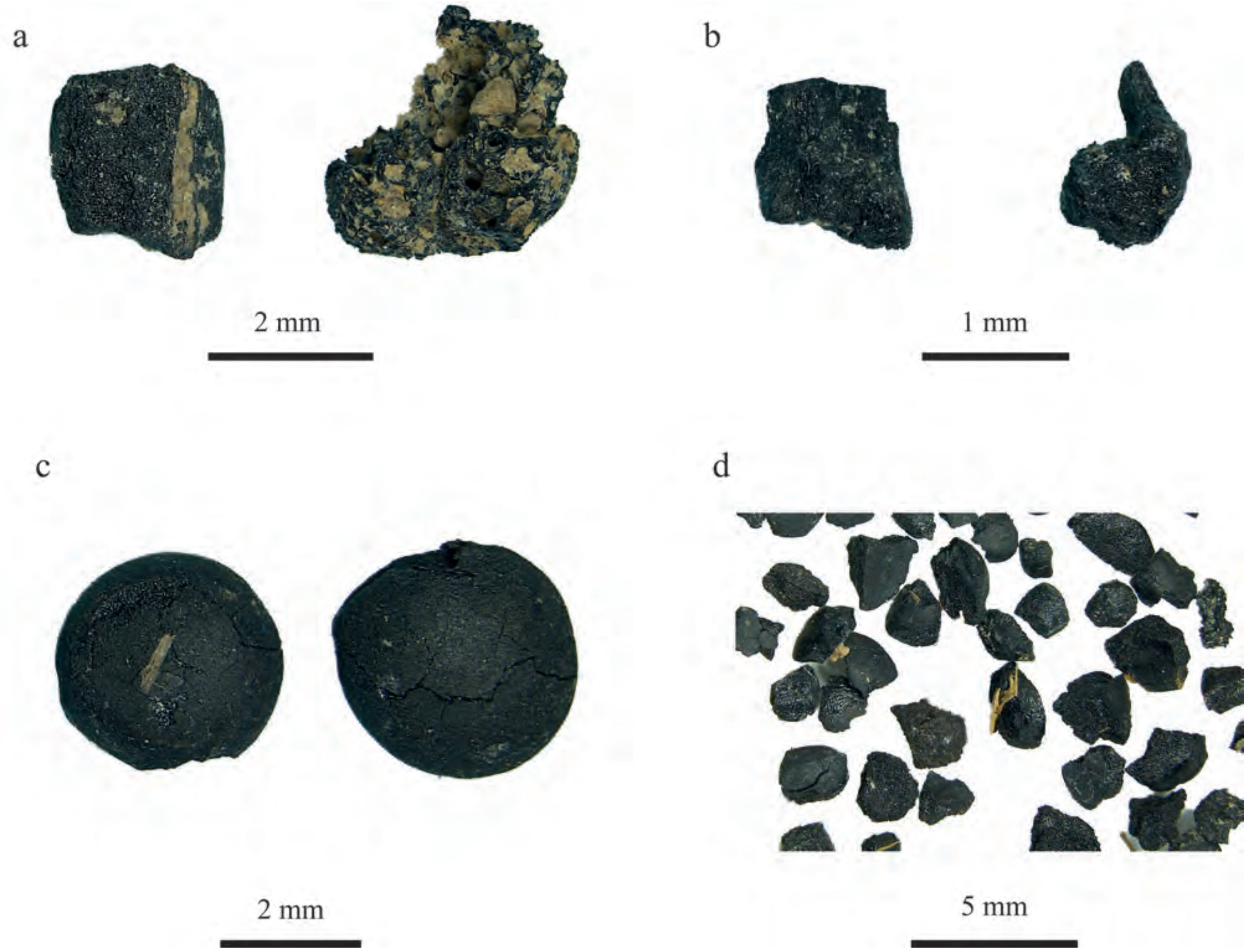


Figure 18.3. Examples of: a) charred cereal grain (C1069, T4); b) charred glume bases (C1485, T12/13); c) charred lentils (C1514, T12/13); d) charred pulse indeterminate fragments (C1514, T12/13), recovered from Bestansur.

four samples from Sp50 in B5 and three from the deep sounding Sp27 (Chapter 9). Twenty-two samples (810 litres) were collected from the late, transitional and early phases of T12/13. Selection of samples for sorting at Bestansur was made on the basis of sample richness (as recorded by scanning data) and stratigraphic information. Consideration was also given to selecting samples from contexts represented in micromorphological thin-section, in order to better compare these two datasets (see Chapter 12). As a result, many of the samples selected were those estimated to contain low numbers of charred plant remains (i.e. 1–10 items).

Full compositional data is presented in the CZAP database and summarised here in Table 18.4. A total of 998 charred plant macrofossils were identified, representing 43 different taxa and types. Densities were low throughout the assemblage with an average of 1.23 items per litre of archaeological deposit. However, this is nearly twice as high as the average density calculated during scanning, reflecting the selection of slightly more productive samples for sorting. A maximum density of 8.46 items per litre was produced by a sample recovered from occupation residues in T10 Building 5 Sp50 closure deposit (BF5045, C1741).

The macrobotanical assemblage was dominated by crop remains, with cereals and pulses present in 94.3% and 100% of samples respectively. Among the cereals, glume wheats were most ubiquitous (88.6%). Glume wheats were represented by both grain (40.0%) and chaff (64.0%); the latter occurring in more samples and having a greater overall abundance (158 compared to 78 specimens). However, the majority of glume bases were poorly preserved and, given time limitations, species identifications have not been attempted. Considering glume wheat grains, most common was two-seeded emmer (*Triticum dicoccum* (Schrank) Schübl.; 25.7%) followed by einkorn (*T. monococcum* L.). Einkorn was represented by a one-seeded variety, found in only two samples (5.7%) and a possible two-seeded type recovered from five samples (14.3%). However, over half of the glume wheat grains identified (40 of 78 specimens) could not be identified to species and were recorded as indeterminate, with an indeterminate two-seeded

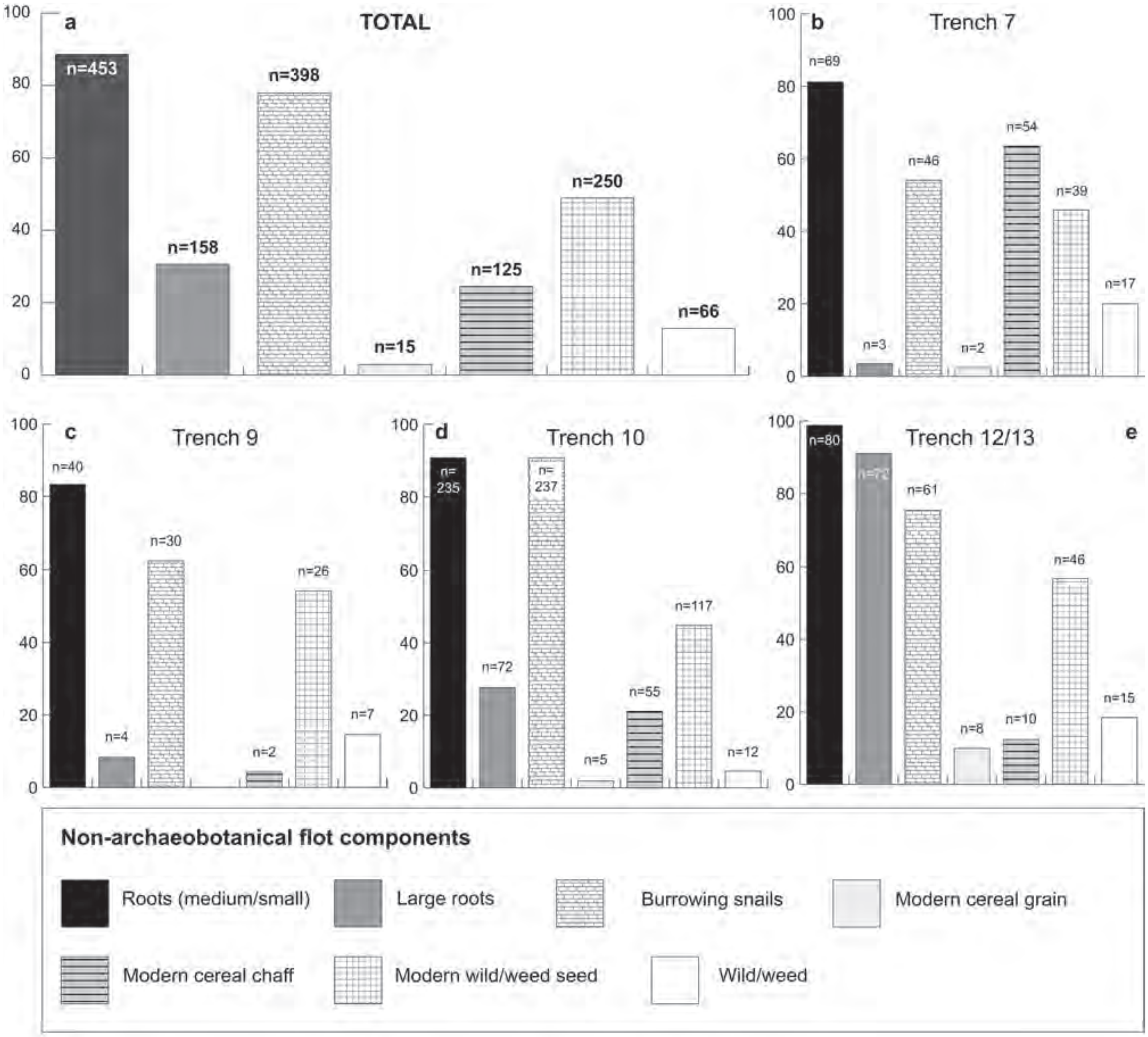


Figure 18.4. Non-archaeobotanical flot components recorded during scanning at Bestansur (see Table 18.1) across: a) all 511 samples studied across ten trenches; b) 85 samples studied across Trench 7; c) 48 samples studied across Trench 9 d) 261 samples studied across Trench 10; e) 81 samples studied across Trench 12/13. Absolute number (n) of samples reported above each bar with ubiquity this represents recorded on vertical (y) axis as % of total samples.

Figure 18.5. Examples of: a) small/medium-sized modern roots (BF1718, C1275, Sp22 T7) corresponding to cereals and other annuals; b) large modern root fragments (BF4325, C1580, Sp45 T12/13) corresponding to long-lived perennials and trees, recovered from Bestansur.

Table 18.3. Summary of samples selected for sorting by trench and space at Bestansur.

Building/ space	*Context*	*Deposit/ layer type*	*BF no.*	*Vol. (litres)*
Trench 10				
	1423	Packing (deliberately laid), occupation residues, surface	2893	46
50	1729	Fill	5026	26
27	1738	Occupation residues	5038	50
50	1741	Fill, packing (deliberately laid), pisé, plaster, occupation residues	5045	13
			5051	10
			5053	22
	1749	Occupation residues	5054	23
Deep sounding	1752	Occupation residues	5079	24
			5098	69
			5099	53
	1772	Occupation residues, surface	5575	20
			5592	24
			5593	33
Total:	n = 7		n = 13	413
Trench 12/13				
	1514	Packing (deliberately laid), occupation residues	3702	44
			3703	77
	1519	Occupation residues	3704	17
	1522	Packing (deliberately laid)	3717	39
	1523	Packing (deliberately laid), occupation residues	3715	47
	1525	Packing (deliberately laid), occupation residues	3722	69
	1526	Occupation residues	3729	27
			3733	10
	1528	Packing (deliberately laid), occupation residues	3735	44
	1529	Fire spot, fuel	3752	6
	1386	Occupation residues	2869	10
	1382	Packing (deliberately laid), occupation residues, surface	2855	36
	1392	Levelling, packing (deliberately laid), surface	2897	37
	1484	Packing (deliberately laid), surface	2894	49
	1485	Occupation residues, surface, fire spot	3460	51
	1494	Occupation residues	3464	54
	1521	Collapse, pisé, occupation residues	3748	51
			4317	29
	1581	Occupation residues	3747	48
			4324	5
	1582	Occupation residues	3753	25
	1665	Packing (deliberately laid), occupation residues, surface	4329	35
Total:	n = 18		n = 22	810
Overall total:	n = 25		n = 35	1223

type further distinguished within four samples (11.4%). Given the limitations of preservation at the site, the domestic status of these cereal remains could not be unequivocally determined. Based on the size of grains and the clean appearance of the scar of disarticulation on a few of the best-preserved glume bases, we tentatively suggest they were domesticated. Other cereals identified at Bestansur included free-threshing wheat (*Triticum aestivum* L./*durum* Desf.; 5.7%) and barley (*Hordeum vulgare* L.; 8.6%). Both were relatively rare and except for a single specimen of two-row/wild barley rachis (*Hordeum vulgare* 2-row/*spontaneum* C. Koch) were represented exclusively by grain.

Turning to the pulses, lentils were the most frequently recorded taxon (77.1%). Although these were less ubiquitous than glume wheat they were more abundant and accounted for the majority of charred plant remains in the sorted assemblage (604 out of 998 specimens). A maximum of 103 lentils were produced by a single sample recovered from occupation residues in T12/13 (BF3735, C1528). The average diameter of lentils at Bestansur was 3.35mm (Whitlam 2015: 308) which lies outside the typical size range of the wild form (2.50–3.00mm; Zohary and Hopf 2000: 99). This suggests these were probably cultivated if not domesticated. In contrast to lentils, other pulse taxa were relatively rare. They included several *Vicia*/*Lathyrus* types (14.3%), with one specimen identified as potential bitter vetch (cf. *V. ervilia* (L.) Willd.). The remaining pulses were identified as indeterminate large-seeded legumes,

Table 18.4. Summary of the frequency and abundance of major plant categories across the assemblage at Bestansur based on 35 samples analysed.

Total no. charred plant remains: 998	*Ubiquity*		*Abundance*	
	n	*%*	*Total sum*	*Max sum*
Einkorn 1-seeded*	2	5.7	6	4
Einkorn cf. 2-seeded	5	14.3	13	7
Emmer 2-seeded	9	25.7	19	8
Glume wheat indet. 2-seeded	4	11.4	9	3
Glume wheat indet.	**12**	**34.3**	**31**	**8**
All glume wheat grains**	**14**	**40**	**78**	**30**
Glume wheat indet., glume base*	**24**	**68.6**	**158**	**23**
Glume wheat total	**31**	**88.6**	**236**	**30**
Barley indet.	3	8.6	4	2
Barley 2-row/wild, rachis internode	1	2.9	1	1
Barley total	**3**	**8.6**	**5**	**3**
Free-threshing wheat	2	5.7	2	1
CEREAL TOTAL.	33	94.3	284	34
Lentil*	27	77.1	604	103
Vicia/Lathyrus* spp.*	**5**	**14.3**	**9**	**3**
Large-seeded legume indet.	20	57.1	44	11
PULSE TOTAL	35	100	657	103
Nut/fruit**	21	60	21	1
Barley/*Taeniatherum-caput medusae*	1	2.9	1	1
Medium-seeded wild grass	1	2.9	1	1
Small-seeded grass	1	2.9	1	1
Medicago sp.*	1	2.9	2	2
Small-seeded legume	1	2.9	2	2
Bolboschoenus glaucus	3	8.6	3	1
Asteraceae sp.	2	5.7	2	1
Galium sp.*	2	5.7	2	1
Asperula sp.	2	5.7	3	2
cf. millet	1	2.9	1	1
Potentially identifiable seeds/fruits	14	40	44	14

n = number of samples, % = percentage of samples.
Bold entries = total of all material (e.g. grain + chaff) including indeterminate categories, *includes cf. material, **amalgamated categories with more than one taxa/type. Unless otherwise stated all remains are seed/grain.

which although found in a relatively high proportion of samples (57.1%) were represented by only 44 specimens in total.

Considering wild taxa, most ubiquitous was the nut/fruit category (60.0%), which in all cases was represented by fragmentary nutshell that was difficult to identify. Other wild and potentially weedy taxa identified at the site include medium-seeded and small-seeded wild grasses, small-seeded legumes, *Bolboschoenus glaucus* (Lam.) S. G. Smith., Asteraceae sp. and *Galium* sp., most of these being present as single specimens in the assemblage. The only other significant category was potentially identifiable plant material. Frequently recorded during scanning, potentially identifiable charred plant remains were recorded in 14 of the sorted samples (40.0%), demonstrating that even with additional analysis these were challenging to identify. It should also be noted that a single broomcorn millet grain (cf. *Panicum miliaceum* L.) was recovered from BF5098 (C1752, T10). This is almost certainly intrusive within these deposits given that millets are not known to appear in Southwest Asia prior to the first millennium BC (Miller *et al.* 2016).

Spatial variation in the distribution of charred plant remains

Figures 18.6 and 18.7 illustrate the stratigraphic distribution of charred plant remains across T10 and T12/13 at Bestansur. Samples are represented by pie-charts illustrating the proportions of major categories of plant taxa and types. Samples from the same archaeological contexts have been amalgamated (based on compositional similarity) and contexts represented by less than ten charred plant remains omitted as these are likely to be misleading.

Trench 10 (Fig. 18.6): there is a clear separation in T10 between samples recovered from Sp50 and those collected from the deep sounding Sp27. Samples from C1741 and C1729 in Sp50 are dominated by lentils along with glume wheat and other cereal grains, while those collected from the deep sounding (C1749, C1752 and C1772) have relatively low proportions of these taxa (especially lentils) and are more mixed in their composition, with glume bases, wild/weed taxa and nut/fruit remains. Fragments of charred nut/fruit have also been identified in thin-section from C1772 (Chapter 12, Fig. 12.11c).

Trench 12/13 (Fig. 18.7): variation in botanical composition is most clearly observed within T12/13 in relation to depth. Samples recovered from archaeological contexts higher up the stratigraphic profile and corresponding to the late and transitional phases here (C1514, C1519, C1522, C1523, C1526, C1528) are dominated by lentils. In contrast, samples recovered from deposits lower down the stratigraphic profile, which correspond to the early phase in this area (C1382, C1392, C1485, C1495, C1521, C1581, C1665), are dominated by glume bases. These early phase samples also contain significant proportions of cereal grain and to a lesser extent nut/fruit remains. Well-preserved undated phytoliths and melted silica phytoliths, mostly from reeds and grass leaves/stem, have also been identified in thin-section from these deposits (Chapter 12, Fig. 12.13a), along with charred pulse seeds, which are comparable in size to those recovered from flotation (Chapter 12, Fig. 12.10c, d). It is worth noting that evidence from the study of micromorphological thin-sections taken here also

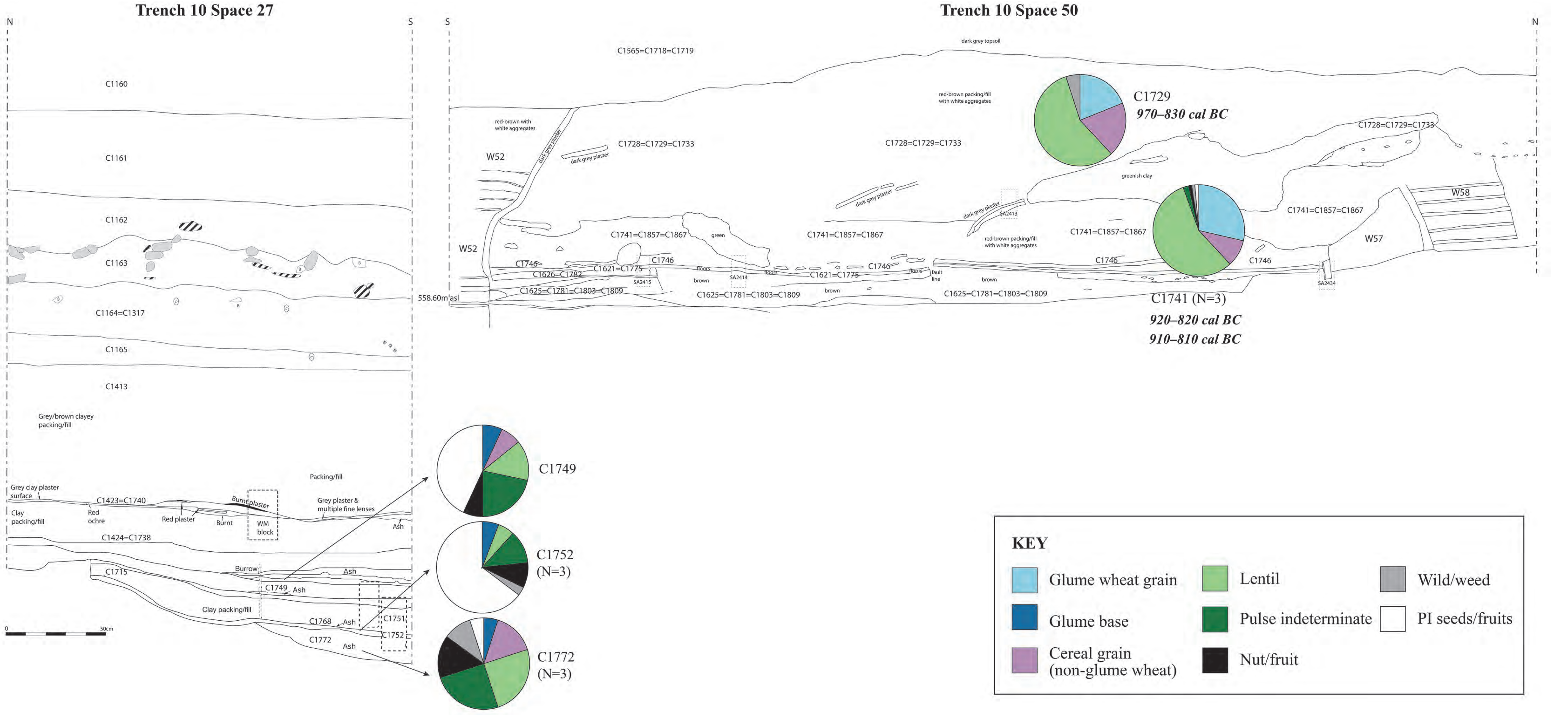


Figure 18.6. Trench 10 section illustrating location of contexts and botanical composition (as pie charts) according to major categories of plant remain. Radiocarbon dates obtained during this study also shown (see Table 18.5).

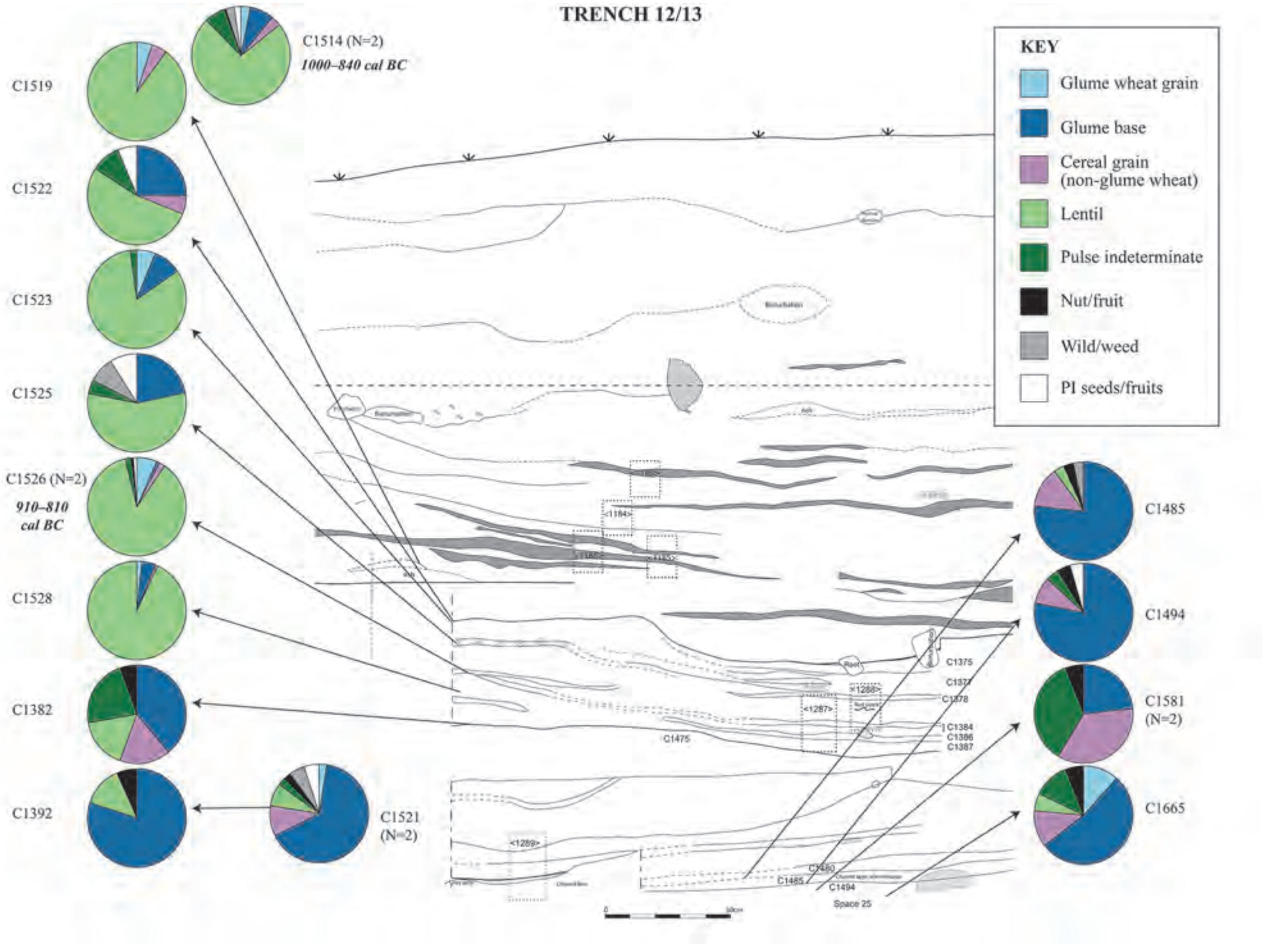


Figure 18.7. Trench 12/13 section illustrating location of contexts and their botanical composition (as pie charts) according to major categories of plant remain. Radiocarbon dates obtained during this study also shown (see Table 18.5).

demonstrates a difference between deposits higher up the section (represented in thin-section SA1499 by C1514 and C1523), which are dominated by calcitic ashes, and deposits lower down in the section (represented in thin-section SA1502 by C1521) which are dominated by phytoliths and yellowish organic matter, as in SA1286 C1494 (Figs 12.12b, 12.13a, 12.14a, 12.16a, 12.26).

The patterns observed across T10 and T12/13 may relate to differences in how these areas were used. For example, the dominance of crop products (cereal grain and lentils) across Sp50 in T10 suggests this area may have had a function relating to the preparation and consumption of food. In contrast the high proportions of glume bases and wild/weed taxa recovered from the deep sounding, suggest this external area may have been used for the processing of crops and/or the disposal of crop processing by-products. However, based on previous radiocarbon dating of charred lentils from T12/13 and T7, we cannot rule out the possibility that the patterns identified in T10 and T12/13 may reflect movement of charred plant remains into these deposits from later levels of occupation. Taking this a step further, we can hypothesise that the decrease in lentils moving downwards in T12/13 and to a lesser extent T10, may be indicative of a decrease in intrusive plant remains and reduced disturbance of archaeological deposits with increasing depth from the surface.

Results of additional radiocarbon dating of charred plant remains

Four samples of charred glume wheat grains and a single sample of charred lentils, from T10 and T12/13 at Bestansur, were submitted to the ORAU for radiocarbon dating. The charred plant material, its archaeological context and the results of radiocarbon dating are provided in Table 18.5, which also provides information about previous radiocarbon dates obtained from charred plant remains during earlier CZAP investigations. The five new dates obtained for this study all have low standard deviations and expected $\delta^{13}C$ values, meaning these can be considered as reliable ^{14}C determinations (see Chapter 11). However, as with dates previously returned from charred plant remains at Bestansur they are not in agreement with the Early Neolithic deposits from

Table 18.5. Radiocarbon samples and dates taken from charred plant remains from Bestansur as part of this study (1–5) and undertaken as part of CZAP investigations (6–8, see Table 11.1, Chapter 11).

No.	*Taxonomic ID*	*Area of site*	*Sample no.*	*Conventional date BP*	*Calibrated date BC 2 sigma (95.4%)*	$\delta^{13}C$ *(PDB)*
1	Glume wheat (*Triticum monococcum/dicoccum*)	Trench 12/13; C1514	OxA-35893	2769±32	1000–840	–21.01‰
2	Glume wheat (*Triticum monococcum/dicoccum*)	Trench 12/13; C1526	OxA-36022	2709±26	910–810	–22.18‰
3	Glume wheat (*Triticum monococcum/dicoccum*)	Trench 10; C1729	OxA–36023	2749±27	970–960 & 940–830	–23.60‰
4	Emmer wheat (*Triticum dicoccum*)	Trench 10; C1741	OxA–36024	2732±26	920–820	–23.53‰
5	Lentil (*Lens* sp.)	Trench 10; C1741	OxA–36025	2712±25	910–810	–23.36‰
6	Lentil (Lens sp.)	Trench 7; C1262	Beta–343963	2740±30	971–816	–22.9‰
7	Lentil (*Lens* sp.)	Trench 7; C1254	Beta–342482	2770±30	997–839	–23.4‰
8	Lentil (*Lens* sp.)	Trench 12/13; C1388	Beta–351365	6380±40	5471–5304	–21.5‰

which they were collected. In fact, all five samples returned Iron Age dates (*c.* 900 cal BC). This is in close agreement with two samples of charred lentils previously dated from T7 at the site (Table 18.5) and supports the view that some, if not most, of the charred plant remains from Early Neolithic levels at Bestansur are intrusive from later (Iron Age) occupation levels at the site.

Two of the samples of charred plant material sent for dating were selected from BF5045 (C1741) (Fig. 18.6). This sample produced 110 charred plant remains and recorded the highest density across the 35 samples that were sorted. Along with BF5051, also recovered from C1741, it was also the only sample from T10 (out of the 261 scanned) to produce more than 25 charred plant remains (see Fig. 18.1d). Similarly, the charred plant remains sent for dating from T12 were selected from samples recovered from C1514 and C1526 in this trench (Fig. 18.7). These contexts were represented by seven samples in total, four of which (BF3702, BF3703, BF3729, BF3722) produced 50–100 charred plant remains. This suggests that the more productive deposits at Bestansur, reported here, are more productive by virtue of containing intrusive charred plant material, rather than as a result of Early Neolithic activity at the site.

Results from Shimshara

During the 2012 and 2013 excavations at Shimshara (Chapter 10), a total of 30 samples and 820 litres of archaeological deposits were recovered from 22 contexts. Samples were collected from T1 and T2 and the West–East section of the site, where a single radiocarbon determination on charred nutshell returned a date of *c.* 7300–7200 BC (Chapter 11). Seventeen samples, representing 13 unique contexts and 447 litres of deposits were selected for preliminary analysis, based on stratigraphic information and their designation as occupation or external deposits (Table 18.6). The coarse fractions of each flot (>1mm) were fully sorted, but due to time constraints fine fractions (0.3mm) were sub-sampled using a riffle box to between half and one-eighth of their total volume. In all cases, where less than 100% of a sample has been examined directly, counts of taxa/types have been multiplied up to give an estimate of the total count that would be expected if 100% of the material had been sorted. For example, if 50% of the fine fraction was sorted, results have been multiplied by two. This was done to allow like-for-like comparisons to be made across samples.

Full compositional data is presented in the CZAP database and summarised here in Table 18.7. An estimated 348 charred plant remains were identified across the 17 samples studied from Shimshara, representing 21 different taxa and types. Densities of charred plant remains were low with an average of 0.89 items per litre and a maximum of 3.19 items per litre (from BF1672, W–E section). Crop taxa represent the greatest proportion of the assemblage, with pulses and cereals found in 100% and 76.5% of samples respectively. Among the pulses, indeterminate large-seeded legumes and lentils were the most ubiquitous types, the former produced by every sample examined. Less frequent were *Vicia* species (23.5%), which included two specimens of bitter vetch (*V. ervilia*). Cereals at Shimshara, excepting a single glume base identified as emmer wheat (*Triticum dicoccum*), were represented exclusively by grain. However, further identification was prevented by the poor preservation of cereal grains at the site and only two specimens identified as indeterminate wheat (*Triticum* sp. indet.; 11.8%) could be distinguished. The lack of positively identified cereal remains precludes any discussion over their domestic status and/or of the diversity and relative importance of different cereal taxa at the site.

Table 18.6. Summary of samples selected for sorting by trench and space at Shimshara.

Context	*Deposit/layer type*	*BF no.*	*Vol. (litres)*
Trench 1			
1637	*In situ* burning/destruction level	4291	20
1643	Destruction layer overlying cobbled surface	4293	20
1661	External cobbled surface with burnt *in situ* remains	4301	30
Total (n = 3)	–	n = 3	70
Trench 2			
1639	Fill of building with potential roof collapse	4289 4292	15 15
1640	Occupation deposit	4284	15
1644	Ashy deposit directly overlying surface	4280	6
1647	Base of fire installation	4287	2
1650	External surface and occupation deposits	4279 4283 4285	50 55 50
1654	Occupation deposit and underlying surface	4290	20
1659	Packing and occupation debris	4298 4296	50 42
1662	Ashy layer on compact packing layer	4297	20
Total (n = 8)	–	n = 12	340
W–E section			
–	Bottom layer of section	1671	21
–	Lowest occupation of section	1672	16
Total	–	n = 2	37
Overall total (n = 11)		n = 17	447

n = number of contexts or samples.

Table 18.7. Summary of the frequency and abundance of major plant categories across the assemblage at Shimshara based on 17 samples analysed.

Total no. charred plant remains: 348	*Ubiquity*		*Abundance*	
	n	*%*	*Total sum*	*Max sum*
Emmer, glume base	1	5.9	1	1
Wheat indet	2	11.8	2	1
Cereal indet.	13	76.5	27	8
Cereal TOTAL	**13**	**76.5**	**30**	**8**
Lentil	11	64.7	44	13
Vicia spp.**	4	23.5	6	2
Large-seeded legume indet.	17	100	40	6
Pulse TOTAL	17	100	90	17
Almond, nutshell	3	17.6	3	1
Pistachio, nutshell (smooth)	13	76.5	25	6
Nut/fruit TOTAL	14	82.4	32	6
Poa sp. (very small grain)	5	29.4	78	32
Small-seeded grass	5	29.4	13	8
Wild barley	2	11.8	22	21
Lolium sp.	1	5.9	1	1
Papaver sp.	3	17.6	58	48
cf. *Bolboschoenus glaucus*	1	5.9	8	8
Linum sp.	1	5.9	2	2
Trigonous cores	1	5.9	2	2
Potentially identifiable seeds/fruits	4	23.5	12	8
Wood charcoal (ml)	12	70.6	6	1.9

n = number of samples, % = percentage of samples.
Bold entries = total of all material (e.g. grain + chaff) including cf. and indeterminate categories, * includes cf. material, **amalgamated categories with more than one taxa/type.
Unless otherwise stated all remains are seed/grain.

Wild plants at Shimshara were represented primarily by nut/fruit taxa. These were ubiquitous across the assemblage (82.4%) and included a smooth-shelled pistachio type (*Pistacia* sp.; 76.5%) as well as almond (*Amygdalus* sp.; 17.6%). Both taxa were found as highly fragmented nutshell and could not be identified to a specific species. A single drupelet of fig (*Ficus* sp.) was also recorded. Other wild and potentially weedy taxa in the assemblage belonged principally to the Poaceae (grass) family and include a very small *Poa* type and a medium-seeded *Lolium* type, both found in 29.4% of samples. Grass grains that corresponded well with wild barley (*Hordeum* cf. *spontaneum*) were also identified. While low in ubiquity (11.8%) wild barley was represented by 22 grains overall, all but one of which were produced by a single sample (BF4285) from occupation deposits on a surface C1650 in T2. This single context, which was represented by three samples overall, yielded half of the charred plant remains identified across the assemblage (174 of 348 specimens). Other taxa identified at Shimshara include *Papaver* sp. and *Bolboschoenus glaucus*, and from BF1672 in the west-east section two seeds of flax (*Linum* sp.).

Spatial variation in the distribution of plant remains

Figures 18.8 illustrates the botanical composition of T1, T2 and the west-east section at Shimshara, as pie-charts showing major categories of charred plant remains across samples. This demonstrates that there is a clear difference between T1, where samples produced a high proportion of cereals and pulses, but few wild and weedy types, and T2 and the West–East section where samples produced a high proportion of wild and weedy types and fewer crops. Nut/fruit remains occur in similar proportions across the site.

Discussion

Analyses of the charred plant remains recovered from Early Neolithic levels at Bestansur and Shimshara have demonstrated that these are present in low

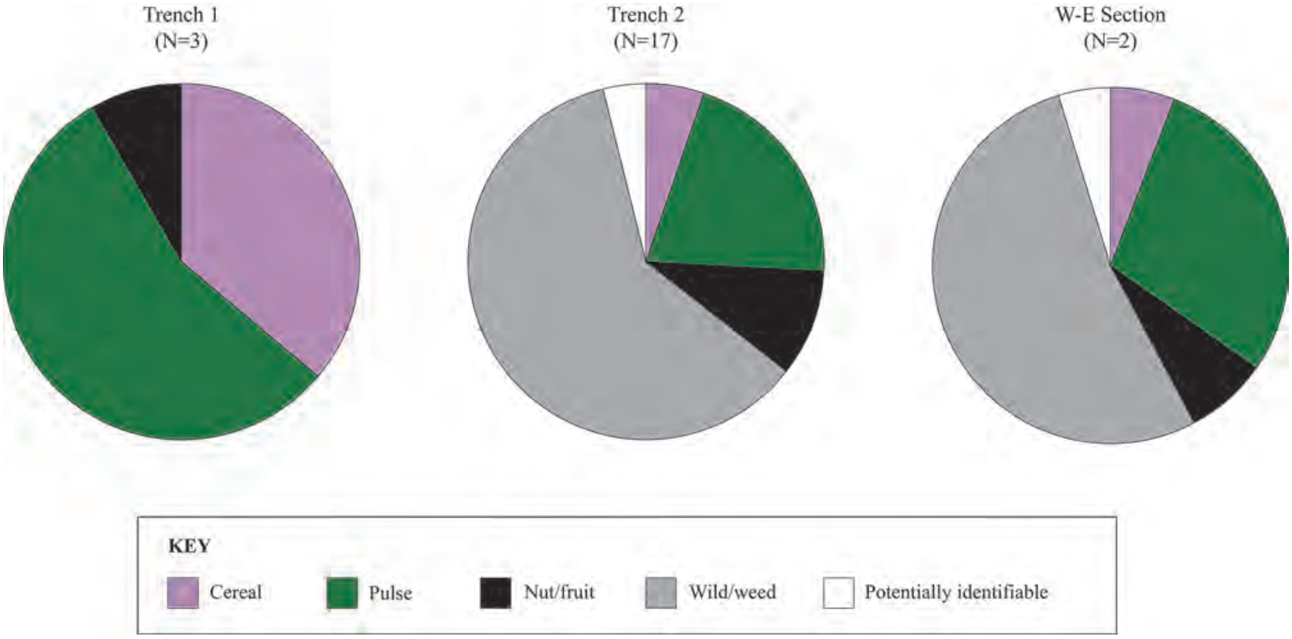


Figure 18.8. Botanical composition of trenches at Shimshara (as pie charts) according to major categories of plant remains.

densities at both sites and generally poorly preserved. At Shimshara further investigation is needed to substantiate this pattern, given the preliminary nature of our analyses. The most promising deposits identified to date come from T2 and the West–East section. However, at Bestansur our findings are based on the study of 511 samples and 14,181 litres of deposits, collected from multiple areas of the site. Furthermore, direct radiocarbon dating of charred plant remains has indicated that a significant proportion of this material potentially originated from Iron Age occupation levels at the settlement, a point which is returned to below. At present, no dated plant remains from otherwise Early Neolithic deposits at Bestansur have returned Early Neolithic dates (see Addendum).

Early Neolithic plant economies

Crop spectra

Analyses of charred plant remains from Bestansur and Shimshara indicate a number of crop species were present at both sites. The presence and absence of major crop types at these and other early farming settlements in the EFC are summarised in Table 18.8. The poor preservation of the charred plant remains recovered at Bestansur and Shimshara means it has not been possible to unequivocally determine the domestic status of crops at either site. At Bestansur we have tentatively identified glume wheats as being domesticated based on the size of grains and the clean appearance of the scar of disarticulation on a few of the best-preserved glume bases. Glume wheats identified at Bestansur include one-seeded and possibly two-seeded einkorn and emmer wheat. Along with lentils, which were plausibly domesticated based on their size, these were the major crops types attested at the site. Free-threshing wheat, barley and a possible seed of bitter vetch were also recovered but were rare. Moreover, many of the crop species recorded here were recovered from samples where charred plant remains have been directly dated to the Iron Age. It is likely, therefore, that these may better represent the Iron Age plant economy at Bestansur.

Turning to Shimshara, it is evident that the crop spectrum is somewhat restricted in comparison to the majority of other early farming settlements in the EFC (Table 18.8). This may be an artefact of the poor preservation of charred plant remains at the site, which has limited species-level identifications, as well the small number of samples considered for this study. Identified from Shimshara are emmer wheat, lentil and bitter vetch, all of which were plausibly cultivated. The absence of barley is particularly striking as this is a major crop at most other sites in the region (Table 18.8). Two seeds of flax are also of interest, given that flax has only otherwise been found at Maghzaliyeh and Ali Kosh (Table 18.8). With just two specimens recovered from Shimshara it is not possible at present to make any inferences regarding the cultivated status of flax at the site, especially as wild flax (*Linum bienne*) is known to favour the type of moist clay soils found in the local environment (Zohary and Hopf 2000: 127; see also Chapter 3).

Wild and weedy plants

At both Bestansur and Shimshara, a narrow spectrum of wild plants has been identified. Wild plants

Table 18.8. Presence of major crops (wild and domesticated) at PPNB equivalent Early Neolithic sites in the EFC.

Date BC	*Site (phase)*	*No. samples*	*Wild barley*	*Wild Einkorn*	*Wild Emmer*	*Wild Lentil*	*Wild pea*	*Wild grass pea*	*Barley*	*Einkorn*	*Emmer*	*Free-threshing wheat*	*Lentil*	*Pea*	*Grass pea*	*Bitter vetch**	*Flax**
7050–6250	Maghzaliya	3	(X)	X	.	.	.	.	2h	X	X	X	X	.	.	.	X
7500–6000	Ali Kosh (BM, AK)	34	(X)	.	.	.	.	.	2h, 6n	X	X	.	(X)	.	.	.	(X)
7200–7000	Chogha Bonut	24	.	X	.	.	.	.	(6r), 2h	X	X	X	X	.	.	.	.
7600	Shimshara	17	X	.	.	.	.	.	.	.	(X)	.	X	.	.	(X)	(X)
7700–7100	Bestansur	511	.	.	.	.	.	.	(X)	(X, 2g)	(X)	(X)	(X)	.	.	(X)	.
7960–7590	Sheikh-e Abad (Trench 2, 3)	36	X	.	.	.	.	.	h	(X)	(X)	.	X	X	.	X	.
8000–7400	Jarmo	-	(X)	X	X	.	.	.	2h	(X)	X	.	X	X	X	.	.
8240–7840	Ganj Dareh	122	X	.	.	X	X	.	2h	.	.	.	.	.	.	.	.
8300–7800	Abdul Hosein	-	.	.	.	.	.	.	2h	.	X	.	X	.	.	.	.
8400–7840	East Chia Sabz	4	X	(X)	(X)	X	.	.	.	.	.	.	.	.	(X)	X	.
8700–7700	Chogha Golan (AH VIII - I)	27	X	(X)	(X)	X	.	.	.	.	X	.	.	.	(X)	X	.

X denotes presence, (X) denotes uncertain identification and/or presence in negligible numbers, 2g = 2-grained einkorn, h=hulled barley, n=naked barley, 2r/6r = 2-row/6-row barley, 2h/6h = 2-row/6-row hulled barley, 2n/6n = 2-row/6-row naked barley. * denotes crops were wild/domesticated differentiation is less certain. Sources: Helbaek (1969; 1972); Watson (1983); van Zeist *et al.* (1984); Hubbard (1990); Miller (2003); Charles (2007); Riehl *et al*. (2012; 2013); Whitlam *et al.* (2013; 2018); Willcox (n.d.).

recovered from Shimshara include pistachio and almond, both of which could have been collected by inhabitants of the site for consumption. These taxa are common at Early Neolithic sites across the EFC and both pistachio and almond trees would have grown in the vicinity of the site based on palaeoclimate and vegetation reconstructions for the region (Stevens *et al.* 2001; see also Chapter 3). Nutshell has also been identified at Bestansur, although due to the high rate of fragmentation and poor preservation of these remains it has not been possible to identify these further within the present study.

Various wild grasses are evidenced at Bestansur and Shimshara, with grains corresponding to wild barley noted as being particularly abundant at the latter, although largely restricted to a single sample from a possibly external surface C1650. Wild grasses may represent plants collected for consumption and/or arable weeds and their presence at these sites warrants further investigation, especially in light of the diverse roles played by wild grasses within Early Neolithic plant economies in this region (Savard *et al.* 2006, Weide *et al.* 2018, Whitlam *et al.* 2018). Evidence that grasses were consumed by inhabitants of Bestansur has been provided by identification of Poaceae phytoliths *in situ* in human coprolites (Chapters 13 and 16).

At both study sites a narrow range of taxa, including *Galium* sp., *Bolboschoenus glaucus, Papaver* sp. and small-seeded legumes may represent potential arable weeds. However, as with wild grasses their presence needs to be considered with respect to the multiple pathways by which these arrived on site, for example through intentional collection as food, within animal dung burnt as a fuel, or as craft/construction material. *Bolboschenus glaucus* for instance, has been variously interpreted as a gathered food resource and as a component of animal dung burnt as a fuel at Early Neolithic settlements in the EFC (Savard *et al.* 2006, Charles 2007, Whitlam *et al.* 2018). Again, it should be noted that at Bestansur the Early Neolithic date of these charred plant remains first needs to be securely established before we can draw any reliable inferences regarding their presence at the site.

Post-depositional processes at Bestansur

While this study has focused on the analysis of charred plant remains, scanning of 511 samples from Bestansur has also demonstrated the frequency of non-archaeobotanical flot components within archaeological deposits at the site. These non-archaeobotanical flot components occur at a frequency and abundance within samples that is not paralleled at other sites in the region within the authors' own experience. While the presence of modern cereal grain and chaff can be explained by their incorporation into samples during collection, modern roots, burrowing snails and modern wild/weed seeds where clearly part of the matrix of archaeological deposits. The presence of modern root material within samples agrees with observations made by excavators in the field concerning the frequency of plant roots encountered during excavation (Chapter 9) and suggests that an extensive and deep root system is present at Bestansur. This is likely to have resulted in considerable 'floral-turbation' (Miksicek 1987). The ubiquity of burrowing snails across samples also suggests a considerable degree of faunal-turbation, and the remains of small mammal burrows recorded during excavation indicate animal activity within archaeological deposits (Chapter 9). Animal burrowing, which has also been evidenced at nearby Jarmo (Reed 1958) has been put forward as one possible explanation for the presence of intrusive lentils within Early Neolithic deposits (Chapter 11).

We hypothesise here that the non-archaeobotanical flot components recorded within samples at Bestansur provide a reliable proxy for the scale of bioturbation at the site. Moreover, we suggest that the scarcity and poor preservation of charred plant remains at the site is, in part, a result of the intensity of bioturbation here as evidenced by these proxies. Other pre-depositional and depositional factors, such as which plants/plant parts were brought to site, how these were processed and charring biases would also have influenced the survival of charred plant remains at Bestansur (see Chapters 12, 13, 16 and 24 for further discussion). However, the presence of low quantities of poorly preserved charred plant remains is, we argue, more consistent with post-depositional effects. Micromorphological analyses at Bestansur have indicated that *c.* 20–30% of each deposit has been subject to bioturbation in the area of the thin-section sampling, and that areas of bioturbation are generally well-defined (Chapter 12). While not providing the same high resolution or *in situ* evidence for deposit formation as thin-sections, bulk samples for flotation and wet-sieving are in the order of 100,000 times larger in volume and provide a complementary perspective of the nature of archaeological deposits at Bestansur.

Other post-depositional processes that may have directly impacted the preservation of charred remains at Bestansur include the alternate wetting and drying of deposits and the impact of expandable clays. In thin-section, the action of shrink-swell clays and/or freeze-thaw has been demonstrated as causing the partial detachment of sections of *in situ* charred plant remains such as parts of outer seed coats (Fig. 12.10c, d [4–5]). The chestnut soils that cover the study area are also known to undergo an annual 'self-mulching' process (Buringh 1960: 253–273), which would have resulted in the mixing of material from the surface into the upper 50–60cm of the soil column and caused considerable mechanical damage. Significantly, this depth range corresponds to the upper levels of Early Neolithic deposits in several areas of the site (Chapters 3 and 6). More recent excavations at the site have reached levels up to 3m below the modern surface were deposits will not have been subject to the more recent self-mulching action of soils.

Conclusions and suggestions of future work

As stated at the beginning of this chapter, archaeobotanical evidence from Bestansur and Shimshara has the potential to elucidate key aspects of the emergence of farming in northern Iraq. However, as the results presented here have demonstrated, there are major limitations associated with the charred plant assemblages from each site, namely the low densities of poorly preserved material. At Bestansur these issues are further compounded by the intrusion of charred plant remains from Iron Age occupation levels into Early Neolithic deposits. Future work at both sites, therefore, needs to address these limitations before more robust inferences regarding plant management and consumption can be made.

At Shimshara, additional work includes sorting samples that have yet to be examined (14 out of 31), as well as undertaking more detailed analyses of the charred plant remains to refine identifications where possible. At Bestansur meanwhile, further radiocarbon dating is a key priority and should specifically target poorly preserved plant remains, such as highly eroded glume bases, which we consider to be plausibly Early Neolithic in date (see Addendum). There is also further scope for integrating the data presented here with data from detailed micromorphological investigations at the site. Reconciling the differences in scale between these two approaches is key to unpacking the complex nature of plant taphonomy at Bestansur. Work on this front is currently being undertaken by Charlotte Diffey as part of the ERC MENTICA project, including the analysis of unprocessed blocks of archaeological deposits that provide an intermediate step between bulk samples and thin sections.

Finally, by incorporating the recording of non-archaeobotanical flot components into our scanning assessment at Bestanur, we have been able to demonstrate the extent of bioturbation at the site and directly link this to the poor preservation of charred plant remains recovered here. In reporting our findings, we hope to encourage more detailed discussions regarding plant taphonomy and depositional environments at Early Neolithic sites in this region, and beyond, which will help us construct more robust models for the emergence of farming in Southwest Asia. This issue is of particular concern in northern Iraq where archaeobotanical evidence is limited and where, by conflating absence of evidence with evidence for absence, we potentially risk underestimating the role this region played in the origins and spread of agriculture.

Addendum

Following the completion of this report and prior to its publication, an additional six radiocarbon determinations were obtained on charred plant remains recovered during the 2019 field season at Bestansur. Two Early Neolithic dates were obtained from specimens tentatively identified as pods from the Brassicaceae family. A further four samples of charred cereal grain and nutshell all returned Ottoman dates. These findings, which will be published in due course, support the observations made within this report and underline the need to take a holistic, integrative approach to the plant evidence, maximising the potential from all possible strands of evidence (Chapters 12, 13 and 16).

19. HUMAN REMAINS FROM BESTANSUR: DEMOGRAPHY, DIET AND HEALTH

Sam Walsh

Introduction

The substantial assemblage of Early Neolithic human remains at Bestansur provides us with a rare opportunity to investigate a range of interconnected issues and questions regarding the human condition at an early stage in the transition from hunter-forager to herder-farmer. In this chapter the Bestansur assemblage is analysed within the context of Early Neolithic human remains assemblages of the region, focusing on burial practices, demography and palaeopathology. The Bestansur human assemblage is important due to the limited number of recently excavated burial sites of this nature and period in Iraq, the Zagros region, and the Eastern Fertile Crescent (EFC). In comparison with less recently excavated assemblages, these remains are also highly significant due to the potential for application of new scientific and contextual approaches.

During the project, the osteoarchaeology team was directly engaged in all aspects of excavation, recording and analysis of the human remains both in the field and in specialist laboratories (Fig. 19.1). This enabled the creation of a highly contextualised data set (see Table 19.28) with which to analyse human osteology, taphonomy, and palaeopathology, through application of an integrated approach in order to investigate demography, health, lifestyle, and burial practices.

The Bestansur assemblage consists of fragmented and often comingled human remains. Larger bones are poorly preserved, while small bones and teeth survive well. The majority of the Early Neolithic human remains recovered so far are from Trench 10, with an additional two articulated burials from Trench 7 and small amounts of human bones from other trenches. Difficulties lie mainly in the post-depositional taphonomic alterations which have caused fragmentation and compaction of the human remains. Within the current study 67 individuals have been analysed and are reported on here. Of these, 50 are juveniles aged from pre-natal infant to adolescent. This chapter presents the results of the analysis of the Bestansur human remains assemblage, including burial practices, demography, and palaeopathology.

Research context

Burial practice, taphonomy and terminology

Burials in the Early Neolithic of Southwest Asia include a diverse range of primary or secondary practices (Croucher 2012). Primary burial practice involves the deposition of an intact body without further disturbance. Secondary burial practices involve multiple stages of mortuary activities including treatment, deposition or manipulation of the body prior to final deposition (Boz and Hager 2014; Knüsel 2014). Examples of secondary burial practice from the Early Neolithic include skull removal and/or burial at Nemrik (Sołtysiak *et al.* 2015), disarticulation and burial of skulls and post-crania at Abu Hureyra (Moore and Molleson 2000), cut-marks at Körtik Tepe (Erdal 2015) and curation in the form of plastered skulls at Jericho and other sites (Bonogofsky 2003; Fletcher *et al.* 2008). To investigate differential burial practices this research examines taphonomic changes to the bones, including surface modifications such as weathering and scavenging, and colour changes such as manganese staining and evidence of microbial activity (Pokines and Baker 2014). Patterns of element distribution are also examined with caution as these

Figure 19.1. Excavation and recording of human remains in the field at Bestansur: Sp50 Building 5, looking southwest.

can also be indicators of secondary burial, as for example, when smaller bones of the hand and foot are left behind when the larger elements have been removed for burial elsewhere (Bello and Andrews 2006: 9).

Mortality and health in the Early Neolithic

The cultivation and domestication of animals and plants has been argued to result in increased social complexity, population growth, differential mortality, reduced dietary variation, and increased ill-health (Bocquet-Appel and Bar-Yosef 2008; Cheronet *et al.* 2016; Page *et al.* 2016; Donoghue 2017; McFadden and Oxenham 2018). As a result, we could expect to find increasing evidence of infectious diseases from enclosed living conditions and zoonoses due to contact with animals, as well increased indications of dietary deficiency and inter-personal violence due to increased social complexity.

Within osteological studies of the Epipalaeolithic and Early Neolithic of Southwest Asia, skeletal evidence has predominantly come from sites in the Western Fertile Crescent including the Levantine area (Eshed *et al*. 2004; 2006; 2010), as well as sites in Anatolia such as Çatalhöyük (Larsen *et al*. 2015; 2019) and Tell Halula and Abu Hureyra in northern Syria (Moore *et al.* 2000; Ortiz *et al.* 2013).

Explanations for differences in inter-site and inter-regional mortality profiles have been sought using evidence for non-specific indicators of stress, such as enamel hypoplasia, Harris lines, stature, subperiosteal new bone formation, and cribra orbitalia (Merrett 2004, Eshed *et al.* 2006; 2010). Changes in the natural and built environment and ecology with the onset of pastoralism and agriculture are argued to result in infectious diseases that were more likely to be zoonotic or environmental (Pearce-Duvet 2006; Bar-Gal and Greenblatt 2007; Chisholm *et al.* 2016).

Research aims and objectives

The aims of this research are to examine the impact of increasingly sedentary and agricultural life-ways on demography, health and diet of the individuals and human interaction with the environment. These aspects have been integrated to provide new insights into how people lived, died and were treated after death during the Early Neolithic in the Zagros region of the EFC. Significant aspects of focus for the study include: human demography and juvenile mortality, evidence for health and physiological stress, differential burial practices, burial phasing, and burial taphonomy. This study contributes to the overall research themes and wider project aims (Chapter 1).

The research questions addressed in this chapter include:

- What is the evidence for different mortuary practices at Bestansur?
- Is there evidence for social or demographic bias in burials?
- What were the possible effects of Neolithic lifestyles and environment on demography, health, and mortality?
- How can we situate the Bestansur evidence within broader regional contexts?

In order to address these questions, the major objectives of this study are:

- To investigate burial practices through analysis of burial context and taphonomy;
- To obtain demographic information including Minimum Number of Individuals (MNI), age estimation, and sex assessment through osteological analysis of the assemblage;
- To assess the health of the assemblage through the analysis of palaeopathology.

Methods

We excavated and recorded the human remains following the methodological approaches and standards of Mitchell and Brickley (2017) and Baker *et al.* (2005; Fig. 19.1). These field excavation procedures were adapted for Bestansur due to the complexity of burial stratigraphy and bone deposits. Procedures included a workflow of the stages of recording human remains, as our approach needed to account for different types of deposits including single burials, large disarticulated deposits, and wide scatters of smaller skeletal elements. Locating burial cuts was extremely difficult, as visibility of sediment differences was highly challenging due to temperature and moisture fluctuations, which caused fast drying of the deposits. Contexts were numbered according to project standards (Chapter 2), with skeletons being assigned SK numbers where multiple individuals were visible within a single deposit.

The human remains were located in 3-D using a combination of plans, total station, standard photography, and photogrammetry. Additionally, we created a skeletal recording sheet to describe the variations in bone deposits in line with the project standards. We excavated and recorded the remains in 'spits' or small layers with measurements and notable diagnostic information recorded prior to lifting due to the severity of fragmentation on lifting of the remains. We carried out 100% sampling of sediment for wet-screening and flotation from the skeletal contexts to be certain of retrieving all skeletal material including perinatal remains and associated grave goods such as beads where present.

The human remains from the 2014–2017 field seasons which were analysed for this phase of research form a minimum of 67 individuals, 65 of which are from Building 5. Further burials are present in the interface between Building 5 and the underlying Building 8 and will be the subject of future research. The minimum number of individuals (MNI) was calculated by analysis of the duplication of identifiable elements and age-related differences (size, development and morphology and attrition) within each burial context when relevant (Mitchell and Brickley 2017). The estimation of adult stature was carried out using the formulae of Trotter (1970) where there was survival of complete long bones, with preference given to the femur. This method was used due to the lack of formulae based on populations that are more comparable. Sex was assessed primarily by analysis of cranial and pelvic features, in conjunction with general morphology, robusticity and size and metric analysis where possible (Buikstra and Ubelaker 1994).

Most osteological age estimation techniques are based on population specific seriation of development or attrition of specific features, which means that any results should be viewed with the caveat of potential error margins due to population specific variation. The features examined to estimate adult age-at-death include the pubic symphysis, auricular surface, cranial sutures and dental wear (Buikstra and Ubelaker 1994). Due to poor preservation, most adult age estimates were obtained using dental wear (Lovejoy 1985) and cranial suture closure in adults (Meindl and Lovejoy 1985). Age-at-death of juveniles was assessed by examination of morphological development, ossification, metrical analysis of the bones, as well as dental development and eruption. Due to poor preservation, most juvenile age estimations were obtained from dental and bone development (AlQahtani *et al.* 2010; Liversedge *et al.* 2010; Cunningham *et al.* 2016). Age groupings within the study reflect these most commonly used methods. Juveniles in this study are defined from peri-nate to 18 years of age, using the completion of long bone growth and completion of most of the permanent dentition, excluding the third molar (Cunningham *et al.* 2016, 474).

Age-at-death estimation should be treated as a reflection of biological age rather than an exact modern chronological age. Biases in skeletal ageing methods mean that estimations become increasingly inaccurate with older individuals and give a false view of the age ranges of past populations (Chamberlain 2006: 11; Appleby 2011: 232).

Evidence of skeletal and dental pathological lesions was recorded by location, description, photography and radiographs when possible. Differential diagnosis was then carried out (Hillson 1996; Aufderheide and Rodríguez-Martin 1998; Ortner 2003; Ogden 2007; Waldron 2009) with reference to age and sex data to give the most likely diagnosis. Dental wear planes (angle of wear) and occlusal wear type were recorded following the methodology of Molnar (1971).

Analysis of taphonomic alterations is in the early stages so is briefly summarised in this chapter, but includes weathering (Behrensmeyer 1978; Junod and Pokines 2014), carnivore activity (Pokines 2014), invertebrate activity (Dirks *et al*. 2015) and, fracture patterns (Outram *et al*. 2005; Symes *et al*. 2014). This analysis aims to increase our understanding of burial history and the different pre and post depositional alterations to the assemblage.

Results of the contextual analysis: mortuary practices and taphonomy at Bestansur

During the Early Neolithic of Southwest Asia, mortuary practices commonly included both primary and secondary activities, including skull removal and burial, burial of post-crania and burial of disarticulated bones (Kuijt 2000; Croucher 2012). Through the analysis of bone taphonomy and the context of the human remains, this section evaluates the evidence for the different burial practices at Bestansur. A primary burial is defined as a deposition of an individual not long after death which is then left undisturbed and not relocated (Bello and Andrews 2006; Knüsel 2014). Secondary burial is defined as any mortuary behaviour that involves a multiple stage process and includes any form of defleshing of the corpse via natural or human agencies, such as cremation, exposure and burial (Roksandić 2002; Redfern 2008). Post-mortem alterations may include cut-marks, removal of certain bones to be placed elsewhere, curation, decoration (such as plastered skulls) and other manipulation of human remains. Most of the burial deposits from Bestansur contain human remains in various states of disarticulation, including near complete flexed burials, spreads of disarticulated bones, and scatters of small bones and teeth (Fig. 19.2).

Mortuary practices appear to have been complex and multi-staged with the largest deposits placed within Building 5, Space 50 in Trench 10 (Fig. 19.3). The majority of the 67 individuals were disarticulated (81%) while 11 individuals were buried in a primary flexed position, nine of which were juveniles (Table 19.1). The burial deposits in Sp50 are associated with

Table 19.1. Number of adult and juvenile primary and secondary burials within T7 and T10.

Burial type	*Adult*	*Juvenile*	*Total*
Primary	2	9	11
Secondary	15	39	54
Not possible to identify	0	2	2
Total	17	50	67

Figure 19.2. A deposit of disarticulated human remains at Bestansur, C1754=C1774 Sp50 Building 5. Looking west, scale = 15cm.

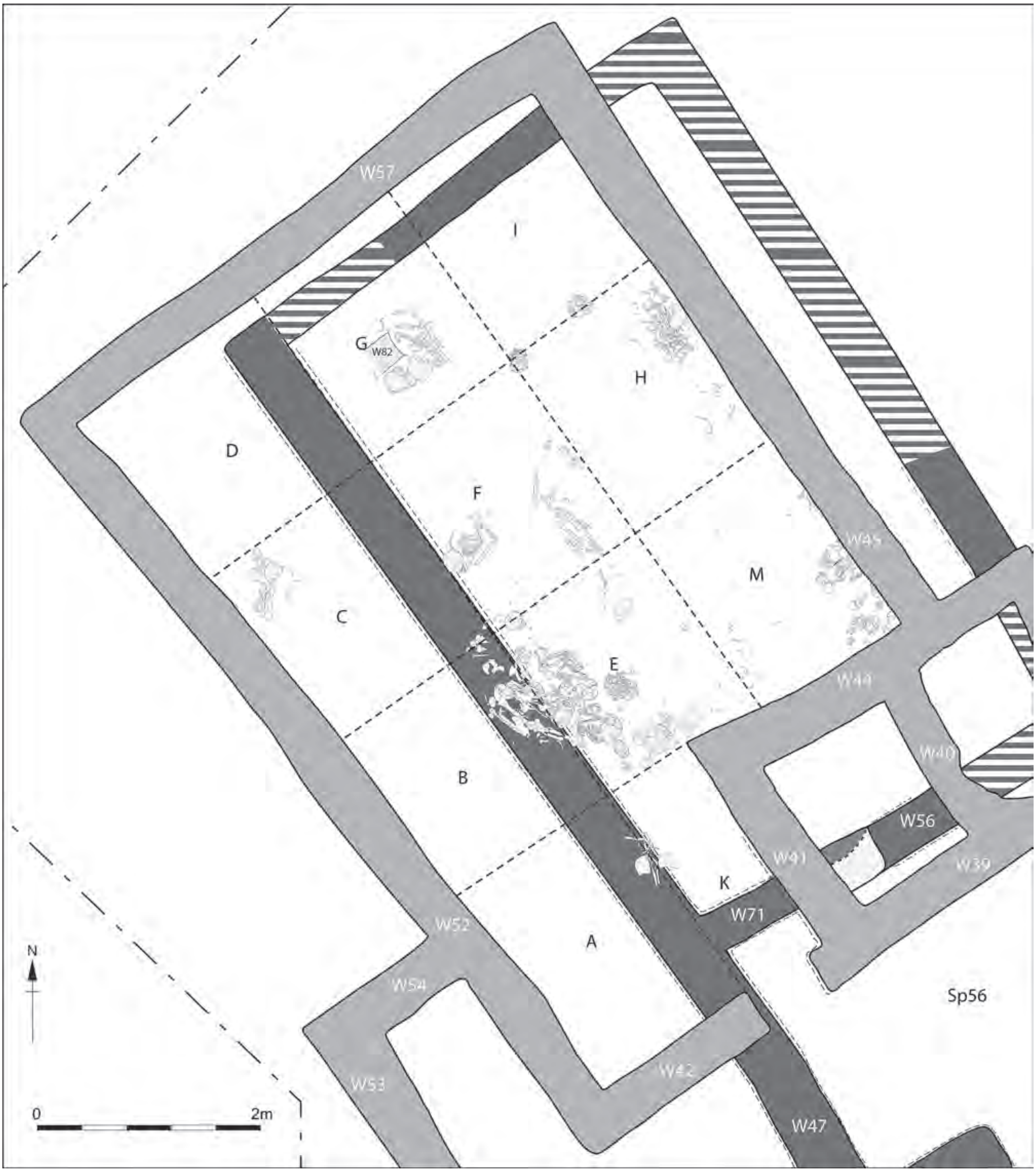


Figure 19.3. Plan of T10 B5 Sp50 to show location of major human burial groups.

three broad phases of activity which to some extent are stratigraphically defined through excavation. The earliest remains, Phase 1, form the densest area of burials, including both articulated and disarticulated adults and juveniles in sub-floor packing and the walls of Building 8 which underlies and pre-dates Building 5.

This phase is succeeded by disarticulated and scattered remains on surfaces and in fill during Phase 2. Finally, in Phase 3 a single adult burial and scattered remains are associated with the upper fill or closure of Building 5. Burial cuts were extremely difficult to see and were only visible for some contexts. Some of the human remains appear to have been deposited as discrete bundles within packing layers or left as scattered remains on floor surfaces. Others appear to have been cut into packing, and in some cases evidently periodically through the thin floors plasters (Chapter 12 Fig. 12.31), as part of larger deposits containing multiple individuals.

Bone preservation and summary of taphonomy

The taphonomy of human remains may be defined as the processes of events occurring from death onwards as the body breaks down, some of which leave signs on the skeleton (Beary and Lyman 2012). The following section summarises bone preservation and the current analysis of taphonomic alterations. Further detailed analysis of the taphonomy of the human remains is ongoing and these early results are summarised here to provide further contextual information on the assemblage and preservational issues relating to burials. In order to understand, identify and interpret burial practices, taphonomy and contextual analyses are crucial when differentiating between natural and human alterations to burials. The processes of decomposition and the context in which the bones are found are highly important for the interpretation of deposit formation.

Bone preservation is moderate to poor across the site; all of the human remains are affected by taphonomic alterations predominantly caused by non-human agents such as soil pressure, root activity, hydrology and temperature and moisture fluctuations. Forms of diagenesis, such as microbial degradation or mineral changes, also affect the integrity of the bone structure (Nielsen-Marsh *et al.* 2000; Kendall *et al.* 2018). Thin-section micromorphology analysis shows increasing evidence of bone mineralisation higher up in the stratigraphic sequence (Chapter 12) while preservation of the remains improves within the lower layers. Human remains closer to the topsoil also show evidence of disturbance from plough activity.

Taphonomic indicators of secondary burial can include disarticulation, cut-marks, fracture patterns (Villa and Maheiu 1991; Knüsel 2005; Outram *et al.* 2005), evidence of scavenging by canids or rodents (Carr and Knüsel 1997: 169; Smith 2006), weathering (Behrensmeyer 1978) and loss of small skeletal elements (Janaway 1997: 69). Alternatively, a group of bones which only contains small bones and teeth can also be indicative of an area of primary deposition of processing of bodies where larger elements have been removed for secondary burial (Bello and Andrews 2006). Small amounts of scattered bone fragments and teeth were found in Sp50 B5 and were also recovered from deposits in different areas across the site (Table 19.2). Scavengers, such as canids and rodents, and invertebrates, such as beetle larvae or molluscs, leave distinctive marks on bones. These marks have not been identified within the assemblage so far which suggests that bodies were not left out in the open (Dirks *et al.* 2015). There is currently no evidence of cut-marks on any human bones at Bestansur such as have been found on human remains at sites including Abu Hureyra (Molleson 2000), Kfar HaHoresh (Simmons *et al.* 2007: 17) and at Tell Qaramel, northern Syria, where there is evidence that stone tools were used for post-mortem decapitation prior to burial (Kanjou *et al.* 2013).

Most bones at Bestansur have suffered significant post-mortem breakage from soil loading which increased on lifting. Limited evidence for post-mortem dry fractures relating to burial practices have been found, examples of which can be seen on skull fragments from C1625, and on long bones including femur and humerus fragments from C1868/C1871. Some burial deposits within Sp50 were more poorly preserved which could be indicative of damage from later burial cuts and related disturbance. For example, bones from some deposits are so compacted they formed a solid mass of bones which are difficult to separate or distinguish, as was apparent in burial deposit C1880 (Fig. 19.4).

It is not always easy to establish whether a burial is primary or secondary, and burials from the wider region during the Early Neolithic can be complex and varied, not fitting neatly into these burial descriptions. For example, nine of ten burials at Körtik Tepe were defined as primary but had cut-marks interpreted as evidence for defleshing (Erdal 2015). A similar process is hypothesised at Çatalhöyük (Pilloud *et al.* 2016) where many burials are described as 'highly flexed' with suggestions of binding or wrapping of the bodies and skull removal, although 80% of burials at Çatalhöyük are classed as primary (Boz and Hager 2014).

The evidence for different burial types at Bestansur is in multiple forms, which may overlap across the categories here:

- Primary burials – fully articulated complete skeletons
    - o In some cases, extreme flexion may indicate wrapping and curation
- Secondary burials – these bone deposits occur in different forms in layers or fills of features including:
    - o Partially disarticulated skeletal remains
    - o Fully disarticulated and at times compact bone deposits
    - o Scatters of small bones, teeth, and fragments
    - o Possible curation and wrapping.

Because these burials are difficult to classify as purely primary or secondary, and there is overlap in these mortuary practices, the burial evidence is discussed here using examples that demonstrate the different stages of articulation and disarticulation at Bestansur.

Eleven individuals from trenches T7 and T10 appear to be primary burial deposits, as they were fully

Figure 19.4. Burial deposit C1880 showing compact bones, Sp50 Building 5. Looking south, scale = 25cm.

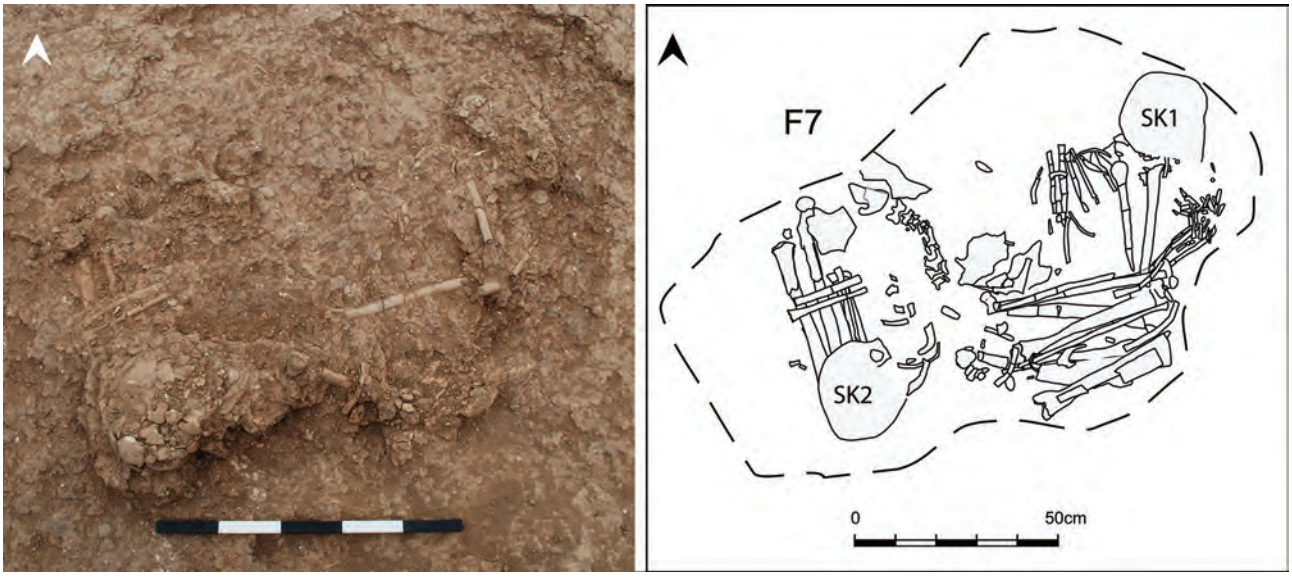


Figure 19.5. Trench 7 burials, C1228 SK1 and SK2. Looking north, scale = 50cm.

articulated *in situ*. Primary burials at Bestansur were made as single or double interments and also occurred within larger disarticulated deposits. One example is a burial of two articulated individuals (C1228) a mature adult male, and an adolescent probable female in T7 (Fig. 19.5). These two individuals were placed in a flexed position, both on the left side; they were positioned closely facing each other's feet.

The only adult primary burial in T10 is from the latest stage of burial activity in Sp50. This individual (C1714) had extremely poor preservation due to its proximity to the surface and had also been disturbed

Figure 19.6. C1731 and cowrie shells SF468 and SF470, Sp50 Building 5. Looking south, scales = 15cm and 25cm.

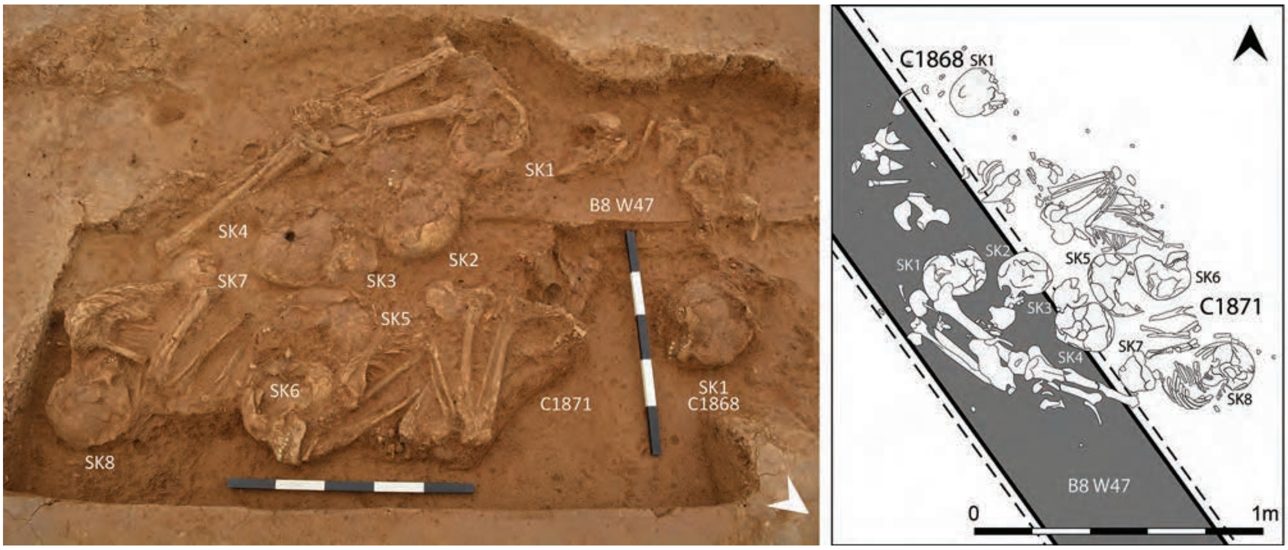


Figure 19.7. Large burial deposit C1784, C1868, C1871, Sp50 Building 5. Looking southwest, scales = 50cm.

by Iron Age pits but appeared to have been in a flexed position. Other examples of possible primary burials within Sp50 T10 include a double burial, C1631, of two juvenile individuals aged 4–5 and 6–8 years. These individuals appear to have been articulated but were very poorly preserved. Within the juvenile burial area, one articulated individual aged 4–5 years from C1804 was deposited in a flexed position on the right side but had infant skulls around and overlying it. As part of a larger deposit, the complete skeletons of two juveniles C1868 SK6 and SK8 were buried as later interments overlying disarticulated remains. Burial C1863, an adolescent, within Sp50 was placed in a flexed position on the right side but the bones were so tightly compacted it seems likely that this burial was wrapped, possibly with some decomposition occurring before final burial. This example demonstrates the difficulties in classifying burials as primary or secondary. Slightly to the north of C1631 was C1731, a very compact deposit of bone (Fig. 19.6). The majority of the bones from this deposit are the remains of a partly articulated child aged 5–8 years. Interestingly, an adult carpal bone within the deposit lay on top of the child skull. The extreme compacted nature of these remains may indicate a delay in burial, and/or wrapping in some organic material prior to deposition into the sub-floor packing. It is unclear whether this burial was primary or secondary due to the inclusion of bones from other individuals.

Skull burials have been found at many sites in the WFC including Jericho, Tell Qaramel and Kfar HaHoresh (Kanjou *et al*. 2013), although skulls with evidence of plastering or modification are more often discussed (Meiklejohn *et al*. 1992; Bonogofsky 2005; Fletcher *et al.* 2008; Slon *et al*. 2014). At Bestansur only one disarticulated cranium was not associated with any other bones, that of a young adult male from C1625. This deposit was sequentially in the latest phase of packing in Sp50. Other deposits contain disarticulated crania associated with long bones. As yet there is no evidence at Bestansur for cranial modification.

Partially disarticulated remains at Bestansur include a young adult female (C1784). From this individual there was an extremely flexed articulated leg, including the os coxa, femur, and tibia indicating some connective tissue may have remained at the last time these remains were moved. Other disarticulated bones from this individual were placed in a curved arrangement of ribs and upper limb bones with the skull on top. This individual forms part of a larger deposit (C1784, C1868, C1871) in the central part of Sp50 (Fig. 19.7).

There were eight disarticulated crania and skulls overlying disarticulated ribs, vertebrae, and long bones, depositionally succeeded by two fully articulated juvenile skeletons (discussed above). The disarticulated and partly disarticulated remains in this deposit appear to have been pushed aside for the later interment of fully articulated individuals. This deposit was formed through a process of successive interment, where a body is placed whole and as the flesh decays, it is moved aside for the interment of later whole bodies. This scenario would explain both the jumbled appearance of some bones and the occasional remaining articulations of others.

Excavation in the area against Wall 45 in Sp50 revealed a disarticulated adult skull and numerous other long bones that were highly compacted and co-mingled (C1810). Some of the bones were partially coated in a plaster-like substance and some had areas of red pigment either directly on the bones or surrounding them (Fig. 19.8). These bones appear to have been completely defleshed and disarticulated prior to abandonment, as there is little to no sediment between the bones.

The completely disarticulated remains of an older adult female outside of Wall 47, Building 8 were placed in a pit and red ochre was associated with the cranium, mandible and thoracic bones.

An area of juvenile burials is situated between the southeast corner of Building 5 and the underlying Wall 47 of Building 8. The later burials from this area (C1631, C1783) are predominantly primary and articulated, with some of these individuals positioned facing the entrance to Sp50. Beneath these articulated juveniles, there was a deposit of numerous young juvenile remains including 17 crania and predominantly disarticulated bones with an MNI of 21 individuals (C1804, C1812, C1861) (Fig. 19.9). Some individuals in this area were also associated with red ochre or beads of shell or carnelian (Chapter 21).

Within Phase 2 of the burials in Sp50 human remains deposits are usually small bone fragments and teeth. Small skeletal elements and fragments were scattered on a floor level from contexts C1621 and C1775 and represent the remains of one infant and one adult. This deposit is also associated with the remains of a basket or matting on which lay an *in situ* adult cranial fragment. Survival of the woven reed mat or basket fragment suggests possible wrapping material or storage containers for curation of the human remains during extended burial practices. Context C1781 is a similar deposit within a layer beneath the floor and remains from this context include loose teeth and fragmented bones.

The lowest represented elements from these deposits are the crania and long bones, which is to be expected from remains left behind after defleshing and removal of the larger bones as part of secondary burial processes. The small bones of the hands and feet, and teeth tend to disarticulate from a body early in the process of skeletonisation and are most likely to be left behind (Table 19.2; Galloway *et al.* 1997; Roksandić 2002; Bello and Andrews 2006: 9). Context C1625/C1781 also contained high amounts of bones from the thorax, which includes the vertebrae and ribs. The disarticulation of vertebrae is one of the latest stages of decomposition (Roksandić 2002, 101).

One spread of adult bones from an adult individual

Table 19.2. Comparison of small element and fragment representation in Sp50.

Context	*Crania*	*Thorax*	*Limb*	*Hand*	*Foot*	*Teeth*
C1621/1775	14	22	10	21	7	50
C1625/1781	32	104	26	51	15	81
C1754/74	1	15	2	0	1	0

Figure 19.8. C1810 with red ochre, Sp50 Building 5. Looking east, scales = 5cm and 10cm.

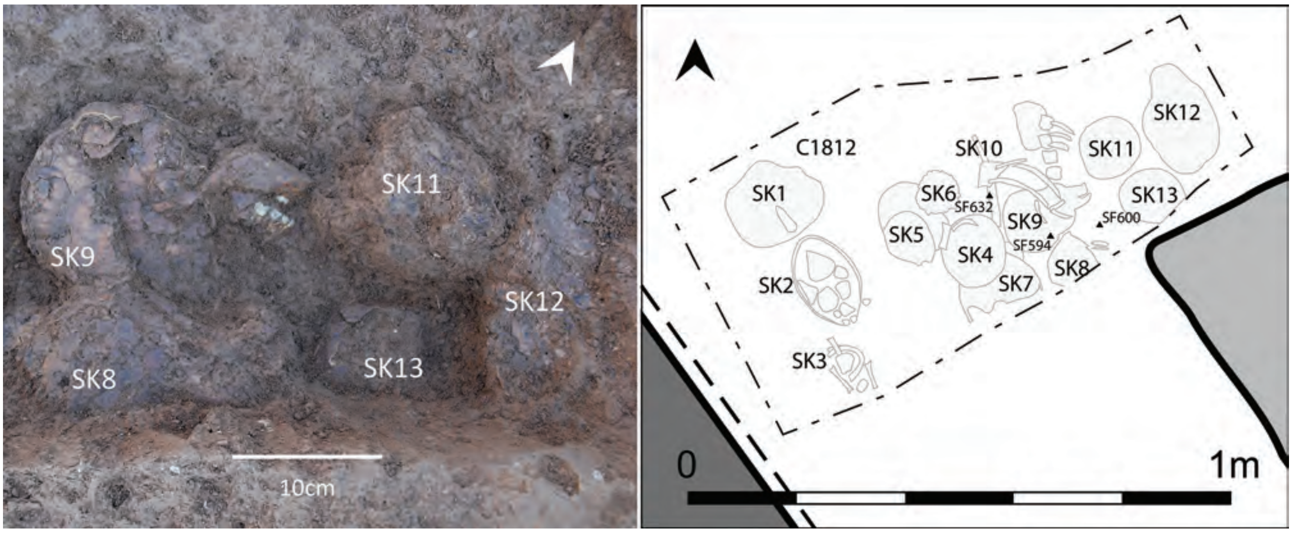


Figure 19.9. Area of infant remains from C1804, C1812, and C1861, Sp50 Building 5. Looking northwest, scale = 10cm.

(C1754) is predominantly composed of ribs and vertebrae. There are also two mostly intact long bones, one skull fragment and one complete pelvic bone. These bones appear to be from one possible female adult skeleton, which was disarticulated and scattered on a floor surface over an approximate area of 4m². Unlike the other contexts of scattered human remains, this deposit contained larger and more complete elements of the limb and pelvis. The way the bones are spread and the partial fragmentation to the limb bones suggests that this may have been a single individual part way through the defleshing and removal of some of the larger bones.

Small fragments of human remains were found in a fire installation, Sp48 adjacent to Sp50, comprising 14 bone fragments and five teeth. Three of the teeth have dark brown to black colouration, indicative of charring. Of the 14 bone fragments, 12 are from juvenile individuals. Two adult fragments of manual phalanx conjoin as part of one bone. All of these bone fragments have signs of charring or heat alteration with colouration. The colouration was either grey or dark brown, with partial alterations to surfaces probably indicating charring at a temperature range of around 200 to 500°C (Naji *et al*. 2014: 44). In interpreting the bone colour; extent of combustion, level of oxygen and position relating to the fire should also be considered. All these elements are small bones including phalanges, metatarsals, teeth, and infant vertebrae, ribs and long bones which could easily be left behind. It is possible in view of preserved matting/basketry evidence that these bones were attached to some form of burial wrappings which were being burnt in the fire installation (Chapter 12).

Mortuary practices and taphonomy: discussion

As discussed above, 54 of the 67 individuals from T7 and Sp50 T10 were in various states of disarticulation and demonstrate diverse practices and stages of interment of individuals and groups at Bestansur. Two key examples from Sp50 illustrate a level of human manipulation, where bones have been moved, or curated prior to being abandoned. The burials from C1868/C1871 demonstrate a sequence of successive interment, with completely disarticulated individuals pushed aside for the later interment of completely articulated individuals. Human remains in deposit C1810 were also in complete disarticulation with evidence of red ochre and plaster application to the bones. Furthermore, scatters of small bones and teeth within Sp50 and small bone fragments in other areas demonstrate areas where bodies were left to deflesh and disarticulate prior to the removal of larger bones for final burial.

At Bestansur most of the skeletal evidence for secondary burial comes from the disarticulated human remains in Building 5. Most of the human burial deposits at Bestansur appear to have been skeletonised as part of extended secondary burial processes within Building 5. Problematically, most studies of taphonomic change relating to skeletonisation through exposure are focussed on external environments affected by sun, temperature fluctuations and scavengers such a rodents, canids and certain birds, though none of these processes is evidenced within the Bestansur assemblage. Placing bodies to deflesh within a contained room, such as Building 5 Sp50, would limit these effects and may have been a way of controlling this process.

Currently there is no evidence for demographic bias or social differentiation between adult males and females in mortuary practices at Bestansur. Juveniles, however, were more often interred as primary burials (Table 19.1) representing 82% of the 11 primary burials, although this may be due to the greater number of juveniles within the assemblage currently. The clearest evidence of social differentiation in burial practices is the association of juveniles, aged from perinate to around 8 years old, with beads. These include beads made of small molluscs (*Theodoxus jordani*), red cylinder and red or white disc beads and also carnelian beads (Chapter 21). These beads are most often found in the area of young juveniles in the southeast corner of Sp50 throughout the sequence of burials in this area. For example, an infant aged 7–10 months (C1866) was associated with red stone, mollusc and cylindrical and disc beads (Chapters 9 and 21).

Results of the osteological analysis

Early Neolithic human remains at Bestansur were identified and excavated across the settlement, in trenches T4, T7, T9, T10 and T12/13. Small quantities of human bone were present in external areas in trenches T4, T9 and T10. An intact double adult burial was recorded in T7 and plough-disturbed remains in Sp26 T12/13. The largest deposits of human remains are from an internal area, Sp50 B5 T10, as discussed above.

In the following sections we discuss the results of the osteological analysis, first the demography of individuals from different areas from the site. This is then followed by detailed analysis of the palaeopathology including enamel hypoplasia, calculus, sub-periosteal bone formation, trauma, and joint degeneration.

Demography

In this section, we discuss the demographic results according to the different spaces and contexts in which the remains were found. A minimum number of 67 individuals were recovered from trenches T7 (n=2) and T10 (n=65). These individuals form the focus of the analysis and results presented in this chapter. This is one of the largest and most informative assemblages of human skeletal remains from the Early Neolithic period discovered in the EFC. Comparative assemblages from the region include six individuals at Sheikh-e Abad (Cole 2013), 116 at Ganj Dareh (Merrett 2004), eight at Jarmo (Braidwood 1983), five at Qermez Dere (Watkins *et al*. 1991) and 94 at Nemrik (Sołtysiak *et al.* 2015).

Trench 7

A single burial deposit, C1228, in T7 contained the skeletal remains of two individuals (Fig. 19.5). From the surviving morphology of the pelvis and cranium of SK1 this individual was an adolescent, probable

Table 19.3. Age distribution of individuals in Sp50 B5 T10, Bestansur.

Age	*Number*
< Neonate	10
1–12 months	6
1–2 y	8
3–5 y	8
6–12 y	7
13–18 y	5
19–30 y	5
31–40 y	3
41–50 y	3
50+ y	1
Adult non-specific*	4
Juvenile non-specific*	5
Total MNI	65

*There are nine individuals (4 adults, 4 juveniles) which could not be assigned a more specific age due to fragmentation or lack of age diagnostic elements.

Table 19.4. Number of adult males and females in Sp50 B5 T10, Bestansur.

Sex	*Number*
Male	2
Male?	3
Female	3
Female?	3
NP	5
Total	16

NP = not possible to identify

Table 19.5. Total minimum number of individuals from contexts in Space 50.

Context	*Adults*	*Juveniles*	*MNI*
C1604	1	1	2
C1621/1775	1	2	3
C1623	1	3	4
C1625/1781	1	3	4
C1626	0	2	2
C1631	0	2	2
C1714	1	0	1
C1731	1	3	4
C1780	0	2	2
C1754/1774	1	0	1
C1784/1868/1871	5	6	11
C1783/1804/1812/1861	0	21	21
C1788	1	0	1
C1789	1	0	1
C1810	1	2	3
C1862	1	0	1
C1863	0	1	1
C1866	0	1	1
Total	16	49	65

female. The proximal epiphysis was fused, with the line just visible, which is seen most commonly in modern samples aged 14–17 with fusion by around 17 years onwards (Cunningham *et al.* 2017). The dentition was well preserved and lacking in wear and had incompletely formed third molars (AlQahtani *et al.* 2010). This in addition to the stage of femoral fusion indicates that this individual was aged around 14–20 years at death. The second individual from this deposit, SK2, has a more robust skull which along with the morphology of the post-cranial remains indicates an adult male. This individual had ante-mortem tooth-loss of the mandibular teeth on the right side, followed by accelerated dental attrition of the left side potentially giving an older age than is accurate. With these caveats in mind and from analysis of the overall skeleton, SK2 was aged around 30–40 years at death.

Trench 10, Building 5, Space 50

Most of the human remains from Bestansur come from contexts within the large room Sp50 in B5. This assemblage has a minimum of 65 individuals (Table 19.3) with 75% of the assemblage in the juvenile age range. Of the 49 juvenile individuals, 24 are aged from 0-2 years representing 43% of the Sp50 assemblage. Of the 16 adult individuals, it was possible to assess the age-at-death of 12 individuals using dental wear (Lovejoy 1985). Five were aged 19–30, three were aged 31–40, three individuals were aged around 41–50, and lastly one individual was aged around 50+. These age brackets are formed from groupings of those from the dental wear method used (Lovejoy 1985) from which the majority of adult age estimations were obtained. It is possible to assess the sex of ten adults and one adolescent, which include two males, three probable males, three females and three probable females. This distribution results in an overall percentage of 31% male, 38% female, while the remaining 31% was not possible to assess (Table 19.4).

The high representation of infants could be due to a range of causes including traumatic birth, weaning problems, poor diet or infection (Kurek *et al.* 2016; Scott and Halcrow 2017). This pattern may also relate to chronology, selection of the burial place or burial rite.

The majority of deposits contained the fragmentary remains of one or more single burials or comingled adult or juvenile remains (Table 19.5). The largest deposit of human remains excavated so far is that represented by C1784=C1868=C1871 which contains the remains of 11 individuals of whom six were adults and five were juveniles. Aside from two fully articulated juveniles the other individuals in this deposit were represented mainly by skulls and long bones. Of the six adults, three were female, and three were male.

Table 19.6. Comparison of age from bone length and dental development.

Context	*Bone ID*	*Bone age+ (W)*	*Age (W*RF)*	*Dental age*	*Pathology*
C1623	Pars basilaris	38–40	34.87	0–4 months	SP
C1625	Ischium	34–36	NA	38–40 weeks	PH/CO
C1781*	Petrous portion	34–36	NA	4–7 months	Cortex resorption
C1812 SK13	Tibia	36–40	36.27	10–18 months	PH
C1812 SK3	Humerus	34–39	36.67	10–18 months	SP

+= Compared with modern samples, W = foetal weeks, W*RF= foetal weeks from regression formulae (Cunningham *et al.* 2016). C1781* is a context of mixed individuals.

Also significant is an area of purely juvenile burials (C1783, C1804, C1812 and C1861) which predominantly comprises skulls and co-mingled infant bones. Excavation of this area recovered 23 groups of bones with an MNI of 21 individuals. Of these, one is an older child aged around 5–7 years, two are aged from 3–5, and the remaining 18 individuals are aged from perinate to 2 years old. Fourteen of the 21 individuals are represented by crania alone, and the other seven are associated with some post-cranial elements.

A more detailed breakdown of juvenile age from individuals in Sp50 shows a minimum of ten individuals at neonatal age-at-death or younger. The number of older juveniles is fairly even with fewer individuals within the adolescent age group (Table 19.3). Five individuals are of juvenile age but it was not possible to obtain a more specific age estimation. Difficulties in ageing infant remains come from comingling of often poorly preserved and very small skeletal elements.

Merrett (2004: 228) compared femoral long bone development of the Ganj Dareh juveniles with those from historic and modern assemblages. This comparative approach indicated that the Ganj Dareh infants had shorter bone lengths for their age, but by 3 years of age they were within the same range as the modern comparative sample. Merrett also compared age estimates from long bone length to those obtained from cranial development and dental crown development, which demonstrated that age estimated from cranial and tooth crown development were consistently older than from bone length measurements (Merrett 2004: 199).

Due to the fragmentation of the Bestansur assemblage, only five infant individuals have both surviving bones and teeth for the comparison of age estimates using these techniques (Table 19.6). Both comparative dry bone measurements and regression formulae were used where possible (Fazekas and Kosa 1978; Scheuer *et al*. 1980; Cunningham *et al*. 2016). Analyses of the remains of these five individuals indicate an older age from dental development than estimated from bone size in three of these individuals. Estimates of juvenile age based on dentition are argued to be more accurate in relation to chronological age than skeletal age estimates, due to the greater range of external factors that affect skeletal development (Cardoso 2007; Cunningham *et al.* 2016). These differences in the skeletal and dental ages could indicate some interruptions to bone growth perhaps due to illness, low birth weight, or other factors including maternal health and deficiencies (Kinaston *et al.* 2009; Macintosh *et al.* 2016). All five of these individuals also have pathological alterations including sub-periosteal new bone formation (SP), porotic hyperostosis (PH), and resorption of the cortex, as discussed below in the section on pathology.

Trench 10 areas other than Space 50

In other areas of T10, small quantities of human remains were found, predominantly loose teeth and small bones of the hands and feet (Tables 19.7 and 19.8). Remains from both Sp48 and Sp29 have skeletal elements indicating the presence of multiple individuals. Sequential *in situ* burnt fuel deposits in a large fire installation (F18, Sp48) in the same building as Sp50, B5, contained human remains including loose teeth, adult hand bones and infant bones which showed evidence of burning as discussed in the previous section. It is possible that the human remains from Sp48 could relate to burial practices within Sp50 and the movement or curation of human remains at Bestansur more widely, and the burning of any wrappings, as the burnt phytoliths within Sp48 are predominantly from reeds and grasses (Chapters 12 and 13). Later external area deposits in Sp29, following the closure of Building 5, contained the remains of an adult vertebra and an infant humerus, in C1330. These remains may indicate continuity in association with burial practices in this area.

Human remains from other trenches at Bestansur

Single teeth and bones were also found in trenches T2, T4, T9 and T12/13 (Table 19.8). These single elements are small fragments, which may indicate the removal of other bones, or they may relate to larger deposits as part of the practice of secondary burial. Only one phalanx was excavated from deposits surrounding the plough-disturbed burial in T13.

Table 19.7. Numbers of fragments from Trench 10, other than Sp50, Bestansur.

Space	*No. fragments*	*Hand/foot*	*Tooth*	*Vertebrae*	*Other bone*	*Spatial type*
27	1	0	0	0	1	Packing, external
29	7	1	1	1	4	Packing, external
40	1	0	0	0	1	Floor, building
44	1	0	1	0	0	Packing, external
47	1	0	1	0	0	Packing, building
48	16	4	2	3	7	Fire installation, building
53	3	0	2	0	1	Occupation, external
Totals	30	5	7	4	14	

Table 19.8. Human remains from trenches T2, T4, T9 and T12/13, Bestansur.

Context	*Trench*	*Bone/tooth*	*Space*	*Internal/ external*	*Context description*
C1344	9	Lower right incisor 2	28	E	Occupation deposit
C1067	4	Upper right canine	6	E	Occupation deposit
C1037	2	Upper molar	–	E	Occupation surface
C1528	12	Infant cervical vertebra	–	E	Packing
C1492	13	Intermediate phalanx	26	I	Occupation, trample

Table 19.9. Number of adult and juvenile individuals at comparable sites in the region.

Site	*Adults*	*Juveniles*	*Reference*
Bestansur	17	50	Current study
Shanidar B1	8	31	Solecki *et al*. 2004
Jarmo	7	1	Braidwood 1983
Qermez Dere	2	3	Watkins *et al*. 1989; Molleson 1989
Nemrik	61	33	Sołtysiak *et al*. 2015
Ganj Dareh	65	51	Merrett 2004, 195
Sheikh-e Abad	5	1	Cole 2013
Abdul Hosein	7	5	Lorentz 2017
Abu Hureyra	50	52	Moore *et al*. 2000

Demography: discussion

How does the evidence of human demography at Bestansur correspond with evidence from other sites and regions from the Fertile Crescent? At Bestansur, 50 of the total current MNI of 67 individuals are juveniles aged from 0 to 18 years. Demographic evidence from other comparable sites indicates that the number of juveniles is usually less than the number of adults, although recorded sample sizes are often small (Table 19.9; Fig. 19.10).

The exceptions are Abu Hureyra where there are 52 juveniles to 50 adults (Moore *et al*. 2000), and at Shanidar B1 where there were 31 juveniles and eight adults (Solecki *et al*. 2004). At Nemrik 33 of the 93 individuals were juvenile (Sołtysiak *et al.* 2015), and at Ganj Dareh 51 of the 116 individuals were juveniles (Merrett 2004: 195).

At Bestansur, 43% of the aged individuals from Sp50 are aged below 2 years, of which 18% are neonates or younger. A number of other Early Neolithic sites have proportions of infants or young juveniles comparable to, or fewer in number than at Bestansur (Table 19.10). When looking at comparative published data, there are problems with a lack of consistency, as juvenile remains documented at comparable sites have little associated information and what information exists varies in quality and consistency. Data on infants and juveniles in general is often presented in categories that are too vague or varied for comparing data sets from different sites. For example, the youngest age group used to compare skeletal assemblages in Eshed *et al*. (2008) is 0–4 years and this is likely due to the primary literature used.

At Abu Hureyra, neonates represented 13 of the total 102 individuals (Molleson 2000). At Ganj Dareh, juveniles aged 0–1 years represented 18 of 116 individuals with another 12 individuals aged 1–3 years (Merrett 2004: 196). ʻAin Ghazal has a high number of 42 juveniles (33 of whom were aged 0-4 years) compared to 38 adults (Eshed *et al*. 2008). The demography of the Abu Hureyra assemblage is the most comparable with Bestansur in terms of the numbers of juveniles. Infant remains are a vulnerable age group, so can be an important indicator of population health.

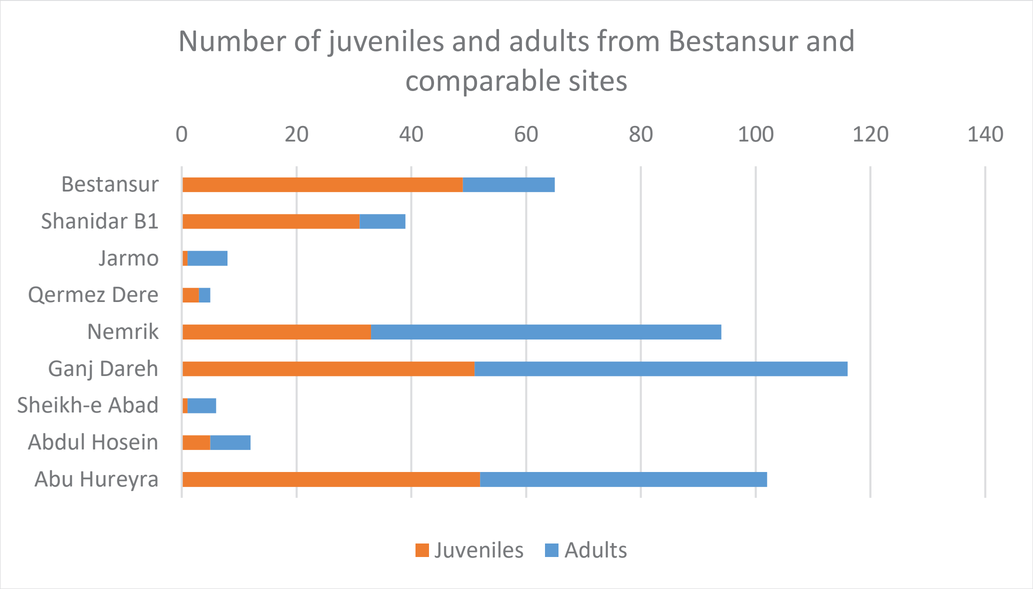


Figure 19.10. Number of juvenile and adult individuals from sites comparable with Bestansur.

Table 19.10. Numbers of known neonates and juveniles from comparative sites.

Site	*Neonates or younger*	*Total juveniles*	*MNI*	*Reference*	*Year excavated*
Bestansur	10	50	67	Current study	2012–present
Abu Hureyra	13	52	102	Molleson 2000	1972–1973
Ganj Dareh	11	51	116	Merrett 2004	1967–1974
Nemrik	3	33	93	Sołtysiak *et al*. 2015	1985–1989
Shanidar B1	2	16	31	Solecki *et al*. 2004	1951–1960
Abdul Hosein	3	5	12	Lorentz 2017	1978

Table 19.11. Available stature measurements from Bestansur.

Context	*Trench*	*Sex*	*Length (mm)*	*Height (cm)*	±
C1228 SK1	7	F	403	153.7	3.72
C1228 SK2	7	M	446	167.6	3.27
C1862	10	F	390	163.81	3.72

Table 19.12. Comparative statures of sites in the region.

Site	*Male height (cm)*	*N*	*Female height (cm)*	*N*	*Reference*
Bestansur	167.6	1	153.7–163.81	2	Current study
Sheikh-e Abad	162	1	0	0	Cole 2013
Ganj Dareh	162.3–177.3	6	162.3	1	Merrett 2004
Abu Hureyra 2	158–169.2	7	153.7–158.8	6	Moore *et al*. 2000
Catalhoyuk	166.1 (mean)	56	154.6 (mean)	57	Hillson *et al.* 2013, 370
Jericho	171 (mean)	23	158 (mean)	11	Smith *et al.* 1984
Zawi Chemi Shanidar	164	2	152	1	Rathbun 1984

Stature

Estimation of stature was obtained for three individuals from Bestansur, two from T7 and one individual from T10, using the maximum femur length or combined femur and tibia length (Table 19.11; Trotter 1970).

Estimated heights at Bestansur range from 153.7cm to 167.6cm, which falls within the range of data

Table 19.13. Number of crania, post-crania, and dentitions available for analysis.

	MNI	*Total dentitions*	*Total crania*	*Total post-crania*
T10	65	41	53	28
T7	2	2	2	2
Total	67	43	55	30

Table 19.14. Number of individuals affected by pathologies.

Type of pathology	*No. affected*	*Adults*	*Juveniles*
Linear enamel hypoplasia	11	8	3
Calculus	10	10	0
Caries	4	4	0
Periodontal disease	4	4	0
Abscess	1	1	0
Ante mortem loss	4	4	0
Sub-periosteal new bone formation	12	1	11
Cribra orbitalia	3	1	2
Porotic hyperostosis	6	3	3
Cranial thickening	6	6	0
Degenerative joint disease	3	3	0
Trauma	3	3	0

Table 19.15. Number of individuals and teeth affected by enamel hypoplasia.

Number	*Teeth*	*Individuals*
Number affected	43	11
From total	854	43
%	5	26

available from other sites, but is shorter than the range of height from Ganj Dareh or Jericho (Table 19.12). The stature of adults from Abu Hureyra (1.55–1.62m) is most comparable to the Bestansur individuals (Molleson 2000).

Palaeopathology and lifestyle at Bestansur

The Early Neolithic is argued to have led to reduced dietary variation and an increase in poor health from enclosed living and increased proximity to domesticated animals (Larsen 1995; Bocquet-Appel and Bar-Yosef 2008). What were the potential effects of Neolithic lifestyles and environment on health and mortality at Bestansur? How does the evidence from Bestansur relate to other pathological evidence in the EFC and the wider regional context? Current evidence of pathology from the Bestansur assemblage includes enamel hypoplasia, cribra orbitalia, porotic hyperostosis, sub-periosteal bone formation and low frequencies of joint degeneration and trauma. Pathological changes were observed in 24 of the 67 individuals from trenches T7 and T10, 18 of whom had multiple pathologies (Tables 19.13 and 19.14). Most of these pathological alterations are affecting infants aged from pre-natal to 2 years. Most frequently occurring pathological alterations include enamel hypoplasia, sub-periosteal bone formation and calculus. Palaeopathological assessment of the assemblage is challenging due to the high levels of fragmentation. Due to the incomplete status of most of the identified individuals, the total available skeletal material for palaeopathological analysis is less than the total MNI (Table 19.13) as not all individuals have surviving or articulated, teeth, crania or skulls, or post-crania.

Dental pathology

Evidence of dental pathology in the assemblage includes calculus, periodontal disease, enamel hypoplasia and low levels of carious lesions and abscess. Some dental pathologies can be linked. For example, calculus or attrition can reduce the structural integrity of teeth which can lead to caries and periodontal disease. This causes pathological alterations of the alveolar bone, which may progress to infection, abscess or tooth loss (Nelson 2016: 472). Other causes of ante-mortem tooth loss include trauma and scurvy (Geber and Murphy 2012). Some studies link high levels of dental calculus and caries with dependence on agricultural diets but these are from new world examples (Larsen 1995) and other factors such as carbohydrate type and fluoride availability should be considered (Hillson 1996: 279; Tayles *et al*. 2000; Humphrey *et al*. 2014).

Enamel hypoplasia occurs when there is interruption to development caused by systemic disruptions such as fever or malnutrition, or by local disturbance such as trauma (Hillson 2005; King *et al*. 2005; Hassett 2012). Enamel hypoplasia occurs in different forms: linear (or furrow), pitted, plane or cuspal (Ogden 2007: 287; Hillson 2014: 162). Enamel hypoplasia was observed on teeth from 11 individuals at Bestansur, affecting 5% of teeth out of 854 teeth (Tables 19.15 and 19.16; Fig. 19.11). Linear defects are most common, affecting 36 teeth. The anterior teeth are the most affected with both incisors and canines affected in similar numbers. The individuals with enamel hypoplasia include seven adults and four juveniles.

Two of these individuals had multiple defects over multiple teeth indicating systemic physiological stress at the time of tooth development. A child aged 5–8 years old from burial C1731 has repeated linear enamel hypoplasia (LEH) to the upper first permanent incisors with eight other teeth affected to a lesser degree. The age of formation of the permanent crowns gives a rough age span for these episodes of stress (Reid and Dean 2006). The defects on the dentition of this individual formed between the ages of 2.0–3.9 years. The adolescent individual aged around 12–15 years from burial C1863 had repeated LEH affecting six teeth: the upper first permanent incisors, the lower second permanent incisors and lower canines on both sides. Both upper canines were also affected with fainter LEH. This individual also had some discolouration defects and opacities (Rajshekar *et al.* 2016). The defects to the dentition of this individual formed between the ages of 2.0–4.0 years (Reid and Dean 2006). Possible causes of these hypoplastic defects include weaning, systemic disease and malnutrition (Hubbard *et al.* 2009: 177; Mann and Hunt 2013: 30). These defects form after an individual has recovered and growth resumes, so would not be visible if they had not recovered.

Figure 19.11. Photo of incisor with linear enamel hypoplasia, C1731.

Only four teeth from four different individuals show evidence of carious lesions, including single teeth with small lesions from separate individuals in C1784, C1789 and C1810. The only large carious lesion was on the right first maxillary molar of C1868 SK1, which may have developed from the occlusal surfaces (Fig. 19.12). Dental caries occur when the tooth enamel, dentine and cement are destroyed by the acid production from bacteria in dental plaque (Hillson 1996: 269; Waldron 2009: 237; Temple 2016). Dental defects such as hypoplasia or tooth wear affecting the integrity of the dental enamel increase the risk of caries (Halcrow *et al*. 2013). The low incidence of caries in the Bestansur population indicates that they were not eating highly cariogenic foods. Not all carbohydrate foods have the same level of cariogenicity, and this is affected by how intensively the foods are processed (Tayles *et al.* 2009).

Dental calculus forms from the mineralisation of plaque. Research has linked its cause to diet including high levels of protein and carbohydrates; more recently, however, calculus has been attributed to other factors such as mineral intake, rate of saliva flow, genetics, age, mechanical and morphological variation, and dental hygiene (Hardy *et al.* 2009; Radini *et al.* 2015; Warinner *et al.* 2015a).

A minimum of eight adult individuals had dental calculus, which in 91% cases was slight, with only two adults from contexts C1625 and C1788 with moderate levels (Tables 19.17 and 19.18; Fig. 19.13). Calculus was usually the sub-gingival type, formed around the cemento enamel junction (CEJ) and was most commonly on the incisor, likely because calculus formation is often greatest near the saliva ducts (White

Table 19.16. Number and type of teeth affected by enamel hypoplasia.

Individual	*Teeth affected*	*Linear*	*Pit*	*Repetitive*	*I*	*C*	*PM*	*M*
C1228 SK1	7	7	1	0	3	4	0	0
C1621 SK3	1	1	0	0	1	0	0	0
C1625 SK1	1	0	1	0	1	0	0	0
C1775* (Adult)	2	2	0	0	0	2	0	0
C1784	2	1	1	0	1	1	0	0
C1788	3	2	1	0	0	2	1	0
C1781* (Adult)	2	1	1	0	1	1	0	0
C1731 SK1	10	10	0	4	5	4	0	1
C1804 SK2	3	2	1	0	3	0	0	0
C1812 SK9	4	2	2	0	3	1	0	0
C1863	8	8	2	6	4	4	0	0
Total	43	36	10	10	22	19	1	1

*Contexts C1775 and C1781 contain multiple individuals.

1997). This type of calculus formation is inflammatory and potentially relates to dental hygiene and/or as part of an immune response to a pathogen such as *P. gingivalis* (Hillson 2005: 261; Crespo *et al.* 2017).

Periodontitis or gum disease is caused by bacteria in dental plaque (Nelson 2016: 472). This process also results in the destruction of the adjacent alveolar bone, which eventually results in tooth loss (Ogden 2007: 292). Periodontal disease is indicated on the skeleton by the recession of the alveolar margins which surround the teeth (Waldron 2009: 240).

Evidence of periodontal disease is observed in five individuals, all older adults: C1788, C1789, C1810,

Table 19.17. Number and percentage of individuals and teeth affected by calculus out of total.

Number of	*Teeth*	*Individuals*
Number affected	53	8
From total	854	43
%	6	19

Table 19.18. Number and type of teeth affected by dental calculus.

Individual	*Teeth affected*	*I*	*C*	*PM*	*M*
C1625	11	7	4	0	0
C1781*	8	7	0	0	1
C1784	4	4	0	0	0
C1788	12	6	1	2	3
C1789	3	2	1	0	0
C1775*	9	2	5	2	0
C1863	2	2	0	0	0
C1871	4	0	0	4	0
Total	53	30	11	8	4

*Contexts C1775 and C1781 contain multiple individuals.

Figure 19.12. Large carious lesion on upper first molar from 1868 (SK1) a young adult.

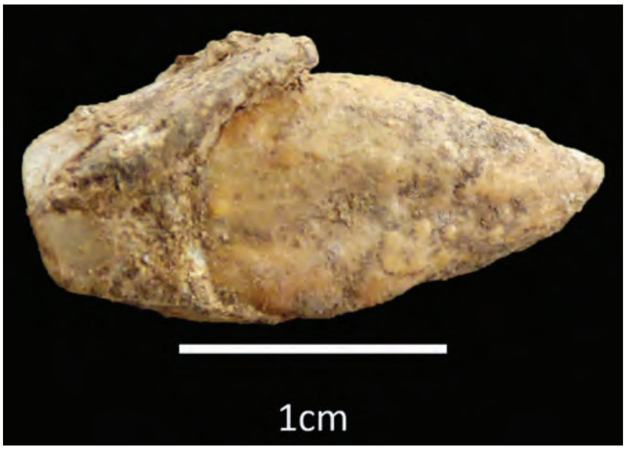


Figure 19.13. Example of dental calculus, C1788.

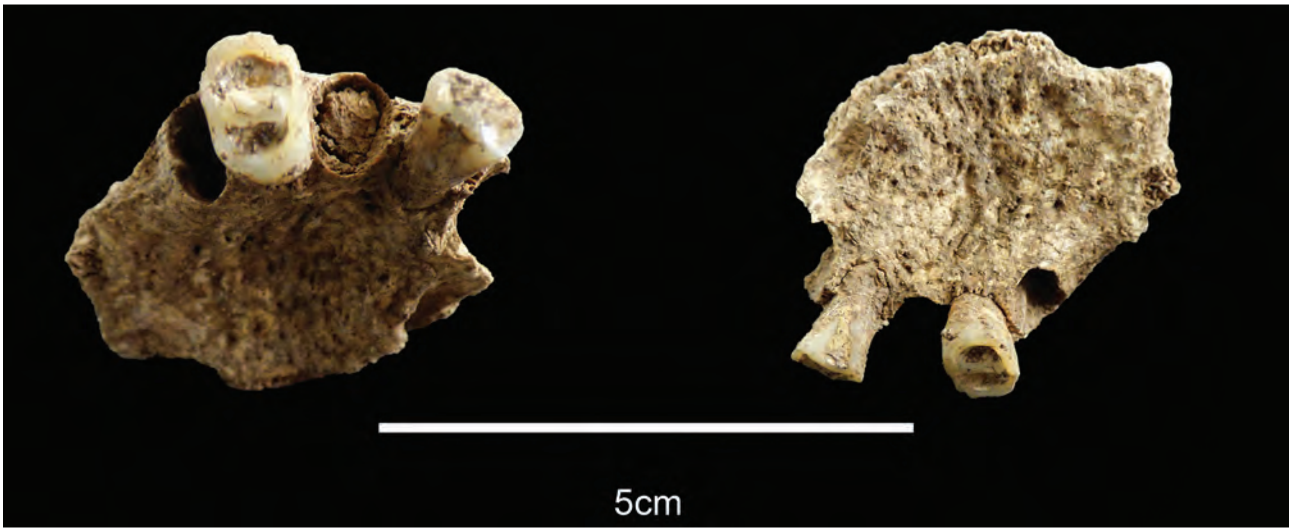


Figure 19.14. Periodontal disease and ante-mortem loss in the maxilla of C1789.

Figure 19.15. Images of partial mandible fragments from C1862, a) top left – from above shows areas of AM-loss and resorbtion, note ochre staining also; b) top right – shows anterior view of abscess and peri-apical space and sinus.

Table 19.19. Individuals with inner table lesions and associated pathologies.

Context/I.D.	*Age*	*Endocranial lesion*	*Other*
C1625/1781	Neonate	Exposure of trabeculae to sphenoid	0
C1621/1775	Neonate	Porosity of cranial fragments	0
C1788	20–30	SES to parietal bones	Thickened crania, PH, CO
C1789	30–40	Large arachnoid lesion to occipital	External lysis

C1862, and C1868 SK4 (Fig. 19.14). It is difficult to determine the extent of periodontal disease due to fragmentation of the bones and post-mortem tooth loss, but severity was slight to moderate except in individuals who also demonstrate ante-mortem tooth loss (Ogden 2007). Individuals affected by ante-mortem tooth loss include C1288 SK2, C1789, C1862, and C1868 SK4. In both C1862 and C1868 SK4 this loss was severe, with bone resorption, exposed tooth roots, extensive tooth loss and compensatory eruption of the remaining dentition. One of these individuals also has an example of a probable dental abscess. Most dental abscesses develop from peri-apical granuloma with the accumulation of pus. The pus usually drains through the bone of the mandible or maxilla resulting in a sinus (Hillson 1996: 287). The mandible from individual C1862 has partial bone resorbtion around the alveoli (Fig. 19.15). The same portion of mandible also has signs of peri-apical granuloma and healing around second premolar and first molar. The lesion underneath the middle of the mandible indicates where the infection has drained through the mandible in a sinus.

Skeletal palaeopathology

The most common part of the skeleton affected by pathology in both adults and juveniles is the cranium, with 16 out of the 24 individuals with skeletal pathologies showing pathological alterations only to the cranium. This pathology may be due to skeletal element representation, as some individuals are represented only by partial or complete skulls. The most common cranial pathologies are forms of cranial porosity and cranial thickening, with porotic hyperostosis being the most common specific pathological change (Table 19.14). There is limited evidence for pathology on the post-cranial bones. Most frequently observed is sub-periosteal new bone formation. Post-cranial pathology is difficult to assess due to fragmentation and co-mingling of the assemblage. It is very challenging to be sure if pathologically affected remains are representative of whole skeletons.

Non-specific infections

One area of pathology which is fairly commonly discussed in skeletal analysis is indicators of non-specific infections where a precise cause is not known. These include sub-periosteal new bone formation, osteomyelitis and endocranial lesions. Sub-periosteal new bone is bone which is formed beneath the periosteum which may be caused by trauma or infection (Ortner and Erickson 1997). Problematically, new bone formed by growth in young juveniles can mimic that formed due to infection, or malnutrition such as scurvy. Because of this, new bone deposits which are thin, diffuse and symmetrical need to be assessed with caution (Ortner 2003: 15; Lewis 2017: 131). Endocranial lesions can be related to illnesses which cause haemorrhage, inflammation, or

Table 19.20. Individuals with cranial sub-periosteal new bone formation.

Context/I.D.	*Age*	*Area affected*	*Other pathology*
C1623	Neonate	Pars basilaris	0
C1731	2–3 y	Pars basilaris	Porosity
C1731	5–8 y	Orbit, temporal	0
C1621/1775	Perinate	Cranial fragments	Porosity of inner table, SES
C1788	20–30 y	Frontal, parietal, and occipital bones	Thickened crania, SES
C1804 SK4	2–4 y	Parietal bone fragments	0
C1812 SK3	10–18 m	Parietal bone fragments	0
C1812 SK5	5–10 m	Cranial fragments	Extreme exposure of diploe, layering of lamellar bone on inner and outer tables, PH
C1861	Perinate	Orbital bone	0

Table 19.21. Individuals with post-cranial sub-periosteal new bone formation.

Context	*Age*	*Bone(s) affected*
C1621/1775	Neonate	Vertebrae, hand, foot
C1621/1775	4–5 y	Vertebrae, ribs, hand, foot
C1623	1–2 y	Long bones
C1861	Pre–natal	Manual phalanges
C1861	Perinate	Manual phalanges
C1866	7–10 m	Long bones, manual phalanges

infection of the meningeal arteries, which can include trauma, chronic meningitis, neoplasms, and vascular malformations (Lewis 2004; Coqueugniot *et al*. 2014; Janovic *et al.* 2015; Huang *et al.* 2017).

Endocranial lesions

Lesions on the inner cortex of the cranium are poorly understood and less often described in the literature. Specimens in the Bestansur assemblage have vascular lesions, expansion of the diploe and Serpens Endocrania Symmetrica (SES), which are irregular maze-like channels on the endocranial surface of the cranium that result from slow development of remodelled periostitic bone on the endocranial surface (Table 19.19; Fig. 19.16; Hershkovitz *et al.* 2002: 202). Aetiologies discussed by Lewis (2004) include chronic meningitis, trauma, anaemia, neoplasia, scurvy, rickets and tuberculosis.

Four individuals had lesions on the inner cortex of the cranium. One of these individuals (adult C1788) has maze-like defects which are SES. A study of twentieth century human remains from the Hamman-Todd osteological collection by Hershkovitz *et al.* (2002: 205) found that 25 of the 32 individuals with SES had tuberculosis listed as the cause of death, with other causes including pneumonia. An infant from Atlit Yam with SES was confirmed through molecular methods to have tuberculosis (Hershkovitz *et al.* 2008). While the exact cause of these lesions is difficult to pinpoint without further scientific analysis, SES is described as a non-specific indication of intra-thoracic inflammation but could also relate to other types of chronic infection such as non-specific meningitis (Hershkovitz *et al.* 2002; 2008). The other endocranial lesions in the assemblage from Bestansur include: non-specific porosity, a large arachnoid lesion, and exposure of the trabeculae or vascular lesions, the latter being a possible indicator of scurvy (Gerber and Murphy 2012).

Sub-periosteal new bone formation

Sub-periosteal new bone is formed as a new layer of bone due to inflammation of the overlying periosteum. Juveniles form porous bone during growth which is difficult to differentiate from pathological processes (Lewis 2004; Klaus 2017). In juveniles below four years of age normal growth causes deposition of disorganised bone on the cortex, this can mimic pathological processes such as infection, scurvy and rickets (Lewis 2017: 132). In addition, rapid growth and remodelling mean the periosteum is less well attached to the bone especially in the long bones which means haemorrhage can more easily occur (Ortner and Ericksen 1997). Eight juveniles and one adult at Bestansur have sub-periosteal new bone formation on the cranial bones (Table 19.20; Fig. 19.17).

Bones of the limbs from at least six infants have evidence of sub-periosteal new bone formation. Normal bone formation occurring as part of growth in young juveniles is usually bilateral and occurring on the long bones (Lewis 2017: 132), as outlined above. Most of the sub-periosteal bone formation on the Bestansur individuals is on vertebrae, bones of the hand and foot, with some ribs and long bones also affected (Table 19.21).

Sub-periosteal new bone formation may relate to non-specific infection, trauma, or tumours (Waldron 2009: 114; Lewis 2017: 131). Bone formation on the temporal area as seen in a child aged 5–8 years (C1731) could be an indication of possible vitamin C deficiency (Geber and Murphy 2012: 515). In four individuals, cranial sub-periosteal new bone formation co-occurs with other cranial or post-cranial lesions potentially relating to a deficiency disorder. The new bone formation and porosity to the pars basilaris from individuals C1623 and C1731 may also

Figure 19.16. Example of SES (Serpens Endocrania Symmetrica), C1812.

be indicative of scurvy (Moore and Koon 2017). In the other three individuals, the bone formation may be due to growth or localised trauma.

Indications of metabolic disease and haemopoietic disorders

Pathological changes to the skeleton which relate to metabolic or haemopoietic illnesses include cribra orbitalia, porotic hyperostosis, and thickening or thinning of the bone cortex. Both cribra orbitalia and porotic hyperostosis can be indicators of nutritional deficiencies, such as types of anaemia, in addition to infections and trauma (Goodman and Armelagos 1989). These lesions do not always co-occur and more recently are considered to have different aetiologies (Rivera and Lahr 2017). Porotic hyperostosis is argued to be linked to deficiencies including vitamins C or D, forms of genetic anaemia, or malaria (Walker *et al*. 2009; Rinaldo *et al*. 2019). Cribra orbitalia has been connected with forms of acquired and inherited anaemia, and infections which can be bacterial, viral, or parasitic (Rivera and Lahr 2017).

Figure 19.17. Example of sub-periosteal new bone formation, C1731.

Table 19.22. Individuals with CO and/or PH (SES= Serpens Endocrania Symmetrica), y= years, m= months.

Context/ID	*Age*	*PH*	*CO*	*Other pathology*
C1228 SK2	30–40+ y	Mild, healed	0	Outer cortex expanded
C1604	Adult	Mild, healed	0	Outer cortex and diploë expanded
C1788	20–30 y	Healed	Unhealed	Diploë expanded, SES
C1812 SK5	5–10 m	Unhealed	0	SES, sub-periostitic bone
C1812 SK13	10–18 m	Healed	0	0
C1861	Infant	0	Healed	Sub-periostitic bone

Table 19.23. Individuals with thickening of different cranial structures.

Context/I.D.	*Age*	*Area expanded*	*Other pathology*
C1228 SK2	30–40+ y	Outer table, decrease in some areas	PH
C1604	Adult	Outer table, diploë	PH
C1788	20–30 y	Diploë	PH, SES
C1789	30–40 y	Outer and inner tables and diploë	Lytic lesion
C1868 SK4	Older Adult	Outer table	Porosity
C1871 SK2	Young Adult	Outer table, diploë	0

Porotic hyperostosis and Cribra orbitalia

Porotic hyperostosis (PH) is characterised by porosity and pitting on the external surface of the cranial vault. Cribra orbitalia (CO) is similar in appearance but affects the orbital roofs (Walker *et al.* 2009: 109). These lesions result from the expansion of the diploë which occurs due to the formation of larger cells and/or an increase in the number of cells. In addition, these processes may cause irregular remodelling and resorption of the outer cortex over time so that the structure of the diploëic bone becomes visible as the cortex is resorbed (Rinaldo *et al.* 2019). A total of six individuals at Bestansur are affected by CO and PH; five individuals have porotic hyperostosis, two individuals have cribra orbitalia, and one of these individuals has both CO and PH (Table 19.22). Of these individuals, five also show other pathological alterations including expansion of the diploë or thickening of the cortex.

The orbital roofs of C1788 have crescent-shaped areas of where the trabeculae/diploëic bone is visible due to resorption of the cortex (Fig. 19.18). This individual also had Serpens Endocrania Symmetrica (see below for more details) and sub-periostitic bone formation, perhaps indicating multiple health issues. At least two juvenile individuals from C1812 had pathological alterations to the cranium: fragments showed porosity, exposure of the diploë and resorption of the cortex (Fig. 19.19).

In addition to the porotic lesions discussed, disorders such as haemolytic anaemias, which may be caused by infections, can cause bone marrow expansion leading to thickening of the cranium (Table 19.23; Waldron 2009: 136; Walker *et al* 2009: 110).

One example is an adult (C1228 SK2) from T7 with thickening of the outer table and in places the almost complete obliteration of the diploë due to expansion of the cortex. Cranial fragments from contexts C1604 and C1871 SK2, in B5 Sp50, show thickening of the external cortex and the diploë. A cranium from C1788 shows expansion of the diploë only, while the adjacent cranium from C1789 had expansion of both the inner and outer cortex in addition to the diploë. Most cases of cranial thickening within the assemblage are due to expansion of the diploë. In three individuals this thickening co-occurs with CO/PH making these cases more likely to be caused by a form of anaemia or other hematopoietic disorder.

Different types of anaemia can be genetic or acquired through poor health or environmental causes (Ortner 2003: 370). Walker *et al.* (2009) argue that not all anaemias cause the hypertrophic expansion of the diploë seen in porotic hyperostosis. For example, iron deficiency anaemia decreases mature blood cell production so should not lead to bone expansion, while by contrast megaloblastic and haemolytic anaemias can cause hypertrophy of the diploë as seen in examples in Table 19.23. Megaloblastic anaemias may be caused by chronic dietary deficiencies and malabsorption of nutrients through other problems such as gastrointestinal parasites. There are many types of haemolytic anaemia, one example being thalassaemia which is hereditary (Walker *et al.* 2009: 112). In radiological studies of thalassaemia, there is expansion of the diploë with reduction of the outer table and thickening of the inner table (Tyler *et al.* 2006) which is consistent with the pathological changes seen in an adult individual from C1228.

Table 19.24. Bones affected by joint degeneration (C= cervical, T=thoracic).

Context	*Joints affected*	*No.*	*Description*
C1625	Manual phalanges	5	Porosity of joint surfaces, extra bone formation
C1810	T-vertebra centra (2)	2	Osteophytosis, porosity to surface
C1784	C-vertebra, T-vertebra, manual phalanges, occipital condyle	6	Porosity, expansion, eburnation, osteophytosis
C1604	Dens of axis	1	Lipping of joint

Joint degeneration

There is very little evidence for joint disease in the assemblage, probably due to the poor survival of articular surfaces. The joints of the skeletal system deteriorate over the life-course due to various factors including genetics, activities and trauma. These pathologies are reflected in either increased bone formation or bone destruction which affects the health and flexibility of the joints. At least four adult individuals at Bestansur have changes to the joint surfaces (Table 19.24), but as these remains are all from disarticulated and co-mingled deposits it is not possible to assign them to a specific age, as it is not possible to establish with certainty whether they belong to specific aged individuals from these deposits.

A small amount of joint alterations can be seen on adult hand bones from C1625 (Fig. 19.20). One proximal phalanx has porosity on the distal articular surface, and four distal manual phalanges have extra bone formation at the distal ends and marginal osteophytes to the joint surfaces. A number of joint alterations were found on bones from C1784, including porosity and eburnation of an occipital condyle, porosity and osteophytosis of the cervical vertebrae, and porosity of the proximal articular surfaces of the distal manual phalanges. Osteophytes are a normal feature of joint remodelling and the aging process (Burt *et al.* 2013: 7). The interphalangeal joints of the hand are commonly affected by osteoarthritis in clinical studies (Dieppe 2008). Osteoarthritis is a degenerative condition of the joints, which leads to porosity, eburnation (an area of polished appearance)

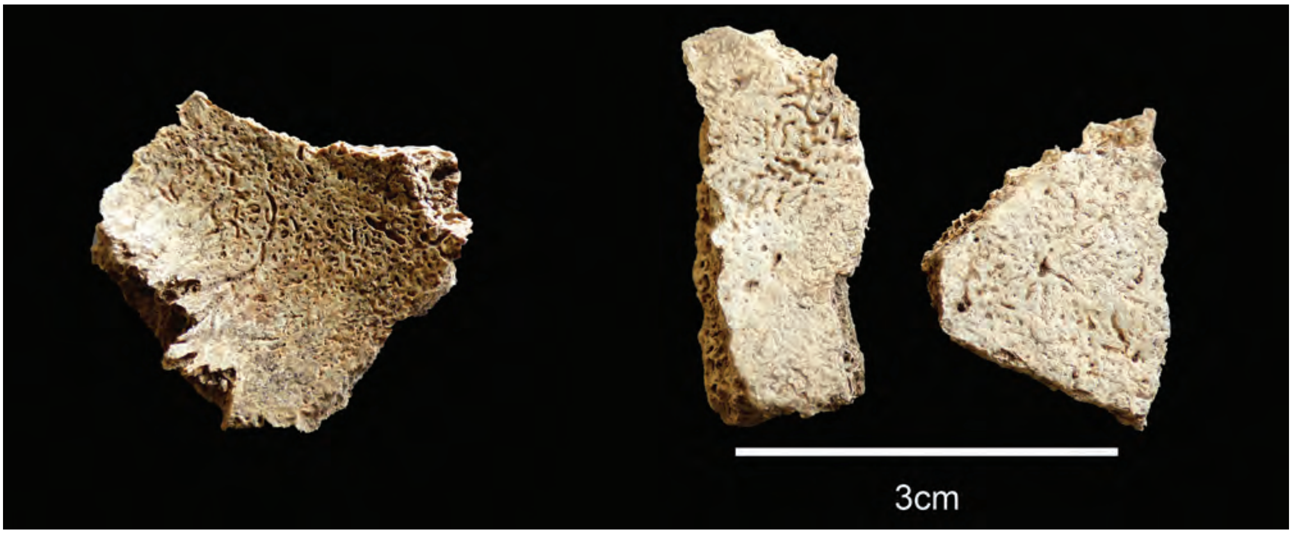


Figure 19.18. Left: partial supra orbital bone with CO; right: cranial fragments with endocranial lesion likely SES (both C1788).

Figure 19.19. Cranial fragments from C1812 SK5 with porotic hyperostosis.

Figure 19.20. Hand bones from adult individual C1625 showing osteophytes.

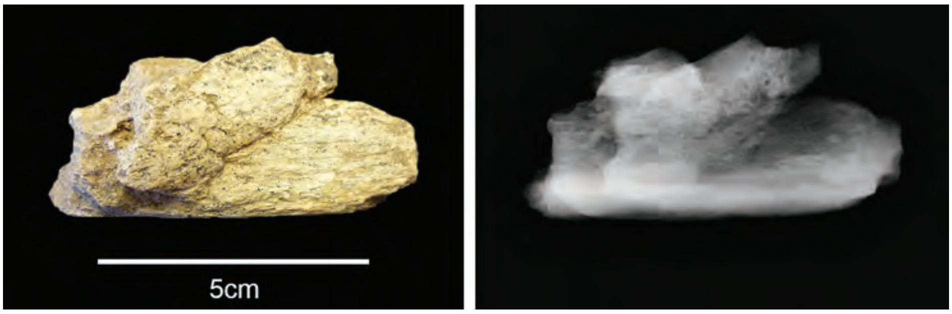


Figure 19.21. X-ray image of fused tibia and fibula C1714.

and osteophytes (Jurmain 1999). Eburnation is regarded as pathognomic to osteoarthritis (Rogers and Waldron 1995). These alterations may indicate mild osteoarthritis or activity related changes, with the remains from C1784 being the clearest example of likely osteoarthritis within the assemblage.

Trauma

There are three specimens within the Bestansur assemblage with indications of trauma: a lower leg fracture, a distal pedal phalanx fracture and one individual with possible cranial blunt force trauma.

A specimen from C1714 comprises two fused fragments of a tibia and fibula which are comprised of the distal third of these bones. Macroscopically, extra bone formation can be seen fusing these elements and x-ray analysis shows no visible space between them (Fig. 19.21). These alterations appear to have been caused by a healed fracture. The type of fracture is difficult to ascertain due to the taphonomic alterations and the incomplete nature of the specimen. The end portions of the fibula are not visible to demonstrate the shape of the fracture margin (for example, transverse or spiral). Fracture types discussed by Waldron (2009: 139; Wedel and Galloway 2013: 63) which could apply include transverse (where the fracture is at right angles to the long axis of the bones), and oblique (fracture at oblique angle to the long axis). A type of fracture which occurs in this portion of the lower leg is a Pott's fracture/Dupuytren fracture, which refers to fractures and dislocations of the distal tibia or fibula caused by forced eversion and external rotation to the lower leg (Mann and Hunt 2013: 166). Causes of such fractures in modern medicine include rolled ankle, landing badly from a jump or a sports tackle injury. Overall, eversion or force to the lateral side of the lower leg was the likely cause. The way the fracture has healed and formed a callus may have led to disability and shortening of the limb (Neri and Lancellotti 2004: 61). Due to Iron Age disturbance of this burial it was not possible to analyse the other joints, but this individual was probably an older adult and the injury would have occurred a significant time prior to death to enable healing to have taken place.

A distal phalanx of the first toe from C1781 shows evidence of a healed fracture, along with displacement and misalignment of the distal end. Modern comparative examples are rare but occur as fatigue fractures in young athletes taking part in sports that lead to repetitive trauma to the big toe (Yokoe and Mannoji 1986; Inokuchi and Usami 1997; Matcuk *et al.* 2016; Kim *et al.* 2017). This type of fracture can also be caused by crush injuries (Morris *et al.* 2017).

The cranium of an older adult female individual (C1862) from a deposit of disarticulated bones has two defects which may have been caused by blunt force trauma prior to death (Fig. 19.22). These defects appear to be depressed fractures. There are two impact points, both to the superior mid right parietal bones (Wedel and Galloway 2013: 131). The clearest defect forms an oval area towards the sagittal line, with one angled smooth, bevelled margin measuring 8.14 × 14.85mm. The lesion has not fully pierced the skull but has broken the outer table of bone to leave the diploe exposed: a loose 'flap' of bone was still *in situ* indicating a hinge fracture. The second feature is shallower and less clear but resembles a depressed fracture. These characteristics appear consistent with blows to the side of the head. It is unclear whether the impacts occurred due to an accident such as a fall or from interpersonal violence, but the area of the skull can be described as above the 'hat line' and such fractures are usually attributed to interpersonal violence in modern populations (Kremer *et al.* 2008; Wedel and Galloway 2013: 95).

There is little discussion of trauma and potential violence in the Early Neolithic within the region, especially with reference to osteological evidence (exceptions being Glencross and Boz 2013; Knüsel *et al.* 2019). This lack of discussion is in contrast to the Neolithic in other areas such as the UK (Schulting and Wysocki 2005), and Europe (Meyer *et al.* 2018). Sołtysiak (2017) describes four cases of healed cranial trauma at Zawi Chemi Shanidar, while Glencross and Boz (2013) highlight evidence of trauma at various sites, the most relevant being examples from Ganj Dareh and Zawi Chemi Shanidar. At Ganj Dareh, there was a healed depressed cranial fracture and a healed humeral fracture. Further healed depressed cranial fractures were found at Zawi Chemi Shanidar

Figure 19.22. Possible blunt force trauma to cranium, C1862.

(Smith 1990; Agelarakis 2004). Goring-Morris and Belfer Cohen (2010) attribute the cranial trauma at Zawi Chemi Shanidar to digging sticks, wooden clubs or axes. Healed long bone and rib fractures are also reported from Jericho (Kurth and Rohrer-Ertl 1981). There is little description or interpretation of objects as weapons in the Early Neolithic of Southwest Asia, although at Nemrik 9 there is mention of 'Bolas balls' and types of ground stone 'axes' (Sołtysiak 2017) (see also 'maceheads', Chapter 22).

Palaeopathology: discussion

The transition to agriculture is often viewed as leading to an increase in population size, mortality and ill health, with assumptions that agricultural practices led to a less varied diet and an increase in carious lesions (Larsen 2006). How do the Bestansur human remains contribute to these issues? Within the Bestansur assemblage, the most frequently evidenced pathologies include enamel hypoplasia, calculus and sub-periosteal bone formation. Due to the availability of comparative data, the main pathologies discussed here will include enamel hypoplasia and carious lesions. Comparative frequencies of pathologies are expressed as numbers or percentages of total individuals affected, or the total teeth or skeletal elements affected, which limits comparisons in some cases.

At Bestansur, enamel hypoplasia was found in 11 of 43 individuals with teeth, or 5% of the total 854 teeth. In comparison, at Shanidar all ten Neolithic individuals showed signs of EH (Agelarakis 2004), and similarly at Tell Qaramel all ten individuals with dentition showed evidence of EH which affected 13.5% of teeth (Chamel 2014). At Ganj Dareh, 32 of 58 individual dentitions had EH (Merrett 2004: 205) and at Sheikh-e Abad only one of six individuals had EH, or 6% of the total teeth (Cole 2013). Lastly, at Abu Hureyra phase 2B only 2% of 889 teeth showed EH (Moore *et al*. 2000). The percentage of affected teeth at Bestansur seems to fall within the range of that at other sites, being most similar to Sheikh-e Abad although this is a much smaller sample (Table 19.25).

Table 19.25. Number and percentage of teeth with EH from comparative sites.

Site	*Teeth affected*	*Of total*	*%*
Bestansur	43	854	5
Sheikh-e Abad	6	101	6
Abu Hureyra	18	889	2
Tell Qaramel	12	96	13.5

Most interruptions to dental development at Bestansur occurred from 2 to 4 years of age. At Dja'de Al-Mughara, from the evidence of EH, most episodes of stress occurred from ages 5–6.5 years. At Tell Qaramel, EH in six individuals occurred from interruptions to development at ages 4–6 (Chamel 2014: 396). Interruptions to development from ages 2–4 years are likely to be caused by weaning stress or a systemic infection.

The agricultural transition is assumed to have led to a lack of variation in diet and to an increased reliance on carbohydrates leading to an increase in carious lesions (Larsen 2006). Most interpretations of caries rates in Neolithic transitional populations are based on evidence from America and or Africa where diets are based on different resources such as maize, millet and potatoes (Cohen 1989: 107). Eshed *et al.* (2006) attribute the concept of increased caries rates in the Neolithic to New World prehistoric studies where the change to a maize based diet impacted on caries frequency. For example, a review of dental caries and related diet in different transitional populations globally by Larsen (1995) suggests that an increase in carious lesions is predominantly based on populations in North America and Canada, with some evidence from Japan (Turner 1979; Milner 1984; Patterson 1984). Larsen (1995) also acknowledges that higher frequencies of carious lesions are not limited to groups consuming carbohydrates, as other foods can be cariogenic.

At Bestansur 9% of individuals, or four teeth equalling 0.46% of the total 854 analysed teeth had carious lesions (Table 19.26). Comparative sites in the EFC with similar low frequencies of caries include: Nemrik (Sołtysiak *et al*. 2015), Jarmo (Dahlberg 1960), Ganj Dareh (Merrett 2004: 233), Abu Hureyra (Moore *et al.* 2000) and Sheikh-e Abad (Cole 2013).

Table 19.26. Number and percentage of teeth affected by caries at various sites.

Site	*Teeth affected*	*Of total*	*%*
Bestansur	4	854	0.46
Nemrik	3	470	0
Sheikh-e Abad	5	101	5
Jarmo	4	126	3
Ganj Dareh	6	554	1
Tell Qaramel	14	118	12
Abu Hureyra	9	459	2

Eshed *et al.* (2006) conducted comparative analyses of both Natufian and Neolithic teeth from sites in the Levant including analysis of dental wear, caries, calculus, ante mortem tooth loss and periodontal disease. Of the 1160 Natufian teeth, 6.4% had carious lesions, while of the 804 Neolithic teeth analysed, 6.7% had carious lesions. Eshed *et al.* (2006) concluded that there was no evidence of changes in dental health during the agricultural transition in the Levantine Neolithic. They suggested that differences in tooth wear relate to changes in the ways foods were produced rather than the types of food consumed, in addition to possible changes in extra-masticatory tooth use (Eshed *et al.* 2006; Temple 2016: 437).

Activity and dental wear

Most individuals from Bestansur have dental wear from attrition over time, formed through normal mastication. Abrasion to the teeth is caused by wear from foreign substances between the teeth and when the teeth are used as tools (Burnett 2016). In total there are at least seven adult individuals at Bestansur with dental wear which may be activity related (Table 19.27). These individuals show varieties of differential wear, some with increased wear to one side of the mouth, with some teeth worn to extreme angles, while some individuals show wear patterns to the anterior dentition.

Individuals with the most attrition wear are C1228 SK2 and C1788. Most frequently recorded are wear planes 2 and 6; wear plane 2 is acutely angled wear, and wear plane 6 is flat wear to the occlusal surface.

An adult female, C1788, has a mixture of teeth affected. The upper molars are extremely worn down to significant dentine exposure, with some roots functioning as an occlusal surface. This wear is much more extreme compared to that of the mandibular molars of this individual, potentially indicating some differential use of the upper dentition.

Table 19.27. Numbers of teeth of individuals affected by possible activity related dental wear, includes numbers of tooth types affected.

Context	*Teeth affected*	*Total teeth*	*I/C*	*PM*	*Molars*	*OWT*	*Wear plane*
C1228	7	12	6	0	1	Notched, rounded, concave	2, 3, 6
C1625	2	28*	1	0	1	Notched, concave	5, 6
C1781	2	23*	1	1	0	Concave, angled	2, 4
C1784	1	21	0	1	0	Concave	6
C1788	5	28	2	0	3	Notched, concave, rounded	2, 4, 6
C1789	1	12	0	0	1	Concave	6
C1868	4	6	0	0	4	Concave	2

*mixed individuals, I/C = Incisor/Canine, PM= Premolar, OWT = Occlusal wear type (see Molnar 1971).

The teeth affected from C1228 are almost entirely incisors and canines, the upper left first incisor has a notched groove from the mesial aspect, and the adjacent second incisor has rounded wear. The lower left canine also has notched wear, a type of occlusal wear which may indicate that this individual was drawing material through the teeth (Capasso *et al.* 1999, 132). Ethnographic studies have shown activities associated with dental grooves to include processing plant fibres, basket and net making, and working sinew (Erdal 2008; Stojanowski *et al.* 2016).

Examples of extra-masticatory dental wear have been found at the Natufian site of Ain Mallaha, where there was grooving of the anterior dentition, and at Atlit-Yam where there was bucco-lingual grooving on the occlusal surfaces of some molars; these examples may have been caused by basket or net making (Eshed *et al.* 2006). Chamel (2014: 535) describes examples of extra masticatory wear at Abu Hureyra; individuals from Phase 2B showed evidence of wear to the incisors and canines potentially indicating fibre processing.

Analysis comparing the dentition of Natufian and Neolithic populations by Eshed *et al.* (2006) showed a shift in wear patterns. The Natufian group had more evenly distributed wear in the molars, whereas the Neolithic group showed an increase in angled and upper molar wear, which is thought to be due to differences in food preparation and extra masticatory tooth use. The types of extra masticatory dental wear from Bestansur are comparable to those Neolithic wear patterns described by Eshed *et al.* (2006).

Conclusions and future directions

This research has added significantly to the data on burial practices, demography, health and diet during the transition to sedentary agriculture in the Early Neolithic in the EFC and more widely. In total a minimum number of 67 individuals have been excavated and analysed for this research from T10 Sp50 and T7, integrating detailed field recording with analyses of osteoarchaeology and palaeopathology. The human remains were recovered from a wide area of the site, indicating close associations between the living and the dead and the importance of burial within the settlement in this early sedentary community.

A minimum of four other individuals have been identified from Sp29 and Sp48, although remains from Sp48 could also relate to individuals within Sp50. The remains from Sp50 include a high number of juveniles (49) in comparison to adults, at 75% of the assemblage from this area. This number of juveniles may be biased by the areas excavated so far within this space, as one area, in the southeast corner of Sp50, seems to be specifically for the deposition of infant and young child remains. Alternatively, there may have been high juvenile mortality.

While most of the human remains at Bestansur are from Sp50, small amounts of bone from other interior and exterior areas contemporary with Sp50 may be remnants from moving bodies or disarticulated bones around this building and area of the settlement as part of extended mortuary practices.

In summary, evidence of pathology at Bestansur is mostly represented by indications of physiological stress, non-specific infection and malnutrition. LEH was identified in 11 of 67 individuals or 16% of the assemblage, and indicates systemic disruption to development in at least two individuals. A significant proportion of the evidence for skeletal pathology at Bestansur is indicative of malnutrition or haemopoietic disorder. Possible causes include forms of anaemia or vitamin C and D deficiencies, in addition to possible infection through bacteria or parasites which would inhibit the absorption of nutrients (Ledger *et al.* 2019). The transition to agriculture is argued to lead to a lack a variation in diet (Larsen 1995; Bocquet-Appel and Bar-Yosef 2008). At Bestansur the zooarchaeological and archaeobotanical evidence (Chapters 15 and 18) shows that a wide variety of dietary resources, both wild and domesticated, were used. It is possible that there were times when important dietary resources were scarce due to seasonal changes that could have caused shortages of essential food sources, which requires future investigation and integration between studies of human health, environmental proxies and dietary evidence from the archaeoboatnical and zooarchaeological records.

Evidence of joint disorders was likely due to ageing, osteoarthritis, or repeated activities. While low levels of evidence for traumatic injuries were identified within the assemblage, the healed lower leg fracture is most interesting as this indicates care in the community.

Further human remains have been discovered during continuing excavations, and analysis of palaeopathology, taphonomy and dental wear is ongoing. Analyses of human aDNA have been conducted by Pinhasi, Reich and Lazaridis and are ongoing. Further radiocarbon dating, and isotope analysis will be conducted, in order to investigate issues of diet, human mobility and inter-regional networks. Specific aspects of focus for future human remains research will include detailed analyses of disease, dental calculus, seasonality in diet and weaning practices, to add to this already significant body of new data from Bestansur on human communities of the transition from more mobile hunter-gathering to sedentary agricultural lifeways.

Table 19.28. (continued over the next three pages) Summary of the Bestansur burial data.

Context	*SK*	*Location*	*Sex*	*Age*	*Age class*	*Pathology*	*Articulation*	*Burial type*	*Context description*	*Finds / materials associated*
1228	2	T7	Male	30–40+	30–40	Thickened cranial bones with porosity, caries, extreme wear	Appeared fully articulated	Primary double burial, highly flexed	External area	0
1228	1	T7	Female	14–20	Adolescent	LEH to 7 of 29 teeth, no skeletal path	Appeared mostly articulated	Primary? double burial, highly flexed	External area, truncated cut visible towards base	0
1604	NA	Sp50	NP	Adult	Adult	0	Disarticulated	Scattered remains	Room fill of Sp50 above cutmarked stones	0
1604	NA	Sp50	NA	5–8	6–12	Wear to dM1	Disarticulated	Scattered remains	Room fill of Sp50 above cutmarked stones.	0
1621/1775	NA	Sp50	NA	4–5	3–5	Fusion of manual phalanges; porosity, lysis and possible SBNBF of foot phalanges	Disarticulated and scattered	Scattered remains	Floor of Sp50	0
1621/1775	NA	Sp50	NP	Adult	Adult	LEH, calculus, no skeletal path	Disarticulated and scattered	Scattered remains	Floor of Sp50	0
1621/1775	NA	Sp50	NA	Neonate/ perinate	Neonate	Porosity and possible SPNBF of infant skull and vert	Disarticulated and scattered	Scattered remains	Floor of Sp50	0
1623	1	Sp50	NA	1–2	1–2	Vascularisation	Disarticulated and scattered	Scattered remains	Lower floor Sp50	Beads of shell, dentalium, and carnelian within deposit
1623	2	Sp50	NA	0–1.5 mnth	Neonate	0	Disarticulated and scattered	Scattered remains	Lower floor Sp50	0
1623	3	Sp50	NA	0–4 mnth	1–12 mnth	0	Disarticulated and scattered	Scattered remains	Lower floor Sp50	0
1623	4	Sp50	NP	Adult	Adult	0	Disarticulated	Scattered remains	Lower floor of Sp50 - floor surface underlying C1621, with bones and teeth on surface	0
1625/1781	1	Sp50	Male	Young adult 20–30	19–30	Uneven tooth wear, calculus, LEH, linear org trabeculae of skull	Disarticulated	Skull burial/deposit and scattered material	Clay packing deposit between floors in Sp50	Beads of shell and dentalium within deposit
1625/1781	NA	Sp50	NA	5–8	6–12	0	Disarticulated	Scattered remains	Clay packing	0
1625/1781	NA	Sp50	NA	1–2	1–2	Porosity and SPNBF of infant petrous, porosity of sphenoid	Disarticulated	Scattered remains	Clay packing/beneath floor	0
1625/1781	NA	Sp50	NA	Perinate/ neonate	Neonate	Porosity, exposure of diploe and trabeculae, PH, CO	Disarticulated	Scattered remains	Clay packing	0
1626	NA	Sp50	NA	Around 2	1–2	0	Disarticulated	Scattered remains	Internal stony deposit at base of W41 and W42	0
1626	NA	Sp50	NA	YC	3–5	0	Disarticulated	Scattered remains	Internal stony deposit at base of W41 and W43	0
1631	2	Sp50	NA	6–8	6–12	Dental wear	Articulated	Double primary burial of 2 juveniles	Human remains cluster in/below C1625	0

Table 19.28. *(continued from previous page and over next two pages) Summary of the Bestansur burial data.*

Context	*SK*	*Location*	*Sex*	*Age*	*Age class*	*Pathology*	*Articulation*	*Burial type*	*Context description*	*Finds / materials associated*
1631	3	Sp50	NA	4–5	3–5	LEH, wear	Articulated	Double primary burial of 2 juveniles	Human remains cluster in/below C1625	0
1714	NA	Sp50	NP	Adult OA from teeth	50+	Fracture of distal tibia and fibula	Appeared in an articulated position but poorly preserved	Primary but disturbed burial	Upper fill of B5, burial cut by Iron Age pits	Shell beads
1731	1	Sp50	NA	5–8	6–12	Repetitive LEH upper I1s, wear to a number of deciduous teeth, CO, porosity to temporal	Disarticulated? May have been partly articulated	Bone cluster, tightly packed, potential wrapped burial	Human remains deposit in packing	Beads of shell and dentalium, 2 cowrie shells, 1 item worked bone
1731	2	Sp50	NP	Adult	Adult	0	Disarticulated	Bone cluster: wrapped burial?	Human remains deposit in packing	0
1731	3	Sp50	NA	1–2/2–3 (latter from teeth)	2 – 3	Possible active periostitic bone on pars basilaris	Disarticulated	Bone cluster: wrapped burial?	Human remains deposit in packing	0
1731	4	Sp50	NA	Neonate	Neonate	0	Disarticulated	Intrusive? Secondary	Human remains deposit in packing	0
1780	NA	Sp50	NA	2–4	3–5	Dental wear	Disarticulated skull	Secondary	Packing from Sp50 same as C1741, part of wider deposit C1812	2 shell beads
1780	NA	Sp50	NA	Infant	1–2	0	Disarticulated skull	Secondary	Packing from Sp50 same as C1741, part of wider deposit C1812	0
1754/1774	NA	Sp50	Female?	Adult	Adult	0	Disarticulated and scattered	Scatter of bones, fairly spread out	Bones relate to packing and building collapse	0
1783	NA	Sp50	NA	Infant 7–12 mnth	1–12 mnth	0	Articulated	Primary burial on R side, over another infant in 1812	Articulated burial of an infant at level of C1812	0
1784	NA	Sp50	Female?	18–24	19–30	LEH, lysis and expansion of toe phalanx, OA	Mostly disarticulated, 1 articulated leg	Secondary	Human remains deposit in packing	Chert bladelet
1788	NA	Sp50	Female	20–30	19–30	LEH, cranial porosity, exposed trabeculae, SES, CO	Disarticulated	Secondary	In packing in NW corner	0
1789	NA	Sp50	Male?	30– 40	30–40	Arachnoid granulations and thickening of crania	Disarticulated	Secondary	In packing in NW corner	0
1804	1	Sp50	NP	Infant/yc	Juvenile	0	Disarticulated	Secondary	Human remains deposit in packing	0
1804	2	Sp50	NA	4-5	3–5	LEH/EH	Articulated	Primary burial, flexed on R side	Human remains deposit in packing	Red ochre
1804	4	Sp50	NA	2–4	3–5	Porosity, bone formation	Disarticulated	Secondary	Human remains deposit in packing	0
1804	6	Sp50	NA	Infant/yc	Juvenile	0	Disarticulated	Secondary	Human remains deposit in packing	Red ochre
1810	1	Sp50	NP	Adult mandible 40–50+	40–50	Carious lesion, porosity, osteophytosis, periodontal disease	Disarticulated	Secondary	Human remains deposit in packing	Red ochre

Table 19.28. *(continued from previous two pages and on the next page) Summary of the Bestansur burial data.*

Context	*SK*	*Location*	*Sex*	*Age*	*Age class*	*Pathology*	*Articulation*	*Burial type*	*Context description*	*Finds / materials associated*
1810	NA	Sp50	NA	Adolescent 13-18	Adolescent	0	Disarticulated	Secondary	Human remains deposit in packing	0
1810	NA	Sp50	NA	Infant/yc	Juvenile	0	Disarticulated	Secondary	Human remains deposit in packing	0
1812	1	Sp50	NA	Infant/yc	Juvenile	0	Disarticulated, E? facing	Secondary	Human remains deposit in packing	0
1812	2	Sp50	NA	7–10 mnth	1–12 mnth	0	Disarticulated, S facing	Secondary	Human remains deposit in packing	0
1812	4	Sp50	NA	Yc from skull thickness	3–5	0	Disarticulated, base of truncated cranium	Secondary	Human remains deposit in packing	0
1812	5	Sp50	NA	5–10 mnth	1–12 mnth	PH	Disarticulated, facing SW, fairly complete	Secondary	Human remains deposit in packing	0
1812	6	Sp50	NA	Infant/yc	Juvenile	0	Disarticulated, base of truncated cranium	Secondary	Human remains deposit in packing	0
1812	7	Sp50	NA	10.5–24 mnth	1–2	0	Disarticulated, facing W	Secondary	Human remains deposit in packing	0
1812	8	Sp50	NA	Infant/yc	Juvenile	0	Disarticulated	Secondary	Human remains deposit in packing	0
1812	9	Sp50	NA	5–7	6–12	LEH	Disarticulated, facing S	Secondary	Human remains deposit in packing	0
1812	10	Sp50	NA	Neonate	Neonate	0	Disarticulated	Secondary	Human remains deposit in packing	0
1812	11	Sp50	NA	Neonate	Neonate	0	Disarticulated	Secondary	Human remains deposit in packing	0
1812	12	Sp50	NA	Infant	1–12 mnth	0	Disarticulated	Secondary	Human remains deposit in packing	0
1812	13	Sp50	NA	10–18 mnth	1–2	Linear striae, cranial porosity	Disarticulated	Secondary	Human remains deposit in packing	0
1861	NA	Sp50	NA	Pre-nate	Neonate	0	Disarticulated	Secondary	Human remains deposit in packing	0
1861	NA	Sp50	NA	Perinate	Neonate	Possible SPNBF	Partly articulated	Secondary?	Human remains deposit in packing	0
1861	NA	Sp50	NA	Neonate	Neonate	0	Partly articulated	Secondary?	Human remains deposit in packing	0
1861	NA	Sp50	NA	Older infant	1–2	0	Partly articulated	Secondary?	Human remains deposit in packing	0
1862	NA	Sp50	F	40–50 older adult	40–50	Possible cranial BFT	Disarticulated	Secondary	Human remains deposit in packing	Red ochre
1863	NA	Sp50	M?	12–15 adolescent	Adolescent	Repeated LEH	Articulated	Primary but tightly packed	Burial in cut feature: cuts W47	0
1866	1	Sp50	NA	7–10 mnth	1–12 mnth	Path phalanges	Disarticulated	Secondary	Burial in cut feature: cuts W47	0

Table 19.28. (continued from previous three pages) Summary of the Bestansur burial data.

Context	*SK*	*Location*	*Sex*	*Age*	*Age class*	*Pathology*	*Articulation*	*Burial type*	*Context description*	*Finds / materials associated*
1868	1	Sp50	M?	20–24	19–30	AM loss pm R, carious lesion	Disarticulated	Secondary	Human remains deposit in packing	Beads of shell and stone spread through deposit
1868	2	Sp50	F?	15-–6 adolescent (dental age)	Adolescent	Slight calculus on canines	Disarticulated	Secondary	Human remains deposit in packing	0
1868	3	Sp50	NA	Juv	Juvenile	0	Disarticulated	Secondary	Human remains deposit in packing	0
1868	4	Sp50	M	40–50+	40–50	Dental wear, porosity on external table, AM-loss	Disarticulated	Secondary	Human remains deposit in packing	0
1868	5	Sp50	F	30–40	30–40	0	Disarticulated	Secondary	Human remains deposit in packing	0
1868	6	Sp50	NA	7–9	6–12	0	Articulated	Primary burial of child skeleton, highly flexed on R side	Human remains deposit in packing	0
1868	7	Sp50	F??	13–15	Adolescent	Slight calculus, porosity of cranial bones	Disarticulated	Secondary	Human remains deposit in packing	0
1868	8	Sp50	NA	6–7	6–12	0	Articulated	Primary burial of child, highly flexed on R side with hands up to face	Human remains deposit in packing	0
1871	2	Sp50	M?	24–35	19–30	Linear striae, expansion of external cranial table, calculus	Disarticulated	Secondary	Human remains deposit in packing	0
1871	1	Sp50	NA	Neonate	Neonate	0	Disarticulated	Secondary	Human remains deposit in packing	0

20. EARLY NEOLITHIC CHIPPED STONE WORLDS OF BESTANSUR AND SHIMSHARA

Roger Matthews, Amy Richardson and Osamu Maeda

Introduction

The site of Bestansur was first identified as having a significant Neolithic component on the basis of surface finds of chipped stone artefacts (Altaweel *et al*. 2012: 21). The chipped stone assemblages from Bestansur and Shimshara provide some of the most tangible and informative sets of evidence with which to approach Early Neolithic life-ways of the EFC (Matthews *et al*. 2018). Because of their hardness and durability, tools and debitage of chert and obsidian occur in every context excavated through five field seasons at Bestansur and two field seasons at Shimshara. In their prehistoric situations, chipped stone artefacts were only one component of Early Neolithic material culture worlds, utilised alongside tools and equipment of more fragile and perishable materials such as wood, bone, leather, reed and fibre, usually attested to lesser degrees in the surviving record. Where organic materials survive at wetland sites, for example, it has been estimated that chipped stone tools formed less than 5% of the 'technological system' (Van de Noort and O'Sullivan 2006), as against lavish use of wood, bone and antler for most tools and implements.

Excellent survivability in the archaeological record could be argued to have accorded chipped stone (and ground stone) materials a disproportionate amount of attention from archaeologists but, at the same time, their sheer numbers and wide spatial distribution indicate the huge importance of chipped stone tools in daily, seasonal and recurrent task-scapes of Early Neolithic worlds of Southwest Asia. From five seasons of excavations at Bestansur, 2011–2014, we recovered and recorded a total of 19,432 pieces of chipped stone, weighing a total of 23,293.45g, while from two short seasons of excavations at Shimshara the totals are 1393 pieces of chipped stone, weighing a total of 1839.87g. The current chapter thus deals with a combined total from both Bestansur and Shimshara of 20,825 pieces of chipped stone weighing in total 25,133.32g, or just over 25kg.

Aims and objectives

In conducting this research into the chipped stone worlds of Bestansur and Shimshara, we are addressing an integrated set of aims and objectives relating to the Early Neolithic transition in the EFC, which are common to the overall project in its AHRC-funded phase and beyond. Within the field of chipped stone research, they can be articulated as outlined below:

Chronology of change and continuity

What is the chronology of change and continuity in the Zagros Neolithic, as seen through the lithic lens? How do chipped stone tool assemblages and their possible uses aid in refining understanding of the chronology of the excavated sites, contributing to the investigation of local and regional sequences of occupation and socio-cultural development (Chapter 11)? The radiocarbon chronology of Bestansur and Shimshara and the typology of their chipped stone tools converge in dating the excavated occupation at both sites to the centuries from *c*. 7700 to 7100 BC. Within the occupation sequences at Bestansur, is it possible to discern elements of change and/or continuity in the lithic assemblages and what might they tell us concerning changing socio-cultural practices?

Sedentism and seasonality

How might the study of lithics inform us with regard to early stages in the sedentarisation of human communities in the EFC, for example by enabling investigation of duration of settlement through articulation of seasonally-shaped tasks and activities? How do lithic technologies inform us concerning modes and intensities of sedentism, and the socialisation of activities within human settlements? The transition from hunter-gatherer to farmer-herder through the Neolithic had major impacts on all aspects of life, including a reduction in levels of mobility and increasingly complex social organisation, as suggested at Bestansur by the density of the settlement and evidence in its layout for higher-level planning. What were the impacts on lithic production and use, in terms of access to raw materials, tool inventories and discard practices?

Food, craft, and natural resources

What roles might lithic tools have fulfilled in the gathering, processing and consumption of food and craft resources through the Early Neolithic transition? Can we identify areas of settlement where food processing and consumption took place, and are there indications of variable or favoured access to raw materials, including those needed for production of lithic tools themselves?

Material engagement and networks

Through analysis of the chipped stone assemblages, how might we articulate the regional and trans-regional networks in which the communities at Bestansur and Shimshara engaged? Did they change through time as geographic horizons altered with increasing sedentarisation or enhanced craft specialisation, for example?

Methodology

From first retrieval from their almost 10,000 year old slumber in the ground through to analysis and final publication, the chipped stone assemblages of Bestansur and Shimshara have been recovered, recorded, analysed and interpreted through the application of an integrated methodology which enables high-resolution investigation of the research aims articulated above. Such levels of investigation are possible only through large-scale, multi-component, scientific projects such as CZAP. In this section we discuss all the methodological stages in this process, starting with retrieval.

Retrieving, defining and characterising the population: recovery and recording protocols

We designed the chipped stone recovery and recording methods employed at Bestansur and Shimshara to sit within the overall field strategy (Chapter 2). In the field, where volume permitted, we collected 30–50 litres of each excavated context in sacks for flotation and wet-sieving, as a whole-earth sample with no artefacts removed beforehand. For some contexts we collected multiple samples in this way, often spatially distinguished. For contexts greater than 30–50 litres, we dry-sieved through a 4mm mesh the deposit in excess of the quantities needed for whole-earth samples, and occasionally we hand-picked chipped stone items from topsoil contexts, for example, or to protect them from damage, while at the same time keeping them within their overall respective method of recovery, which was recorded in every case. We recovered chipped stone materials at the trowel's edge in the trench, from the adjacent dry-sieving installations, and in the laboratory from sorting of heavy residues following integrated wet-sieving and flotation, using 10mm, 4mm, 2mm and 1mm sieves (Chapter 14).

In the lithics recording process we integrated all streams of recovery, enabling study of the full range of chipped stone material in almost all contexts. In all our analyses and interpretations, therefore, we are confident in the representativeness of our chipped stone assemblages, and that we are not missing lithic evidence for particular types of activities (van Gijn 2010: 40–41), except in so far as such activities may have been taking place in areas not excavated by us. This multi-stranded recovery and recording methodology enables a full appreciation of the constitution and complexity of Neolithic chipped stone assemblages from the EFC. Failure to recover and integrate tool and debitage characteristics from dry-sieving and wet-sieved heavy residues alongside hand-collected materials means that published assemblages are often only partial, typically lacking full representation of small-scale components such as microliths and micro-tools as well as the full range of debitage (Szymczak 1996). Of the total 19,432 pieces of chipped stone from Bestansur a total of 9775 pieces, or 50.25%, was recovered from heavy residue, as discussed in Chapter 14 (see also Iversen 2015). The proportion of debitage to tools increases as we examine lithic assemblages from ever finer mesh sizes, with 78% debitage at 4mm and 97% debitage at 2mm.

We recorded the chipped stone materials in two Excel spreadsheets, following division of the lithics from each context into tools and debitage sorted by raw material type. We define debitage as all waste pieces removed by the Neolithic tool-maker from a core, nodule or block of chert or obsidian in order to create or modify a desired chipped stone tool (Andrefsky 2005: 16). The major area of uncertainty in defining debitage is the issue of unretouched blades with no obvious evidence of use, which occur in large numbers at both sites. Clearly a blade without retouch can serve as an effective cutting or slicing tool, especially if made of obsidian, but unretouched blades may also be generated as debitage during tool production. For recording and analytical purposes, we decided to treat all unretouched blades as potential tools, which means that the tool assemblages are dominated by blades. In many instances, it is likely that unretouched blades were in fact debitage rather than the intended product of knapping episodes, especially where we find such blades in association with more obvious knapping debris as in Context 1172 in Trench 7. In any case, the recording methodology allows us to treat unretouched blades either as tools or as debitage in the following analyses. Other forms of debitage include cores and core rejuvenation flakes (also called core trimming elements), all of which were individually weighed, measured and recorded, as well as unmodified flakes and shatter debris, much of which we recovered from flotation heavy residues.

After dividing the material into chert and obsidian material groups, as defined by colours and inclusions (see below), we recorded the count and weight of debitage by material code for each excavated context in an Excel spreadsheet. Each raw material group, within each excavated context, was counted and weighed, using an Ohaus Scout Pro balance accurate to .01g, and then labelled and bagged. We recorded chipped stone tools in a separate Excel spreadsheet, each tool being assigned an individual ID number. All tools were individually weighed, measured in three dimensions (length, width, thickness), labelled and bagged. For each tool we recorded details on retouch (density, location, steepness, type) and on striking/pressure platforms and bulbs of percussion where present, as well as any other distinctive features such as cortex, evidence for use-wear and burning. Many cores and tools were selected for photography and drawing, as well as for material analysis through pXRF.

Overall, from Bestansur we recorded a total of 4014 retouched tools, or 7536 tools if unretouched blades are included, while from Shimshara we recorded a total of 369 retouched tools, or 665 tools including unretouched blades. A total of 224 cores and core trimming elements were recorded from Bestansur, and seven cores and core trimming elements from Shimshara. Following recording, all chipped stone materials were labelled, bagged, boxed and catalogued prior to submission to Slemani Museum, where they are permanently stored in a purpose-built facility.

The manner of recovery and recording for the Bestansur and Shimshara lithics enables a detailed analysis of the absolute and relative counts and weights of cherts and obsidian, as tools and as debitage, within individual contexts, rooms, buildings and trenches, and across each site as a whole. We analyse possible raw material preferences for manufacture of specific tool types, as well as searching for spatial variation in the making, use and discard of tools within archaeological levels and spaces and across stratigraphic sequences. The density and interconnectedness of recorded detail facilitates rigorous approaches to the study of lithic biographies within the social contexts of Early Neolithic lifeways in the EFC.

Lithic materials analysis

We conducted material analysis of all chert and obsidian tools from both sites, first using by-eye characterisations of raw materials, supported secondly by chemical characterisation of materials through systematic pXRF investigation of selected chert and obsidian pieces, integrating visual and chemical approaches to material characterisation. This approach enables in-depth investigation of patterns of material usage in both cherts and obsidians across both sites, and at Bestansur in particular. The methods and their application are critically evaluated in the relevant sections below.

Interpretative frameworks

Our approach to the chipped stone assemblages from Bestansur and Shimshara is integrative, situating chipped stone assemblages, tools in particular, within their archaeological contexts in spatial, chronological and conceptual senses. In keeping with the object-oriented ontological turn (Olsen 2010), we treat chipped stone artefacts as active components in a constitutive dialogue in which Early Neolithic peoples shaped, and their lives were shaped by, the material worlds of their time. To this end, we explore the notions of artefact biographies and social identities as critical routes towards deeper understanding of the meaning of chipped stone artefacts, and of their modes of production, use and discard, within human ecological and social contexts (Gosden and Marshall 1999; Joy 2009; Witmore 2014). Recent studies have pursued approaches of object biography in the study of prehistoric chipped stone artefacts, viewing the selection of raw materials as an artefact's 'conception', its manufacture as its 'birth', its exchange and actual use as its 'socialisation', and its discard as its 'death' (van Gijn 2010: 11; Nazaroff *et al*. 2016; Marciani *et al*. 2018). We adopt an object biographical approach in this chapter, maximising the potential for detailed contextual analysis which can illuminate every stage in the life-ways of individual artefacts and thereby of the individual and social human lives with which chipped stone artefacts were entwined. Our object biographies now begin with investigation of access to, and exploitation of, the raw materials necessary for lithic production.

Tools in conception: acquiring the raw materials

Early Neolithic societies of the Zagros were not engaging *de novo* with their surroundings, near and far, as they were the inheritors of wisdom and skills (and genetic make-up – Broushaki *et al.* 2016; Gallego-Llorente *et al.* 2016) accumulated and constructed by their Palaeolithic forebears, whether locally or more distant. For millennia prior to the Early Neolithic, Palaeolithic societies of the Zagros developed an in-depth familiarity with many of the raw materials available to them from proximate and occasionally distant sources. Palaeolithic and Epipalaeolithic chipped stone assemblages at Zagros cave sites such as Shanidar, Ghar-i Khar, Yafteh, Warwasi, Zarzi and Palegawra show well-developed expertise of human communities in an increasing range of hunting, gathering and processing activities (Kozlowski 1994; Olszewski 1994; Matthews *et al*. 2013e; Thomalsky 2016). In particular, the exploitation of chert sources proximate to seasonal camp sites was well developed through the Upper Palaeolithic and into the Epipalaeolithic (Olszewski 1996), a feature which continues into and throughout the Neolithic. Sites of so-called Proto-Neolithic date, such as Zawi Chemi Shanidar, Shanidar Cave levels B1 and A and Tell Der Hall provide evidence for a continuous development in lithic technologies from the preceding Epipalaeolithic into the Early Neolithic (Kozlowski 1996; 1999: 59–62).

Major exploitation in the EFC of obsidian sources was substantively an achievement of Neolithic communities. Evidence for significant distribution and use of obsidian in the Upper Palaeolithic, Epipalaeolithic and the earliest phase of the Neolithic is low across most of Southwest Asia (Nishiaki 1993; Cauvin 1994; Carter 2014; Healey 2014). Within the Zagros region, Early Neolithic sites such as Sheikh-e Abad, East Chia Sabz, Chogha Golan, Ganj Dareh, Abdul Hosein, Asiab and Satu Qala have either no obsidian at all or frequencies of less than 1% of chipped stone by quantity (Smith 1976: 17; Pullar 1990: 113; Rafifar 1996; Kozlowski 1999: 64; Darabi and Glascock 2013; Vahdati Nasab *et al*. 2013b: 125; Zeidi and Conard 2013: 318; Nishiaki 2016; Barge *et al*. 2018; Maeda and Pappi 2019). This situation is in contrast to the WFC where significant quantities of obsidian from central Anatolian sources reached sites of PPNA and even Natufian date (Khalaily and Vala 2013).

Epipalaeolithic and Early Neolithic sites of the Taurus zone, closer to volcanic sources, by contrast did engage with obsidian use much earlier, as attested at Hallan Çemi and Körtik Tepe (Rosenberg 1994; Özkaya 2009; Rosenberg and Erim-Özdoğan 2011; Carter *et al*. 2013a; Healey 2014; Kartal *et al*. 2018) although only marginally at Nevalı Çori (Schmidt 1994: 239), Göbekli Tepe (Schmidt 2000) and Hasankeyf Höyük (Miyake *et al*. 2012; Maeda 2018). Thereafter, obsidian increased steadily in popularity amongst Neolithic communities of the central and EFC (Nishiaki 1993: table 1; Barge *et al*. 2018). At Çayönü through the Aceramic Neolithic period obsidian increases from *c*. 20% of chipped stone by quantity in the earliest phases to 62% in later phases (Redman 1982: 26; Caneva *et al*. 1994: 263) and up to 95% of chipped stone at Cafer Höyük in the PPNB (Cauvin 1991a: 171). At Tell Halula on the Syrian Euphrates, obsidian increases from 6% in the Middle PPNB to 32% in the Late PPNB (Molist *et al*. 1996: 5). The Aceramic Neolithic levels at Jarmo in the lower Zagros have 23–33% obsidian by quantity (Hole 1983: 257), increasing in Pottery Neolithic levels to 31-50% obsidian (Kozlowski 1994: 158). Neolithic levels at Shimshara excavated in the 1950s have *c*. 85% obsidian by quantity (Mortensen 1970: 27–28; see below for new data from Shimshara). In Aceramic Neolithic levels at Qalat Said Ahmadan, only 25km east of Shimshara, obsidian pieces represent 17% of the chipped stone assemblage (Tsuneki *et al*. 2015: 21).

Aceramic Neolithic and Pottery Neolithic levels at Tepe Guran in the Iranian Zagros have consistent representations of chert at 89% and obsidian at 11% (Mortensen 2014: 40). At Neolithic sites of Khuzestan in southwest Iran, percentages of obsidian in lithic assemblages steadily increase from 1–2% in the Aceramic to 8% in the Pottery Neolithic (Hole *et al*. 1969: 75; Hole 1994: 102). At Late Neolithic Çatalhöyük in central Anatolia, obsidian comprises 93–98% of the chipped stone assemblages (Bezić 2007; Nazaroff *et al*. 2014). Taken together these figures demonstrate a steadily increasing exploitation of obsidian as a desired tool-making commodity through the course of the Neolithic of Southwest Asia.

At Bestansur, all excavated trenches summed, the proportions of chert to obsidian are 74.29% chert to 25.71% obsidian by count, or 89.29% chert to 10.71% obsidian by weight. At Shimshara, the proportions are 20.38% chert to 79.62% obsidian by count, or 37.92% chert to 62.08% obsidian by weight. These figures demonstrate the significantly lighter average weights of fragments of obsidian as opposed to chert at both Bestansur and Shimshara, indicative of knappers' desire to maximise use of a valued resource, as supported by analysis of the chipped stone material from heavy residues (Chapter 14). The closer proximity of Shimshara to Anatolian obsidian sources is doubtless a factor in its much higher representation of obsidian as compared to Bestansur. The much higher proportion of obsidian as against chert in use at Shimshara, as compared to the nearby Aceramic Neolithic site of Qalat Said Ahmadan (Tsuneki *et al*. 2015: 28), may indicate both that Qalat Said Ahmadan is likely slightly earlier in date than Shimshara but also that Shimshara is situated more closely to the potential trade routes along which Neolithic communities were moving

Table 20.1. Raw material codes for visual characterisation by colour.

Code	*Material*	*Colour*
O1	Obsidian	Black/grey with green tinge in transmitted light
O2	Obsidian	Clear/translucent
O3	Obsidian	Strongly green/grey
C1	Chert	White/cream
C2	Chert	Pale grey
C3	Chert	Pale grey with dark grey bands or mottling
C4	Chert	Mid grey
C5	Chert	Dark grey
C6	Chert	Beige/yellow
C7	Chert	Mid-dark grey/brown
C8	Chert	Mid-dark brown
C9	Chert	Pale red
C10	Chert	Red/brown/orange
C11	Chert	Red
C12	Chert	Grey/pink/red/purple
C13	Chert	Pale brown/grey
C14	Chert	Black
C15	Chert	Grey/green/olive green
C16	Chert	Brown w white spots
C17	Chert	Dark green w red banding
C18	Chert	Red/yellow streaked
M	Chert	Mixed, not sorted for analysis
Q	Quartz	
T	Tuff	
S	Sandstone	
B	Basalt	

obsidian, and was therefore in a stronger position to gain access to obsidian.

Characterising the cherts

The chipped stone raw materials used at Bestansur and Shimshara can be entirely divided into cherts and obsidians, accepting Luedtke's (1992: 5) definition of chert as "all sedimentary rocks composed primarily of microcrystalline quartz, including flint, chalcedony, agate, jasper, hornstone, novaculite, and several varieties of semiprecious gems". We employed an integrated approach to classifying the cherts in use at Bestansur and Shimshara. On the one hand, while recording details on tools and debitage, we divided chert materials into 18 raw material groups, visually defined by colour, inclusions and type or degree of mottling or banding, as detailed in Table 20.1. These chert categories need to be viewed in a flexible and non-exclusive way. Frequently a single tool showed such variety in colour and inclusions along its length as to be eligible for two or even three of the defined

Table 20.2. Chert items selected for pXRF analysis.

Tool	*Trench*	*Context*	*Description*	*Colour*
Bestansur				
90	1	1102	Core	C4
210	2	1036	Blade core	C2
229	2	1038	Blade core	C8
362	4	1067	Blade core	C4
388	4	1080	Blade core	C1
447	5	1074	Flake core	C15
564	7	1091	Blade core	C3
609	7	1094	Blade core	C12
624	7	1172	Blade core	C3
656	7	1174	Flake core	C12
690	8	1131	Blade core	C13
1077	10	1161	Blade core	C2
1464	7	1248	Blade core	C9
1478	7	1254	Flake scraper	C15
1479	7	1254	Flake scraper	C12
1482	7	1260	Blade core	C12
1483	7	1260	Chert blade	C15
1552	7	1274	Diagonal-ended blade/let	C3
1575	7	1254	Blade core	C12
1877	7	1212	Mixed core	C2
2102	11	1246	Blade core	C12
2146	11	1240	Blade core	C4
2202	11	1241	Chopper	C3
2203	11	1241	Blade core	C5
2204	11	1241	Bullet core	C1
2205	11	1241	Bullet core	C12
2218	11	1241	Mixed core	C10
2228	11	1241	Core trimming element	C13
2230	11	steps	Blade core	C5
2374	7	1227	Blade core	C2
2540	10	1332	Blade	C1
2728	9	1303	Awl	C13
2753	9	1303	Awl	C14
2761	9	1303	Flake core	C15
2775	9	1303	Retouch fragment	C14
2999	10	1330	Bullet core	C4
3000	10	1330	Bullet core	C2
3002	10	1330	Flake core	C4
3093	10	1330	Core trimming element	C15
3094	10	1330	Flake core	C3
3099	9	1344	Bullet core	C4
3121	9	1344	Blade	C14
3126	9	1344	Notched blade	C10
3131	9	1344	Blade	C14
3186	10	1331	Bullet core	C14
3191	10	1331	Serrated blade	C13
3198	10	1331	Bullet core	C4
3199	10	1331	Bullet core	C3
3200	10	1331	Bullet core	C4
3201	10	1331	Bullet core	C4
3202	10	1331	Bullet core	C5
3556	9	1340	Blade	C1
3630	10	1329	Diagonal-ended blade/let	C13

Table 20.3. Chert classification by visual inspection and portable x-ray fluorescence.

pXRF ID	*Visual category*	*Colour*	*Composition*	*Notes*
1	C11	Red	SiO2 96–99%, Fe 0–1%, K 0.1–0.4%, Al 0.2–1.2%	Termed 'jasper' elsewhere, known deposits at Penjwin and Sargat
2	C10	Orange	SiO2 96–99%, Al 1–2%	Pure colour, variations assigned to yellow or brown as appropriate
3	C6	Yellow	SiO2 96–99%, Fe 0–1%	Also honey-coloured
4	C15	Green	SiO2 96–99%, Fe 0–1%, K 0.1–0.4%	Known deposits at Penjwin
5	C7, C8, C13	Brown	SiO2 95–98%, Ca 2–3%, K 0.1–0.4%, P 0.1–2%	Reserved for pure cherts, not including Ca-rich variants
6	C1	White	SiO2 96–99%, Ca 0–2%	Also cream and white-translucent
7	C2	Pale grey	SiO2 94–96%, Ca 2–4%, Fe 0.1%	Reserved for pure cherts, not including Ca-rich variants
8	C4	Mid grey	SiO2 92–94%, Ca 4–5%, Fe 0.2%	Reserved for pure cherts, not including Ca-rich variants
9	C5	Dark grey	SiO2 92–94%, Ca 4–5%, Fe 0.5%	Reserved for pure cherts, not including Ca-rich variants
10	C14	Black	SiO2 96–98%, Ca 0–1%, Fe 0.5–1%	As distinct from obsidian
11	C3	Grey/brown with mottle	SiO2 92–95%, Ca 4–6%, Al 0–1%	Reserved for pure cherts, not including Ca-rich variants
12	C3, C13, C16	Grey/brown with limestone	SiO2 85–90%, Ca 5–10%, Al 1–2%	Reserved for CaCO3-rich (coarse) cherts, often used for sickle blades
13	C9, C12, C17, C18	Other	Varied	Including purple and pink striped, red/yellow streaky, green/red banded, all rare

chert categories, for example. In every case a value judgement had to be made, generally in some haste. Used by itself, this method of chert classification might be seen as convenient but lacking in rigour.

Supported by the second method of classification, however, the method's validity is significantly strengthened. A combined approach integrating visual and chemical characterisation has demonstrated multiple chert resource acquisition strategies employed by the inhabitants of Çatalhöyük (Nazaroff *et al*. 2014). Our complementary approach since 2012 has been to employ chemical characterisation of a large sample of chert tools and cores by portable x-ray fluorescence (pXRF) (Table 20.2).

Non-destructive XRF analysis was conducted using a Niton XL3t GOLDD+ handheld analyser, set to 'Mining' mode in order to optimise the range of elements for chert analysis. Each chemically characterised tool was analysed under field laboratory conditions, in a tungsten-lined stand. Two readings from the 8mm window were taken at different points on the sample, with the results averaged to account for variations in the chert. Each of the high, low and main analyser filters were allowed to run for 20 seconds, with a longer run of 60 seconds on the light elements, for a total run-time of two minutes per reading, in order to balance accuracy with expediency.

A match between visual and pXRF categorisation of cherts is summarised in Table 20.3, indicating a significant degree of correlation between chert colour and chemical composition. Thus, the purest chert colours correlate with the purity of their compositions. At 96–99% pure SiO2, the red, orange, yellow, white, black and green cherts are distinctly differentiated from the grey and brown cherts. Pale varieties of brown chert comprise 88–93% SiO2, 5–10% Ca and 1.5% Al, with higher than average K, P and S values (between 1500–2500ppm). Cherts categorised as pale brown, grey–brown or beige appear to be a limestone/chert blend, differentiated from pure brown cherts which are more similar to the intensely coloured varieties. Grey cherts are characterised by their mixed composition, 93-96% SiO2, and elevated Ca at 3–5%. Mottled cherts, extremely common at Bestansur, tend to sit between the standard values for brown and grey cherts.

Table 20.4. Chert colour and average Fe content.

Chert colour	*Average Fe content (%)*
White	0.04
Pale grey	0.07
Mid-grey	0.2
Dark grey	0.54
Black	0.69
Green	0.44
Red	0.53
Yellow	0.6

The colour tones of cherts are determined largely by their Fe content, with higher Fe making cherts darker and/or more intense in tone, as demonstrated in Table 20.4. Colour is also determined by minor elemental contributions to the overall composition, such as Fe (yellow), Al (orange), Fe and K (green), and Fe, K and Al (red). But there is an extent to which colour description fails to address the compositional differences between cherts. The pure cherts are texturally different from those with high Ca content, but the overall colour may be the same. A combined approach of visual and pXRF characterisation of chert types is needed to encourage confidence in raw material classification.

What do we know about the location of the chert sources exploited by the Neolithic inhabitants of Bestansur? Major deposits of grey, red and green cherts occur in the regions of Penjwin and Sargat in the higher Zagros 40km to the northeast of Bestansur (Karim 2004; Karim *et al*. 2015), and there are beds of chert nodules in the Dokan area, 30km north of Bestansur (Al-Barzinjy 2008). Inhabitants at Bestansur will also have been able to use cobbles and nodules from local river beds. A distinctive red chert was used at several Early Neolithic sites of the Zagros region, including Asiab, Ganj Dareh and Abdul Hosein, possibly indicating long-range contacts between these sites (Kozlowski 1999: 63; Kozlowski and Aurenche 2005: 83). At Bestansur, pure red cherts are not common but there is evidence for on-site knapping of small quantities in Trench 7 and occurrences elsewhere at the site (see Fig. 20.23).

Did Neolithic knappers select specific chert and obsidian types for specific tool types? Table 20.5 shows the distribution of tool types across visual chert and obsidian categories, for Bestansur.

Within the chart there are many indications that tool-makers preferred specific raw materials with which to fashion their desired tools, while maintaining a degree of flexibility for most tool types. In a few cases, there was a strong preference for specific materials for specific tools. First, shouldered drills and reamers were often made from a tough, soapy-textured mid-grey chert, chosen for its robustness and ability to withstand pressure and torsion in making and enlarging holes, initially pierced by awls, through thick materials such as hides or leather. Secondly, many chert blades with evident sickle sheen were made from a grey/brown chert with limestone inclusions, showing as elevated Ca and CaCO3 content. This material was chosen because of its ability to take a sharp edge and to endure repeated usage in plant-cutting conditions while maintaining its cutting ability. Thirdly, the highly distinctive Çayönü tools were exclusively made from green/black obsidian, with one exception (Table 20.6), and never in chert.

Characterising the obsidians

As with the cherts, a combined visual and chemical characterisation approach was applied to the obsidian assemblage. Three broad obsidian colour categories were assigned based on the assemblage: O1 – black or dark grey obsidian with a green tinge in transmitted light (when held up to the light by hand); O2 – translucent with or without black or grey tint; O3 – strongly green or grey–green obsidian, with or without striations. Although it is the impurities embedded within the silica matrix that both give the obsidian its colour and determine the chemical fingerprint of obsidian composition, these by-hand specimen identifications alone are not sufficient to identify the provenance of the material. Considerable caution needs to be exercised in attributing significance to visual colours of obsidian, as they can be highly variable depending on the intensity and source of light (Renfrew 1977: 293). Visually, our grey/black obsidians clearly overlap with green obsidian, for example, at the macroscopic level. In order to investigate this issue, a cross-section of all obsidian tools, debitage and unretouched tools was selected for pXRF analysis, as well as all obsidian cores, Çayönü tools, translucent (O2) tools and a high proportion of strongly green-tinted (O3) tools (Table 20.6). At Bestansur, black/grey/green obsidians constitute 97.76% of the assemblage: only 2.24% of the assemblage is visually distinctive from the bulk. A total of 90 recorded fragments were noted for their translucency (O2, 1.87%), and only 0.37% (or 18 tools) were noted for their strong green tint (O3). Although the Shimshara assemblage was dominated by black/grey/green obsidian (99.63%), it also contained 0.37% strongly green obsidian.

Provenance studies of obsidian have flourished in the age of portable technologies, but the attribution of source is still dictated by subtleties in the material. Portable XRF analysis of the chemical composition of obsidian followed the same procedures as those for chert (see above). Inter-instrument variability is a recognised difficulty in the use of pXRF analysers (Goodale *et al*. 2012). Published NIST standard reference samples were used to calculate correction factors to calibrate the data for key elements, in order to achieve comparability with published sources.

The O1 black/grey/green obsidians from Bestansur broadly correlate with the east Anatolian Nemrut Dağ/Bingöl A peralkaline obsidian group, as one might anticipate for this area and period (Campbell and Healey 2018), accounting for 99% of the obsidian that was transported to the settlement (Fig. 20.1).

Both sources produce obsidian in a range of colours, varying from black, grey to green (as in group O3), with an equally heterogeneous composition. The overall chemical difference between the Nemrut Dağ and Bingöl A materials is slight, particularly between the peralkaline deposits at each of the source locations. In a region-wide study of these chemical characterisations, Chataigner (1998: 298–312) demonstrated the dominance of Nemrut Dağ obsidian across the Neolithic Zagros, to the exclusion of Bingöl A obsidian at any sites south or east of Yarim

Table 20.5. Tool types and material categories at Bestansur, calculated as a percentage of tool type total.

Tool group	*Tool type (%)*	*Chert class*																		*Obsidian class*			*Tuff*	
		C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*	*C18*	*O1*	*O2*	*O3*	*T*	*n =*
Blade/bladelet	Retouched blade	4	10	9	8	4	2	2	3	1	2	0	5	10	1	1	0	0	0	38	0	0	0	2184
	Notched	8	13	13	9	5	2	2	4	1	2	1	6	9	1	1	0	0	0	24	1	0	0	592
	Serrated/ denticulated	6	7	8	8	6	3	3	6	0	4	1	6	20	0	4	0	0	0	17	0	1	0	71
	Backed	20	0	20	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	20	0	0	0	5
	Beaked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	1
	Crested	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	1
	Scoop/ handle	40	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Blade with sheen	Blade	1	21	28	18	7	8	4	1	0	3	0	1	6	0	0	0	0	0	1	0	0	0	98
	Notched	0	15	54	0	0	0	0	0	0	0	0	8	23	0	0	0	0	0	0	0	0	0	13
	Serrated/ denticulated	0	22	11	22	0	0	0	33	0	0	0	11	0	0	0	0	0	0	0	0	0	0	9
	Backed	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Scraper	Scraper (other)	14	10	5	0	0	5	0	10	0	5	0	10	5	0	0	0	0	0	38	0	0	0	21
	Blade scraper	13	0	7	7	27	0	0	7	0	0	0	7	0	0	0	0	7	0	13	0	7	7	15
	Blade end scraper	10	9	12	11	4	4	3	4	1	3	1	11	6	0	1	0	0	0	19	0	0	0	93
	Side scraper	23	8	8	15	8	8	0	0	0	8	0	0	8	0	0	0	0	0	15	0	0	0	13
	Flake scraper	7	9	9	10	7	6	8	1	1	1	0	10	6	0	7	0	1	0	14	0	0	0	96
	Notched scraper	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Round/ thumbnail scraper	0	13	0	13	13	0	0	0	0	0	0	0	0	0	13	0	0	0	50	0	0	0	8
	CRF/CTE/core scraper	0	14	14	0	0	0	0	0	0	14	0	0	14	0	0	0	0	0	43	0	0	0	7
Flake	Retouched flake	3	8	8	9	4	1	1	3	0	8	1	4	9	0	4	0	0	0	36	0	1	0	77
	Notched flake	14	0	0	29	0	0	0	0	0	14	0	14	0	0	14	0	0	0	14	0	0	0	7
Point	Point/awl/ drill/borer	7	18	5	16	4	1	3	3	0	5	1	4	7	1	1	0	0	0	22	0	0	0	148
	Shouldered drill	22	6	16	12	2	4	4	6	4	4	0	4	14	0	2	0	0	0	2	0	0	0	51
	Flake borer/point	25	13	13	0	0	0	0	0	0	13	0	0	13	0	13	0	0	0	13	0	0	0	8
	Blade point	17	0	33	0	0	17	0	0	0	0	0	17	0	0	0	0	0	0	17	0	0	0	6
	Reamer/fabricator	16	8	16	0	0	32	0	0	0	0	0	16	0	0	0	0	0	0	8	0	0	0	11
Micro-tool	Burin	0	12	6	6	0	6	0	0	0	0	0	0	18	0	0	0	0	0	48	0	0	0	16
	Diagonal-ended blade/let	12	10	3	6	4	12	3	2	0	3	2	1	10	1	1	0	0	0	30	0	1	0	156
	Trapeze/ trapezoid	0	17	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	6
	Transverse arrowhead	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Crescent/ lunate	60	0	20	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
	Microlith	8	33	0	0	0	0	0	8	0	17	0	8	0	0	8	0	0	0	17	0	0	0	12
Other	Çayönü tool	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	93

Figure 20.1. Map showing location of Early Neolithic sites and major obsidian sources.

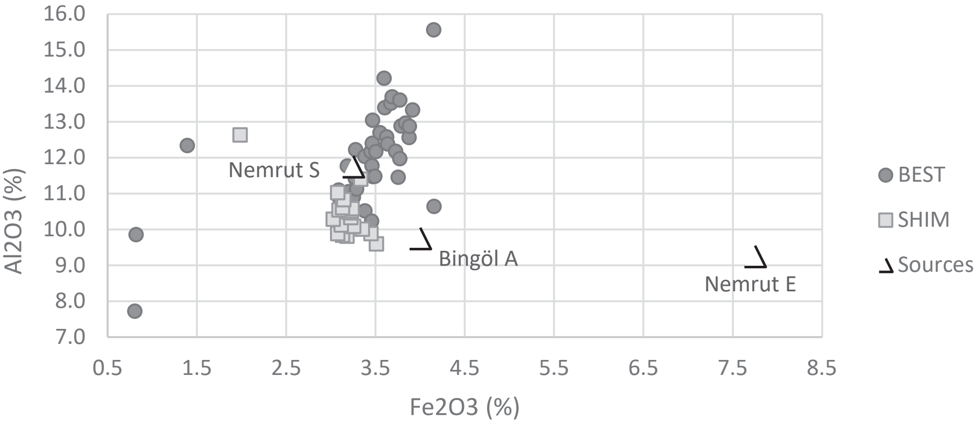


Figure 20.2. Portable XRF analysis to distinguish between the Nemrut Dağ South and Bingöl A obsidians. A biplot of Al2O3 and Fe2O3 weight % using the Poidevin (1998) method.

Table 20.6. (continued on next page) Obsidian items selected for pXRF analysis and result of source determination: BB = Bingöl B, ND= Nemrut Dağ, SD = Suphan Dağ, SS = Sarıkamış South.

Tool	*Trench*	*Context*	*Description*	*Colour*	*Source*
Bestansur					
16	1	1000	Çayönü tool	O1	ND
21	1	1001	Çayönü tool	O1	ND
124	2	1029	Çayönü tool	O1	ND
125	2	1029	Çayönü tool	O1	ND
153	2	1030	Çayönü tool	O1	ND
162	2	1031	Blade core	O1	ND
163	2	1031	Blade core	O1	ND
173	2	1031	Microburin	O1	ND
174	2	1031	Çayönü tool	O1	ND
188	2	1034	Flake scraper	O1	ND
198	2	1034	Çayönü tool	O1	ND
199	2	1034	Çayönü tool	O1	ND
219	2	1036	Notched blade	O1	ND
252	2	1038	Notched blade	O1	ND
276	3	1045	Blade	O1	ND
291	3	1045	Çayönü tool	O1	ND
292	3	1045	Çayönü tool	O1	ND
293	3	1045	Çayönü tool	O1	ND
298	3	1046	Çayönü tool	O1	ND
331	4	1065	Blade core	O1	ND
334	4	1065	Diagonal-ended blade/let	O1	ND
360	4	1067	Çayönü tool	O1	ND
373	4	1069	Diagonal-ended blade/let	O1	ND
374	4	1069	Notched blade	O2	SS
403	5	1070	Çayönü tool	O1	ND
439	5	1073	Core rejuvenation flake	O1	ND
440	5	1073	Çayönü tool	O1	ND
441	5	1073	Çayönü tool	O1	ND
442	5	1073	Çayönü tool	O1	ND
495	5	1074	Core used as scraper	O1	ND
502	5	1074	Graver	O1	ND
504	5	1074	Çayönü tool	O1	ND
505	5	1074	Çayönü tool	O1	ND
520	5	1075	Çayönü tool	O1	ND
534	5	1076	Çayönü tool	O1	ND
548	5	1078	Çayönü tool	O1	ND
550	5	1078	Çayönü tool	O1	ND
581	7	1092	Drill/borer	O1	ND
600	7	1093	Blade	O1	ND
661	7	1175	Notched blade	O2	ND
682	8	1130	Core used as scraper	O1	ND
683	8	1130	Çayönü tool	O1	ND
684	8	1130	Flake scraper	O1	ND
700	8	1131	Çayönü tool	O1	ND
702	8	1133	Çayönü tool	O1	ND
1076	10	1162	Blade (unretouched)	O2	SD
1306	7	1217	Blade(unretouched)	O3	ND
1312	7	1223	Çayönü tool	O1	ND
1313	7	1223	Çayönü tool	O1	ND
1329	7	1223	Çayönü tool	O1	ND
1524	7	1259	Çayönü tool	O1	ND
1576	7	1256	Core trimming element	O1	ND
1822	7	1215	Blade (striped)	O1	ND
1829	7	1215	Blade	O1	ND
1835	7	1215	Blade	O1	ND
1867	7	1212	Flake core	O1	ND
1897	7	1214	Blade	O1	ND
1903	7	1214	Blade	O1	ND
1948	7	1221	Blade	O1	ND
1955	7	1221	Blade	O1	ND
2051	11	1246	Blade (unretouched)	O2	SD
2143	11	1240	Blade	O1	ND
2173	11	1241	Bi-polar core	O1	ND
2362	7	1224	Blade	O1	ND
2383	9	1304	Core used as scraper	O1	ND
2388	9	1304	Çayönü tool	O1	ND
2671	10	1412	Çayönü tool	O1	ND
2694	10	1412	Çayönü tool	O1	ND
2695	10	1412	Çayönü tool	O1	ND
2740	9	1303	Çayönü tool	O1	ND
2811	10	1312	Core used as scraper	O1	ND
2815	10	1312	Blade	O1	ND
2816	10	1312	Diagonal-ended blade/let	O1	ND
2833	10	1312	Blade	O1	ND
2862	10	1312	Blade	O1	ND
2928	10	1315	Blade (striped)	O1	ND
2931	10	1315	Blade	O1	ND
2937	10	1321	Blade	O1	ND
2944	9	1333	Blade	O1	ND
3001	10	1330	Bullet core	O1	ND
3086	10	1330	Blade	O1	ND
3087	10	1330	Blade	O1	ND
3136	9	1344	Blade	O1	ND
3137	9	1344	Blade	O1	ND
3178	9	1308	Blade (striped)	O1	ND
3181	9	1308	Blade	O1	ND
3189	10	1331	Blade	O1	ND
3203	10	1331	Bullet core	O1	ND
3204	10	1331	Bullet core	O1	ND
3254	10	1331	Blade	O1	ND
3256	10	1331	Blade	O1	ND
3270	10	1331	Blade	O1	ND
3433	9	1354	Blade	O1	ND
3458	10	1402	Blade	O1	ND
3463	10	1402	Blade	O1	ND
3561	9	1340	Blade	O1	ND
3567	9	1340	Blade	O1	ND
3822	13	1370	Blade	O1	ND
3847	13	1373	Blade	O1	ND
3859	13	1386	Blade	O1	ND
3869	13	1377	Blade	O1	ND
3875	13	1489	Blade	O1	ND
3912	10	1422	Blade	O1	ND
4546	10	1534	Çayönü tool	O1	ND
4816	10	1620	Blade	O1	ND
4817	10	1620	Blade	O1	ND
5335	10	1409	Çayönü tool	O1	ND
5345	10	1409	Blade	O1	ND
5430	12	1526	Çayönü tool	O1	ND
5777	10	1727	Çayönü tool	O1	ND
5935	10	1752	Core trimming element	O1	ND
Shimshara					
20	Section	1276	Beaked blade	O1	ND
21	Section	1276	Beaked blade	O1	ND
32	Section	1276	Notched blade	O1	ND
33	Section	1276	Notched blade	O1	ND
41	Section	1276	Core trimming element	O1	ND
48	Section	1276	Blade	O1	ND
115	Section	1276	Blade	O1	ND
116	Section	1276	Blade	O1	ND
117	Section	1276	Blade	O1	ND
221	2	1658	Pierced Çayönü tool	O1	ND

Tool	*Trench*	*Context*	*Description*	*Colour*	*Source*
253	1	1653	Complete Çayönü tool	O1	ND
260	1	1660	Blade (unretouched)	O3	ND
349	1	1632	Blade	O1	ND
350	1	1632	Çayönü tool	O1	ND
351	1	1632	Çayönü tool	O1	ND
352	1	1632	Çayönü tool	O1	ND
385	1	1634	Flake scraper	O1	ND
389	1	1634	Çayönü tool	O1	BB
390	1	1634	Çayönü tool	O1	ND
397	1	1649	Blade	O1	ND
398	1	1649	Çayönü tool	O1	ND

Tepe in Upper Mesopotamia. Recent investigations have reanalysed material and are building a more nuanced understanding of the distribution of obsidians across Southwest Asia, drawing on high resolution geochemical data and least-coast pathway analyses to map out networks of exchange. These studies have emphasised the dominance of Bingöl obsidians particularly at sites in Anatolia and Upper Mesopotamia in the Early Neolithic, and further south in the Late Neolithic (Carter *et al.* 2013a; Barge *et al.* 2018; Campbell and Healey 2018). Distinctions between Nemrut Dağ and Bingöl A obsidians can be made using key elemental differences from the source data, through a comparison of Al_2O_3 and Fe_2O_3 compounds (Fig. 20.2; Poidevin 1998: 142) and more recently using modern portable EDXRF analysers in the concentrations of Al, Fe, Ti, Mn and Zr (Frahm 2012; Frahm and Tryon 2018). Two pieces of obsidian from Zarzi cave have now been identified as originating from the Nemrut Dağ source (Frahm and Tryon 2018).

Comparison of the compositions of the Bestansur and Shimshara obsidians reinforce the case for the dominance of Nemrut Dağ obsidian distribution to Zagros sites in the Early Neolithic, highlighting the almost exclusive use of obsidians gathered from the exterior slopes of Nemrut Dağ (Fig. 20.3; corresponding with Frahm 2012 cluster 1; see also Robin *et al*. 2016). The rare Aceramic Neolithic tools of obsidian at Abdul Hosein, East Chia Sabz and Chogha Golan in the Iranian Zagros have also been suggested to originate from Nemrut Dağ sources (Pullar *et al.* 1986; Zeidi *et al*. 2012; Darabi and Glascock 2013; Khazaee *et al*. 2014), as has obsidian from the Deh Luran Neolithic sites in southwest Iran (Renfrew *et al*. 1966; Renfrew 1977), suggesting a major network link with this source.

The difficulty in identifying obsidians from sites in Iraq, as elsewhere, has been highlighted by Carter *et al*. (2013) and due caution must be taken in the use of pXRF for archaeological provenance studies, as there continue to be issues with inter-instrument variability (Goodale *et al*. 2012). Nonetheless, correspondence analysis of the published values for four key elements (Rb, Sr, Zr and Zn) permits us to assess the Bestansur and Shimshara obsidians in comparison with a wide

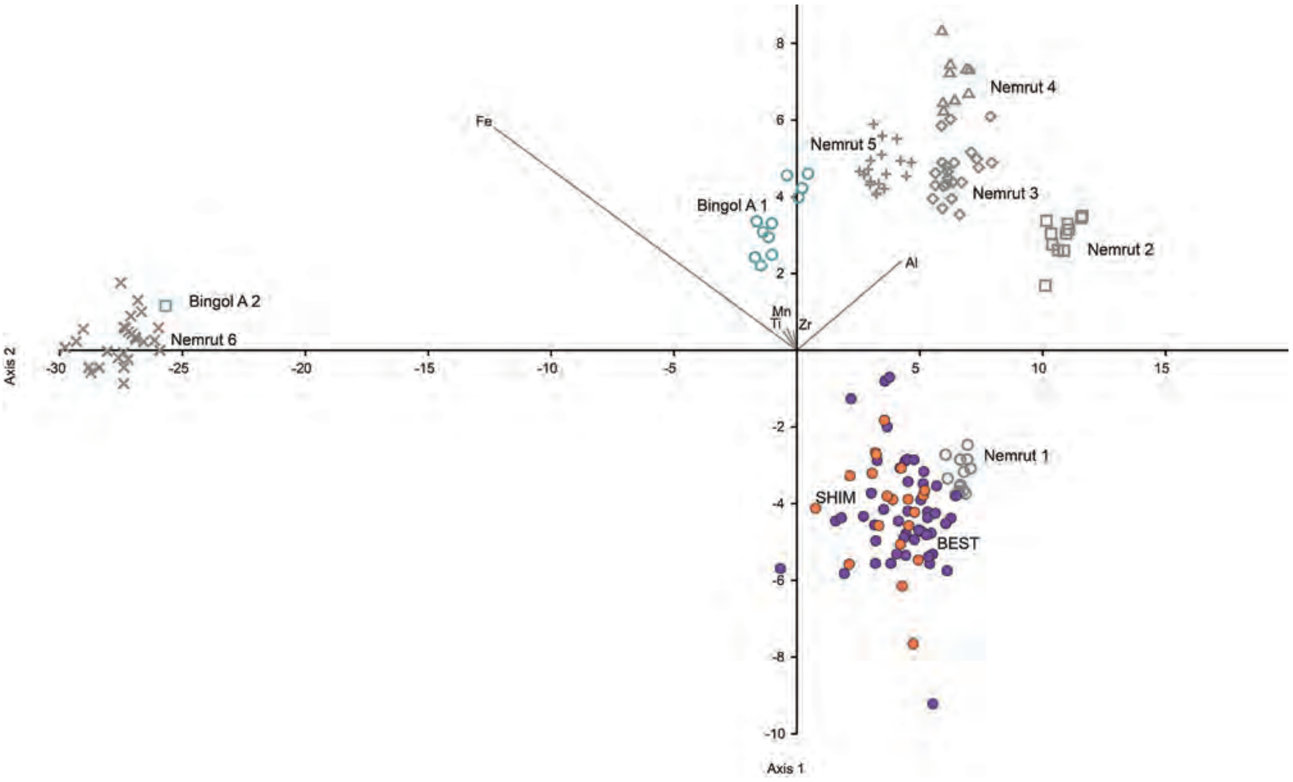


Figure 20.3. Portable XRF analysis to distinguish between the Nemrut Dağ South and Bingöl A obsidians. Linear discriminant analysis depicting statistical groupings according to Al, Fe, Ti, Mn, and Zr compared with data from Frahm (2012).

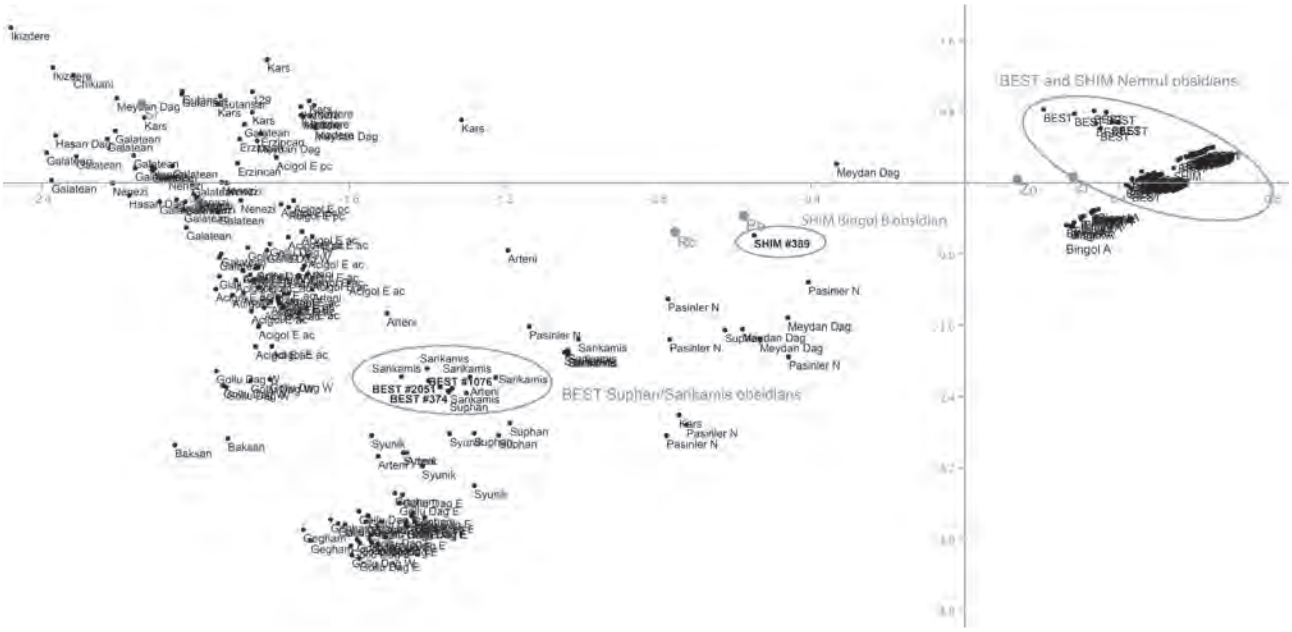


Figure 20.4. Correspondence analysis for obsidian sources and artefacts (based on pXRF results for elemental concentrations of Rb, Sr, Zr, Zn and Pb compared with data compiled in the Obsidatabase: https://www.mom.fr/obsidienne/).

range of known sources. This assessment reinforces the attribution of the majority of obsidian artefacts to the Nemrut Dağ source.

Three translucent obsidian blades from Bestansur were identified as bearing distinctively different chemical signatures from the Nemrut Dağ material (BEST Tools 374, 1076 and 2051; Fig. 20.4), as does a large fragment of a Çayönü tool from Shimshara (SHIM Tool 389; Fig. 20.5).

The chemical signatures of the three Bestansur blades correspond with the published values for samples from Suphan Dağ, to the north of Lake Van (Blackman 1984; Oddone *et al.* 1997; Delerue 2007) and the Sarıkamış South (Sarıkamış 1) source on the edge of the Araxes Valley (Keller *et al.* 1996; Chataigner and Gratuze 2014a). Suphan Dağ yielded translucent obsidian that is highly variable in its composition (Blackman 1984: 26). Excavations at the Late Ubaid site at Tell Nader, near Erbil, have recovered "translucent purple-grey obsidian", four samples of which have been attributed to the Suphan Dağ source using EDXRF (Carter *et al*. 2013b). Obsidian from Sarıkamış South has been identified at sites from as early as the tenth millennium BC in Armenia (Chataigner and Gratuze 2014b: 59–60) and possibly as far south as Shanidar in the Upper Palaeolithic (Campbell and Healey 2018: 149). The chemical difference between Suphan Dağ, Sarıkamış South (1) and Sarıkamış North (2) can be discerned in the ratios of Ba/Zr versus Ba/Sr (Fig. 20.6; Chataigner and Gratuze 2014a).

Bestansur Tools 1076 (Trench 10) and 2051 (Trench 11) both compare well with the average values from Suphan Dağ, whereas BEST Tool 374 (Trench 4) is likely to come from the Sarıkamış South deposits. The latter is a notched blade from a well-stratified Early Neolithic external surface, and demonstrates the continued circulation of this material in spite of the comparative abundance of Nemrut Dağ material in the eighth millennium BC. Tools 1076 and 2051, however, are from more mixed deposits and may represent the eroded horizons of later Neolithic activity at the site; Tool 2051 was recovered from an obsidian-rich context (C1246), which also contained six fragments of Çayönü tools. Nonetheless, the chemical correlations between Bestansur and the Suphan Dağ material raise the possibility that this

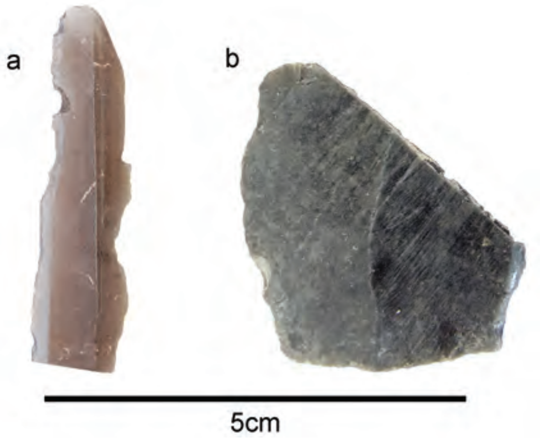


Figure 20.5. a) Tool 374 from Bestansur T4 C1069, made from obsidian possibly from Sarıkamış South; b) Tool 389 from Shimshara C1246, made from obsidian likely from Bingöl B.

source could have been in use earlier than previously known, with the resultant material passing through the same networks as the Nemrut Dağ obsidians from the late Aceramic Neolithic onwards.

One Çayönü tool from Shimshara, SHIM Tool 389, has no parallels in either group (Fig. 20.4). The chemical composition of this black obsidian is very similar to the Bingöl B, calcalkaline source in east Anatolia. This source is known to have been in use from the ninth millennium BC, with its materials distributed throughout the Zagros from the eighth millennium BC (Chataigner 1998: 298). The results correlate with Renfrew's findings from the Danish investigations at Shimshara in the 1950s (Mortensen 1970) and confirm suspicions raised by Campbell and Healey (2018), although the proportion of Bingöl B obsidian in the analysed assemblage from CZAP investigations at Shimshara is very low (less than 5%). Bingöl calcalkaline obsidian is well documented across the Neolithic Zagros and spread south and east of Shimshara, occurring in small quantities at Jarmo, Sarab, Guran and as far south as Ali Kosh (Chataigner 1998: 302–303). Distributed through the same networks as the Nemrut Dağ obsidian, and present at sites that are contemporary with the later levels at Bestansur, it is therefore notable that Bingöl B obsidian has not yet been identified amongst the Bestansur obsidian, even amongst Çayönü tools.

Characterisation of obsidian from Bestansur and Shimshara confirms the participation of both sites in Zagros-wide networks with suppliers of obsidian almost exclusively from eastern Anatolian sources, in contrast to Early Neolithic communities of the north Levantine region to the west, such as Abu Hureyra, Sheikh Hassan, El Kowm 2 and Mureybet, who had access to obsidian from both east and central Anatolian sources (Cauvin 1991a; Nishiaki 1993; Chataigner 1998; Carter *et al*. 2013a; Healey 2014; Campbell and Healy 2018). The geographic locations of Shimshara and Bestansur confirm that the distribution of obsidian from east Anatolia into the Iranian Zagros to the south and east was conducted principally along the western flanks of the Zagros chain. This is attested at sites such as Abdul Hosein and East Chia Sabz (Khazaee *et al*. 2014), and at sites on the western plains of the southern Zagros such as Ali Kosh and Chagha Sefid (Renfrew 1977), with communities at Shimshara and Bestansur acting both as consumers and, no doubt, also as transmitters of materials, practices and ideas to their contemporaries living in the high mountains and low plains close by.

Estimating the volume of lithics

In order to investigate patterns of consumption, it is important to establish the absolute quantities of chert and obsidian in use at Bestansur and Shimshara through the Early Neolithic centuries. The total counts of all chert and obsidian pieces (tools and debitage) recovered from both sites are displayed in Figure 20.7, while Figure 20.8 shows the chert and obsidian totals by weight. Figure 20.9 draws from these two figures the average weights of pieces of chert and obsidian, for both sites. The significantly lower average weight of obsidian pieces, as against chert, in all trenches at both sites is indicative of the valued nature of obsidian over chert due to its remote origin. Obsidian knappers made more careful use of their raw material than chert knappers did (see also Fig. 20.16), as attested at many other Neolithic sites of Southwest Asia (Caneva *et al*. 1994: 254). Evidence from a range of sites indicates that knappers located more remotely from obsidian sources made increasingly careful use of this resource, as demonstrated by a correlation of decreasing mean weight of debitage pieces with increasing distance from source, an attribute interpreted by Renfrew as indicative of a 'down-the-line' model of exchange (Renfrew 1966; 1977: 295-296).

As every excavated context has a recorded volume in litres, we can calculate the density of chipped stone per litre across the sites. At Bestansur the average density of chipped stone is 0.06 chert pieces and 0.01 obsidian pieces per litre of excavated soil, which equates to 60 fragments of chert and ten of obsidian per excavated cubic metre. But when we examine the main excavation areas at Bestansur, where rigorous sampling procedures were conducted, we see much higher densities of lithic recovery, up to 200 pieces per cubic metre with notable variation according to type of excavated context (Fig. 20.10; Iversen 2015). These density numbers broadly fit with those articulated in Voigt's (1983: table 34) and Szymczak's (1996: table 4) tables of lithic densities at key Neolithic sites of the EFC, including M'lefaat, Jarmo, Ali Kosh and Chagha Sefid.

Within Neolithic deposits excavated and sampled from Trenches 7, 9, 10 and 12/13 at Bestansur, excluding topsoil, the average weight of lithics is 0.1043g/litre. This lithic density is lower than that at Neolithic Çatalhöyük where, using excavating and sampling procedures similar to ours at Bestansur (indeed originally devised and applied by us at Çatalhöyük since 1993), an average density of 0.1856 g/litre has been calculated (Cessford and Carter 2005: 307). The excavation of extensive midden deposits at Çatalhöyük, and their absence so far at Bestansur, is likely to lie behind the higher density figure. On the basis of this figure, the total site volume and the duration of occupation, Cessford and Carter (2005: 309) estimate that *c*. 130 metric tons of obsidian were 'consumed' at Çatalhöyük during the lifetime of the site, at a rate of at least 100kg per year.

For the sake of argument, estimating the putative volume of the Bestansur Neolithic settlement (excluding the Iron Age levels) as 10,000m^3 (100 × 100 × 1m) gives a figure of 600,000 pieces of chert and

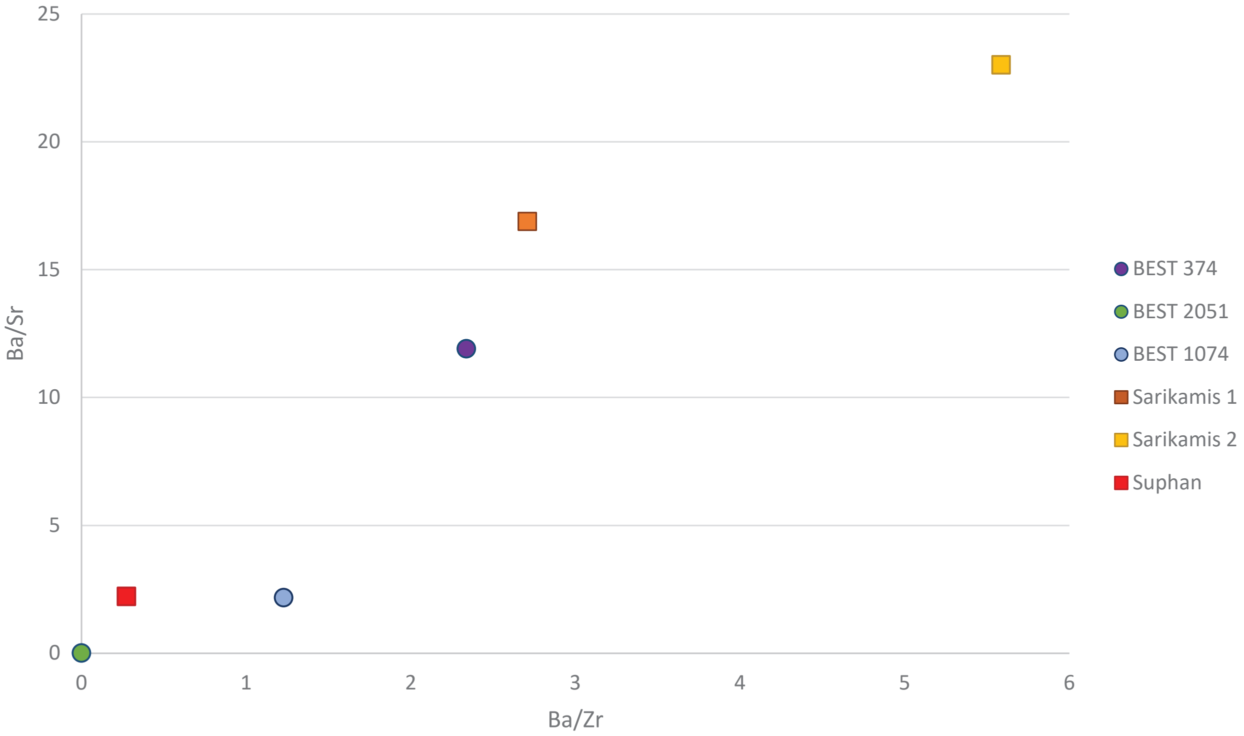


Figure 20.6. Portable XRF analysis to compare Bestansur Tools 374, 1074 and 2051 with the Suphan Dağ, Sarıkamış South (1) and Sarıkamış North (2) sources (after Chataigner and Gratuze 2014a).

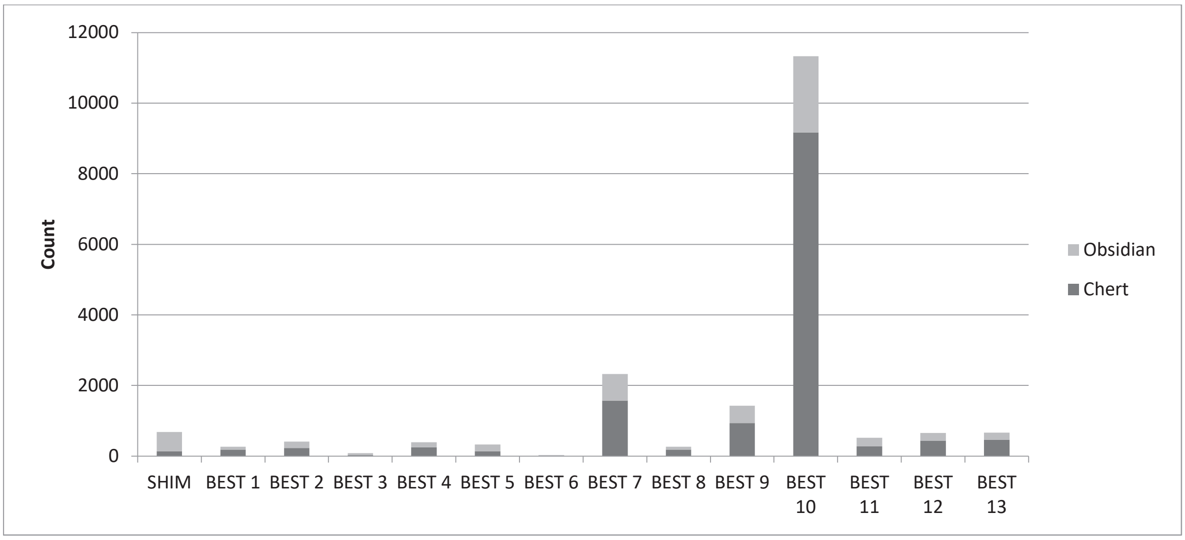


Figure 20.7. Total counts of chipped stone pieces at Shimshara and Trenches 1–13 at Bestansur.

100,000 pieces of obsidian currently within the site, with a combined total weight of *c.* 950kg, of which *c.* 850kg is chert and *c.* 100kg is obsidian. Given that occupation at Jarmo is longer-lasting than at Bestansur, this figure is in broad agreement with the calculation of a total of 196kg of obsidian consumed at Jarmo through its entire occupation (Braidwood 1983: 285, contra the original estimate of Renfrew *et al.* [1966: 52] of 4 metric tons of obsidian consumed at Jarmo), as well as with Renfrew's (1977: 299) estimate of 200kg of obsidian consumption through the entire Neolithic occupation of Chagha Sefid on the Deh Luran plain.

Estimating the duration of occupation at Bestansur is challenging due to the shortage of good radiocarbon dates (Chapter 11) and the fact that the earliest date of occupation remains to be established, but the lithic repertoire and the available radiocarbon dates agree

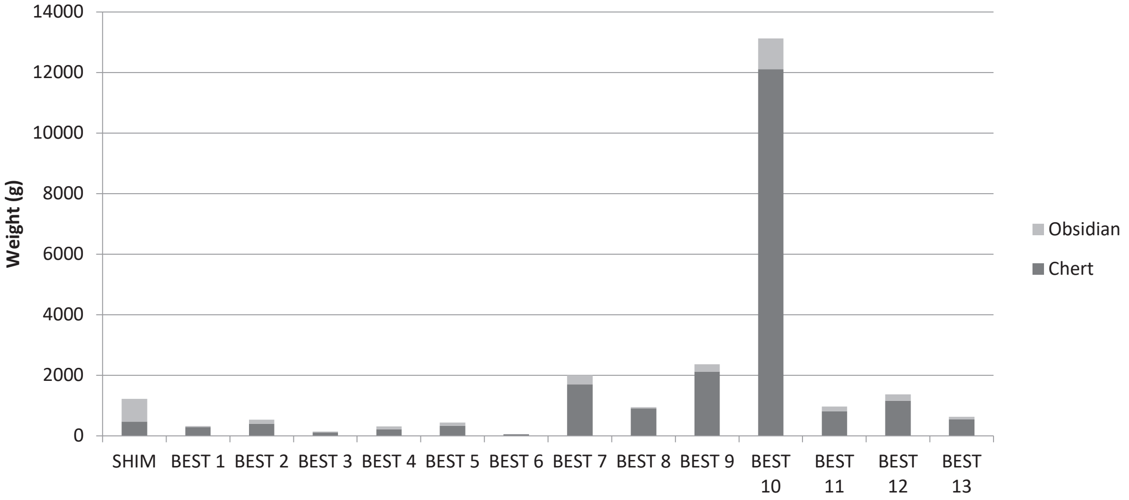


Figure 20.8. Total weights of chipped stone pieces at Shimshara and Trenches 1–13 at Bestansur.

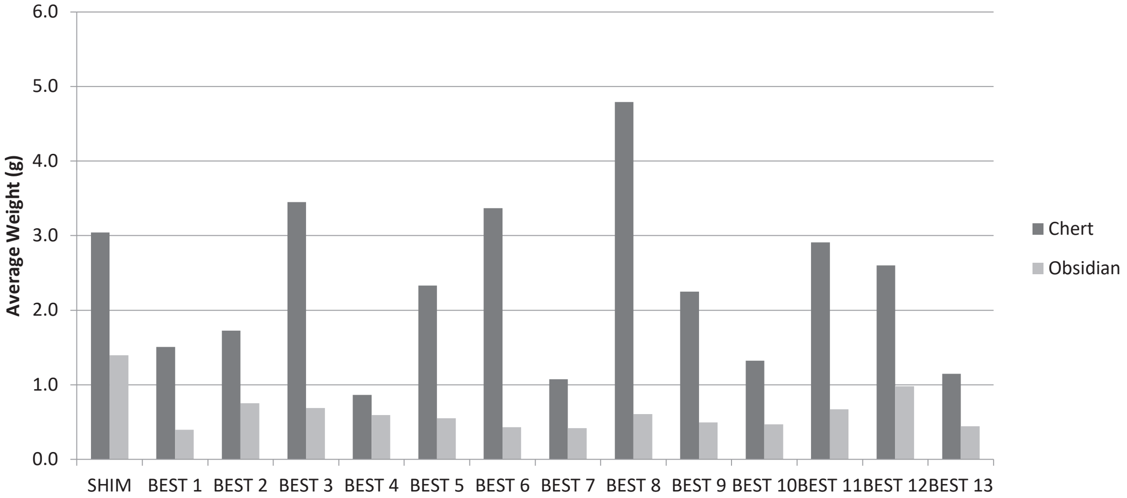


Figure 20.9. Average weights of pieces of chert and obsidian at Shimshara and Trenches 1–13 at Bestansur.

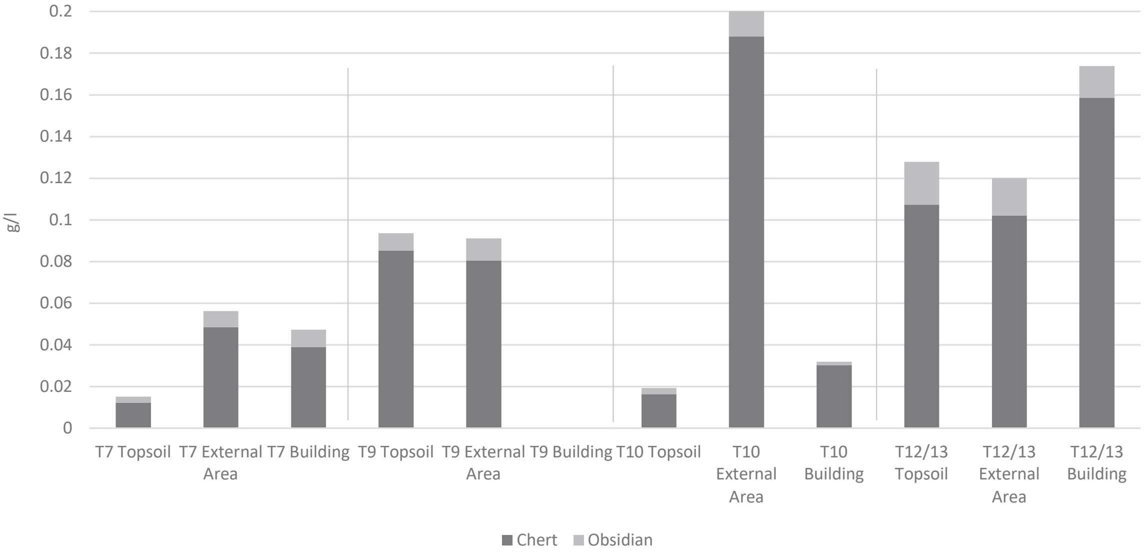


Figure 20.10. Densities of chipped stone per litre across the major excavated trenches and context types at Bestansur.

on an eighth millennium BC dating for the entire sequence of Neolithic occupation, which may be of the order of >600 years. From these approximate figures, it is clear that the quantities of obsidian reaching Bestansur on an annual basis would have been far below the Çatalhöyük level of >100kg per annum. No more than 0.2kg of obsidian per annum would be needed to account for the 100kg total spread over 500 years, but it is much likelier that obsidian arrived at Bestansur more episodically than these figures suggest, in particular with increased volumes of traffic towards the end of the site's occupation when Çayönü tools become more common. If we reduce the site's occupation to 200 years, it would require a total of 0.5kg per annum of obsidian to reach the site. Even if we quadruple the site's volume and the density of obsidian per m^3, and reduce its occupation to a single century, we have only 16kg of obsidian per annum reaching the site, easily portable by a single individual on a single trip. Again, these figures agree in scale with those calculated by Linda Braidwood (1983: 287) for the amounts of obsidian reaching Jarmo, at less than 1kg per annum, and with those calculated by Renfrew (1977: 299) for obsidian reaching Chagha Sefid.

These estimates outline the broad parameters of the volumes of traffic in obsidian along the Zagros flanks, and encourage us to be cautious in envisaging intensities of exchange amongst Neolithic communities of the region. It is feasible that all the obsidian reaching Bestansur did so through low-key networks of engagement by elements of neighbouring communities in regular contact with each other, for example at the intersection of community hunting and gathering territories or at trans-regional social occasions when groups of communities foregathered for seasonal feasts and festivities, rather than through a system of highly organised, even 'commercial', exchange as originally posited by Renfrew *et al.* (1966: 52) for the Jarmo and Shimshara obsidian.

In any case, the arrival of new consignments of glossy black nodules or roughed-out cores of obsidian from far-away places is likely to have been greeted with respect, regarded as 'pieces of places' to use Fontijn's phrase (2002), and the carriers of obsidian themselves might accrue distinction thereby (Carter 2011: 9). Were they bringing finished artefacts with them, such as Çayönü tools made by specialist knappers for example, their status as messengers of the exotic would be further enhanced. Beyond their exotic status, moreover, carriers of obsidian blocks, blanks and tools served as vehicles of communication and contact between widely separated Early Neolithic communities across the entire Zagros-Taurus zone. The distribution of Çayönü tools, for example, spans an enormous region of the northern and Eastern Fertile Crescent, from the Upper Tigris in Anatolia to the Qara Su in Iran and from the shores of Lake Urmia to the steppe west of the Euphrates in Syria (Kozlowski and Aurenche 2005: fig. 1.3.4.2). These large-scale networks of interaction (Coward 2010; 2013; Ibáñez *et al.* 2015; Ortega *et al.* 2016) enabled a steady diffusion of social and technological practice as widely dispersed human communities addressed the challenges and opportunities afforded them by the newly shaping environments of the Early Holocene world. Increasingly sophisticated modelling of Neolithic networks now indicates that simple exchange models, such as Renfrew's 'down-the-line' model, fail adequately to characterise the nature of these networks. More nuanced and systematic interpretations, using agent-based modelling and network analysis coupled with ethnographic analogy, emphasise the importance of "long distance links between non-neighbouring villages" in underpinning the distribution of obsidian across Neolithic Southwest Asia (Ortega *et al.* 2016: 11).

By contrast, it is likely that the majority of nodules and blocks of chert were brought to Bestansur and Shimshara from local sources, within 1–40km of the sites themselves and within a day or two walking distance. The most frequently attested local cherts at Bestansur, including the mottled grey and grey–brown varieties, were used for production of almost all tool types, while rarer varieties, including pure red, black and green cherts, were brought from places further afield such as Penjwin and beyond in the high Zagros up to 100km distant. Given the evident mobility at least of elements of the population at Bestansur and Shimshara, attested in the broad range of hunted animals for example, Early Neolithic peoples of the area would have had intimate knowledge of the resources available to them over extensive regions of the EFC.

A significant attribute of the Bestansur assemblage is the negligible quantities of items of chert and obsidian with any trace of cortex. At other sites, such as Aceramic Neolithic Çayönü, for example, 10–20% of debitage pieces were classified as decortification flakes in all levels (Redman 1982: 29). Their almost complete absence from the Bestansur and Shimshara assemblages suggests that decortification, both of chert and obsidian, was taking place either in areas of the site not yet excavated, perhaps at the fringes of the settlements where this messy task and hazardous residues would least impinge upon the inhabitants or, more plausibly, at the source areas themselves, which would have the added benefit of reducing the volume and weight of material to be carried back to the settlement or, rather, of maximising the value of the load to be carried. Similar interpretations have been suggested for the low representation of cortex in the lithic assemblages at Jarmo (Braidwood 1983: 287), Chogha Golan in the west-central Zagros (Zeidi and Conard 2013: 320), Chagha Sefid in southwest Iran (Renfrew 1977: 297) and Hajji Firuz in northwest Iran (Voigt 1983: 227).

A tool is born: technologies of production

The Early Neolithic represents an apogee of lithic technological achievement in prehistoric Southwest Asia. During this period, skilled artisans produced a wide range of fine tools, many of them custom-made for specific purposes, others serving more for a multiplicity of applications. The scale and competence of chipped stone production throughout the Early Neolithic is impressive, as we aim to investigate for Bestansur throughout this chapter. It is difficult for us to appreciate the full significance of stone technologies, chipped and ground, for communities living in an era when ceramics and metals were unknown. The introduction of pottery and of significant copper metallurgy from the Late Neolithic onwards transformed the social and economic lives of prehistoric societies of Southwest Asia, stimulating major changes in fields such as food production, storage and cooking, as well as in a host of agricultural and craft pursuits. These new technologies in time underpinned the development of increasingly complex and hierarchical societies. But all that lay far in an unimaginable future from the perspective of the societies of the Zagros in the eighth millennium BC, who we should view as highly successful hunter-gatherers in tune with the full range of natural environments in which they dwelt, as well as proto-farmer-herders on the cusp of new Neolithic life-styles.

Approaching lithic technologies

The manufacture of chipped stone tools is a skilled process, requiring both an ability to conceptualise a finished product prior to starting its creation and a fine manual dexterity. Like sculpture in stone, lithic tool production is an essentially reductive process, whereby the artisan must 'see the tool' within the block of chert or obsidian held in the hand, and possess the competence to reduce the block or nodule into the envisioned tool or at least a satisfactory approximation of it. Moreover, the artisan must be sensitive to the future user, context and cost of the desired chipped stone tool within its composite situation.

Many of the chipped stone tools produced in the Early Neolithic at Bestansur and Shimshara were designed as integral components of multi-material tools and implements, whereby the chert and obsidian elements constituted barbs, edges, blades and points embedded within hafts, shafts and handles made of bone, antler or wood, themselves probably more valued and curated than the lithic components (Keeley 1982). Rare examples of such hafts come from burial contexts in the northern Zagros at Shanidar Cave, level B1, and from nearby Zawi Chemi Shanidar (Solecki and Solecki 1963; Solecki *et al*. 2004: fig. 45).

Larger tools such as blade and flake scrapers, shouldered drills and reamers, need not have been hafted and could have been used as stand-alone tools held in the hand. In a seminal article, Lawrence Keeley (1982) demonstrated the importance in lithic studies of distinguishing hafted tools from non-hafted tools, on the grounds that hafted tools would be more likely encountered archaeologically at locations where hafts were being retooled – for example, new chert blades inserted into a sickle haft to replace broken blades – while unhafted tools would be more likely recovered from contexts proximate to their actual use. This distinction is one we recurrently address in considering the lithics from multiple contexts at Bestansur.

The Early Neolithic chipped stone artisan had to have intimate familiarity with the raw materials, knowing how to select particular types, sizes and shapes of raw material for the production of specific tool types without being wasteful of cherished raw materials, especially a concern with obsidian brought from afar. He or she will have been trained in chipped stone production by experts who themselves will have drawn on generations of lithic expertise reaching back into the Palaeolithic. In recent decades the sequences of lithic tool production have widely been situated within the theoretical framework of the *chaîne opératoire* (Pelegrin *et al*. 1988; Schlanger 1994; Shott 2003; van Gijn 2010), an approach which stresses the culturally-situated contexts of stone tool manufacture. Critical to this approach is an appreciation of the zone between limitation and opportunity afforded to the artisan by the nature of his or her task and of the raw materials at hand. Precisely within this zone lies the scope for technological choice, which will be differentially exploited by individual stone-workers on the basis of their own aptitudes, skills and learned practices. Even where chipped stone tool assemblages appear to be highly standardised, as in the case of Çayönü tools for example, there is scope for exploration of variability and the recurrent exercise of individual choice.

Of major significance for Early Neolithic assemblages, such as the Bestansur and Shimshara ones studied here, is the evidence for a high degree of care and skill dedicated to the production of virtually all chipped stone tools, in marked contrast to the workaday production of most (but not all) chipped stone tools in later prehistoric and historic times (van Gijn 2010: 199). Both in the knapping of tool blanks or shapes and in the often highly refined retouching of tool edges, Early Neolithic artisans expended considerable time and skill to achieve their desired end. This commitment strongly suggests that lithic artisans enjoyed a well-developed aesthetic sense in conceptualising, shaping and refining their stone tools. Very occasionally we have the privilege of recovering rich evidence for this degree of skill and commitment, as in the deposit of *c*. 800 tiny fragments of chert micro-bladelets found in C1172 in Trench 7.

Table 20.7. Chipped stone tool typology for Bestansur and Shimshara.

Tool/debitage	*Blade or bladelet, unretouched*
Blade tools	Blade or bladelet, retouched
	Blade or bladelet, notched
	Blade or bladelet, serrated or denticulated
	Blade or bladelet, backed
	Blade or bladelet, beaked
	Blade or bladelet, crested
	Scoop/handle
Blade tools with sheen	Blade
	Blade, notched
	Blade, serrated/denticulated
	Blade, backed
Scrapers	Scraper (other)
	Blade scraper
	Blade end scraper
	Side scraper
	Flake scraper
	Notched scraper
	Round/thumbnail scraper
	Crf/cte/core frag reused as scraper
Flake tools	Flake, retouched
	Flake, notched
Pointed tools	Point/awl/drill/borer
	Shouldered drill
	Flake borer/point
	Blade point
	Reamer/fabricator
Micro-tools	Burin
	Diagonal-ended blade/let
	Trapeze/trapezoid
	Transverse arrowhead
	Crescent/lunate
	Microlith
Çayönü tools	
Cores	Core, blade/let
	Core, flake
	Core rejuvenation flake/core trimming element

Articulating an Early Neolithic tool typology for Bestansur and Shimshara

The lithic industry for Bestansur and Shimshara is dominated by blade technology. Almost all tools are in the form of blades or bladelets, or comprise a modified form thereof. According to Binder's (2007: 237) classification, blades can be defined as micro-bladelets (4–8.5mm in width), bladelets (8.6–13mm in width) and blades (>13mm in width). The full tool typology for both sites is presented in Table 20.7. In summary, tools can be grouped according to their basic roles, including cutting (blades), scraping (scrapers), piercing or drilling (points, awls, drills, piercers, reamers) and other less evident functions (Çayönü tools, micro-tools, miscellanea).

Blades were modified for a wide range of specific purposes by means of retouch, notching or denticulation, each of which provides clues as to the intended use of the tool (Figs 20.11–20.13). Designed to strengthen otherwise brittle edges, the retouch of blades varies from occasional nibbling, often hard to distinguish from use-wear or post-depositional edge damage, to dense intersecting networks of fine steep retouch as best attested on Çayönü tools. Blades with characteristic sheen were clearly used for repeated cutting of plant materials and are conventionally interpreted as sickle blades. In addition, many blades with sheen have traces of a bituminous fixative indicating that they were attached to a handle or haft of some kind. A wide range of scraping tools is found at both sites, including blade end scrapers, side scrapers, thumbnail scrapers, flake scrapers and exhausted cores and core trimming elements retouched and used as scrapers. Notched blades, very common at Bestansur, may have served multiple roles, as cutting tools and as scrapers for whittling lengths of wood, for example as arrows. Piercing tools were made in a wide variety of shapes and sizes, ranging from extremely delicate micro-drills to sizeable shouldered drills and reamers, almost all of them manufactured on blades by chipping and retouching from one or both sides in order to achieve a point. In the majority of cases, the fine pointed end of piercing tools is missing, broken during use.

Micro-tools are not common at either Bestansur or Shimshara with one exception, the diagonal-ended bladelet. Geometric microliths, such as trapezes and lunates, as well as burins, occur in very small numbers and are clearly not a major component of the tool typology of either Bestansur or Shimshara. Obsidian Çayönü tools are found at both sites, as discussed in detail below.

The blade and bladelet technology at Bestansur was produced by almost universal use of pressure flaking, both in the removal of blades from prepared cores and in the fine retouching of tools. The technique of pressure flaking, as opposed to percussive techniques of tool blank detachment from cores, was developed from the earliest phase of the Neolithic, at *c.* 9000 BC, at sites on the Upper Mesopotamian steppe such as M'lefaat, Qermez Dere and Nemrik (Dittemore 1983; Ohnuma 1993; Inizan and Lechevallier 1994; Wilke 1996; Binder 2007), on imported obsidian blades at Early Neolithic Taurus sites such as Göbekli Tepe (Carter *et al*. 2013a: 567), as well as in the high and low Zagros at Early Neolithic sites such as Sheikh-e Abad, Asiab, Ganj Dareh, Abdul Hosein, Karim Shahir, Ali Kosh, Chogha Golan and Satu Qala (Howe 1983; Pullar 1990: 110; Ohnuma 1993; Hildebrand 1996; Kozlowski and Aurenche 2005: 23; Vahdati Nasab *et al*. 2013b; Zeidi and Conard 2013; Maeda and Pappi 2019). At Çayönü, pressure technology commences in the Channelled Building phase at *c.* 8500 BC,

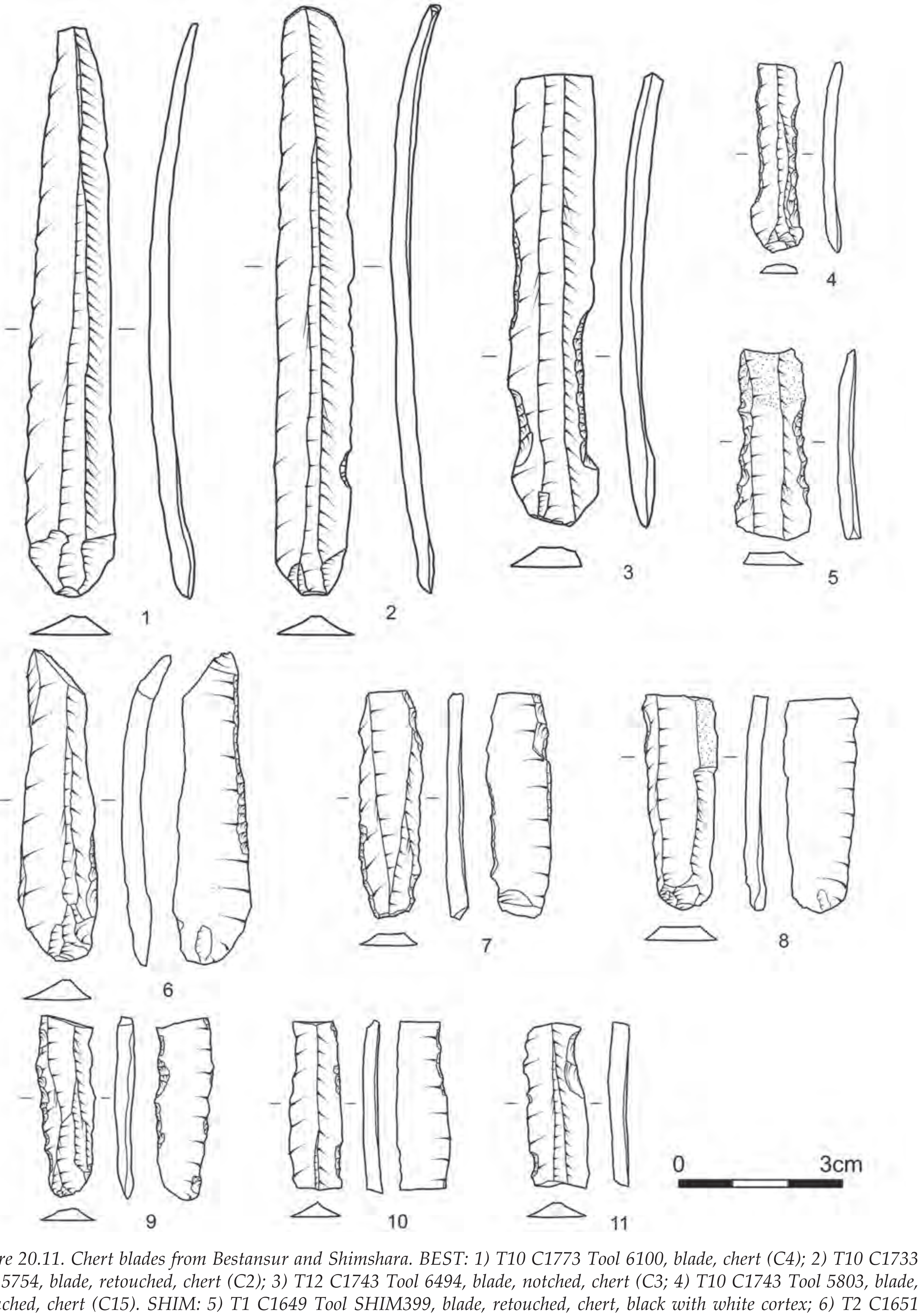


Figure 20.11. Chert blades from Bestansur and Shimshara. BEST: 1) T10 C1773 Tool 6100, blade, chert (C4); 2) T10 C1733 Tool 5754, blade, retouched, chert (C2); 3) T12 C1743 Tool 6494, blade, notched, chert (C3; 4) T10 C1743 Tool 5803, blade, retouched, chert (C15). SHIM: 5) T1 C1649 Tool SHIM399, blade, retouched, chert, black with white cortex; 6) T2 C1651 Tool SHIM289, blade, retouched, chert, pale brown; 7) T1 C1632 Tool SHIM333, blade, retouched, chert, green/grey; 8) T1 C1634 Tool SHIM369, blade, chert, mid grey; 9) T1 C1634 Tool SHIM370, blade, retouched, chert, dark grey/brown; 10) T2 C1651 Tool SHIM290, blade, chert, pale green/grey; 11) T1 C1649 Tool SHIM402, blade, retouched, chert, yellow/brown.

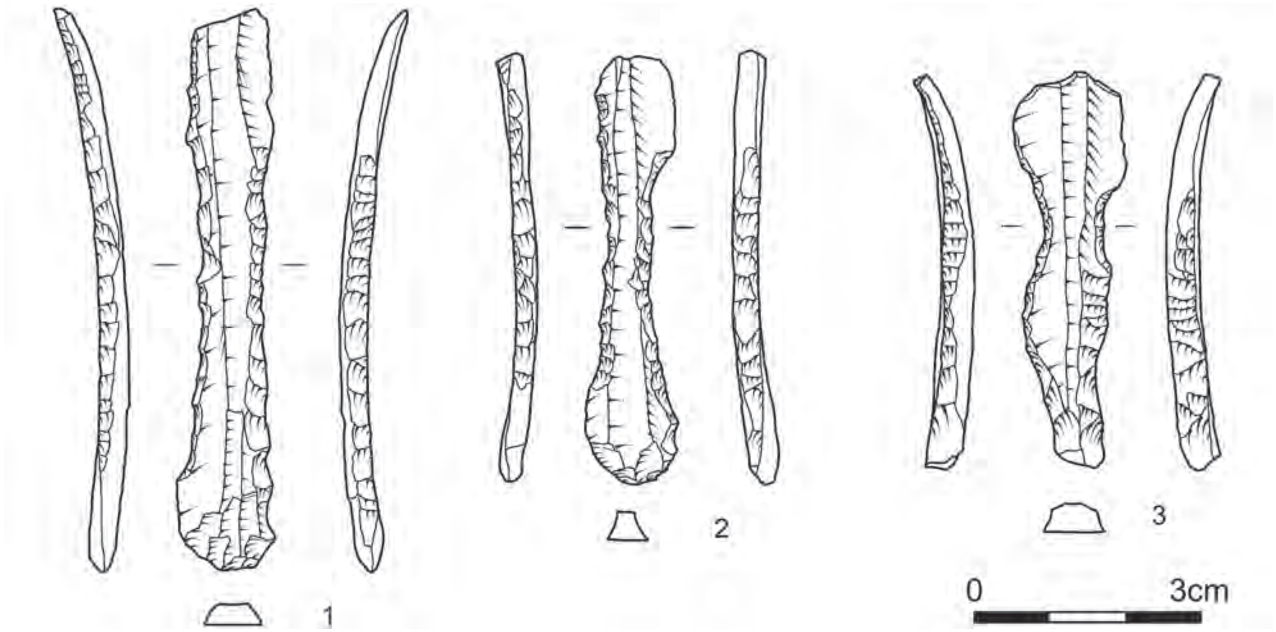


Figure 20.12. Chert blades from Bestansur: 1) T13 C1392 Tool 6692, blade, retouched, chert (C2); 2) T13 C1556 Tool 7120, blade, notched, chert (C12); 3) T10 C1540 Tool 6931, blade end scraper or notched blade, chert (C6).

resulting in the common production of the so-called 'bullet cores' that are characteristic of pressure flaked assemblages across the Early Neolithic EFC (Redman 1982: 27; Kozlowski and Aurenche 2005: 40, fig. 1.3.5), a technological tradition that reaches as far west as the Khabur valley in northern Syria (Nishiaki 2013a). There are also indications of the use of heat treatment of cores prior to blade detachment at sites such as M'lefaat and Nemrik (Inizan and Tixier 2000), but we lack evidence for this technique at Bestansur and Shimshara.

Binder (2007: 237) suggests that copper tools may have been used at Çayönü as blade detachers and retouchers, as well-attested in Early Bronze Age Europe. Experimental studies have generally used antler pressure tools (Pelegrin 1988; Wilke 1996). We lack evidence for any copper or antler use in Neolithic Bestansur and Shimshara but there are candidates for pressure flaking tools in the form of well-crafted alabaster hand tools, found in several trenches at Bestansur (Fig. 20.14).

These tools are conical in shape, fit perfectly into the hand, and have the right hardness and shape for removal of blades and bladelets from chert cores, although they differ significantly in shape from tools identified at Jarmo as possible retouchers (Moholy-Nagy 1983: 293, fig. 131: 1–4). Finer retouching would have been carried out with smaller tools of bone or antler (Pelegrin 1988; Wilke 1996). Binder (2007: 241) proposes that micro-bladelets could be produced in the hand of the craft worker, while bladelets and blades would require at least a sitting, and sometimes a standing, position for sufficient force to be applied to the prepared core platform. Experimental studies have shown that controlled force can be applied to blade cores using supporting equipment in the form of a piece of deer antler for the contact point, a grooved bone or wooden frame in which to situate the core, and a range of wooden or bone crutches to transmit the force of either the hand, the shoulder or the abdomen from the knapper to the point of the antler tool pressing against the chert or obsidian (Pelegrin 1988; Ohnuma 1993; Wilke 1996). Production of Çayönü tools through pressure flaking was probably conducted using a flaking tool set into a wooden shoulder crutch, in order to apply sufficient pressure to detach the sizable blade blank (Binder 2007: 239).

The widespread use of controlled pressure flaking, in contrast to tools produced by striking, encouraged standardisation in blade production (Inizan and Lechevallier 1994: 29), as demonstrated through measurement of blade widths and width/length ratios. Blade width-length distributions should not be taken too seriously in any case, as almost all recovered blades are broken at either the proximal or distal ends, or both. In most cases it is not possible to determine whether such broken blade tools were originally designed to be truncated or were broken during use. Figure 20.15 shows the maximum and minimum widths and the average widths for both retouched and unretouched blades from Bestansur, of chert and obsidian combined. The significantly lower average widths for unretouched blades from all trenches support our interpretation of unretouched blades as likelier to be elements of debitage rather than desired tools. Blade widths for chert and obsidian are represented separately, trench by trench,

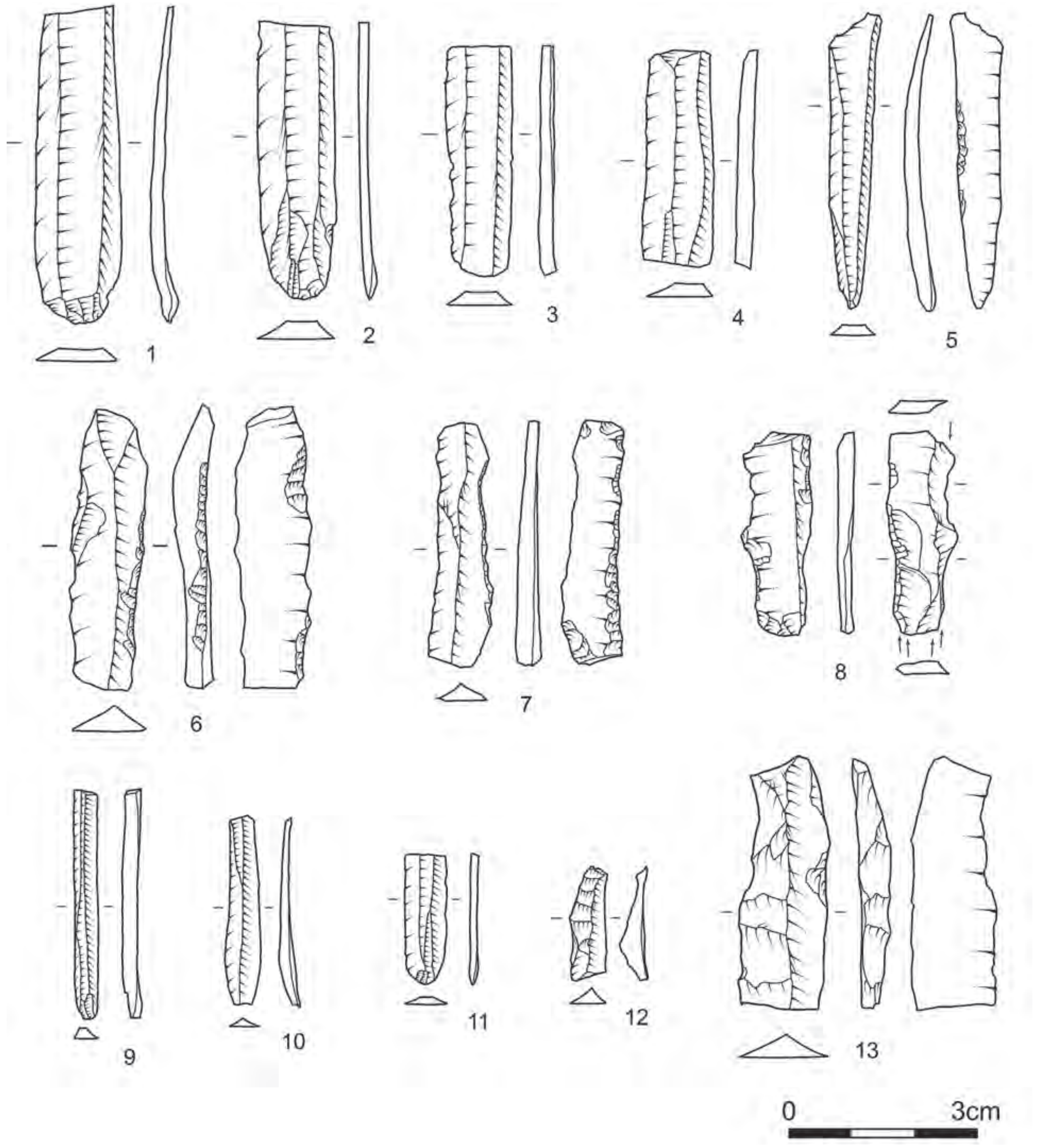


Figure 20.13 Obsidian blades from Bestansur and Shimshara. BEST: 1) T13 C1569 Tool 6322, blade, obsidian (O1). SHIM: 2) T2 C1658 Tool SHIM238, blade, obsidian (O1); 3) T2 C1640, blade, obsidian, black (greenish); 4) T1 C1653 Tool SHIM357, blade, obsidian, black (greenish); 5) T1 C1653 Tool SHIM323, blade, retouched, obsidian, dark grey/black; 6) T2 C1658 Tool SHIM239, blade, retouched, obsidian, black (greenish); 7) T2 C1658 Tool SHIM244, blade, retouched, obsidian, black (greenish); 8) T2 C1640 Tool SHIM362, blade, retouched, obsidian, black (greenish); 9) T1 C1661 Tool SHIM261, blade, obsidian, black (greenish); 10) T1 C1653 Tool SHIM316, blade, obsidian, dark grey/black; 11) T1 C1653 Tool SHIM356, blade, obsidian, black (greenish); 12) T2 C1652 Tool SHIM307, blade, obsidian, black (greenish); 13) T1 C1653, blade, obsidian, black (greenish).

in Figure 20.16. The lower average widths of obsidian blades in all trenches at Bestansur indicate a concern by obsidian knappers to conserve imported raw materials more efficiently than might be acceptable for chert knapping, given the long distances from which all obsidian had been imported (see also Fig. 20.9).

The Bestansur chert blade widths are strongly comparable to those of chert blades from the Early Neolithic site of Sheikh-e Abad in the high Zagros (Vahdati Nasab *et al*. 2013b: fig. 9.8). These size ranges also match those of several other Zagros Early Neolithic sites considered by Kozlowski (1996: fig. 3;

Figure 20.14. Alabaster and marble tools, possibly used as pressure-flaking tools: a) SF16 T7 C1092; b) SF188 T12 C1320; c) SF326 T10 B5 Sp42 C1540.

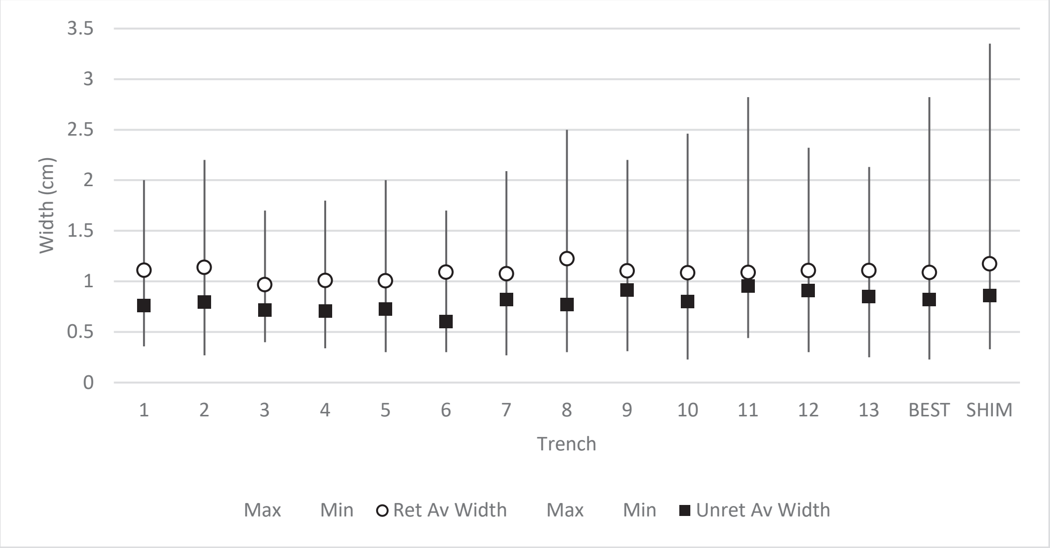


Figure 20.15. Blade widths for Bestansur and Shimshara blades, chert and obsidian combined.

1999: 53, 63), who makes the point that from about 7500 BC there is a marked increase in the proportion of broader blades in Neolithic tool assemblages, marking a major shift in lithic technology and capability. The Bestansur assemblage appears immediately to pre-date this technological transition. While showing considerable variability, the blade width–length ratios for chert and obsidian (Fig. 20.17) have rather low averages when compared to other sites such as Sheikh-e Abad (Vahdati Nasab *et al*. 2013b: fig. 9.10), perhaps indicative of the nature of excavated deposits at Bestansur whereby many of the recovered tools come from external deposits where they may have been broken during use. The Shimshara blade dimensions are broadly similar to those of Bestansur, although obsidian blades tend to be wider and chert blades longer than at Bestansur, which may indicate regional variation in the precise blade knapping techniques at the two sites.

There is much evidence for on-site production of all sizes of blades and bladelets at Bestansur, particularly in chert, in the form of exhausted cores and core trimming elements, as summarised in Table 20.8 and Figures 20.18–20.22. The vast majority of cores are blade and bladelet cores, always with multiple blade removal scars and often in the bullet-core form typical of Early Neolithic chipped stone technology in the so-called M'lefaatian tradition of the EFC (Kozlowski 1999: 51–75). Small numbers of cores were recovered from almost all trenches at Bestansur, but only in Trench 10 were large quantities encountered. Cores from Trench 10 are mainly blade cores, largely of chert with some obsidian examples (Fig. 20.21), but there are also significant numbers of flake cores. In Space 53 of Building 9 in Trench 10, nine chert cores were recovered from the same occupation deposit on a floor, of which two are large blade cores and five are rather large single-platform flake cores (Fig. 20.22). These cores, not associated with significant debitage quantities, may be remnants of an early stage in nodule reduction prior to fine blade and bladelet production, as illustrated by Wilke (1996: fig. 2). They may have been left on the floor of Space 53 by a chert worker who expected to return to them at some future

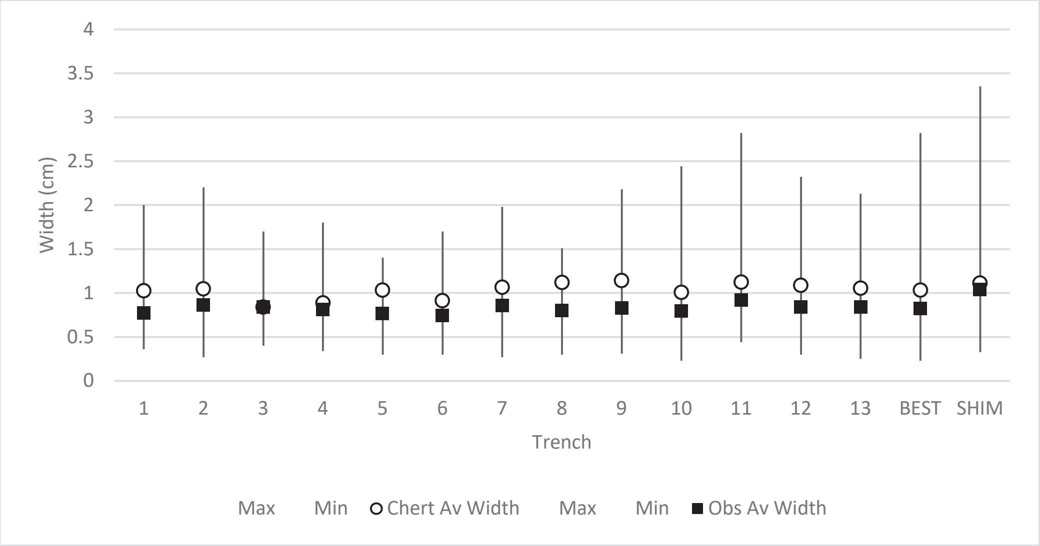


Figure 20.16. Blade widths for Bestansur and Shimshara blades, chert and obsidian separately.

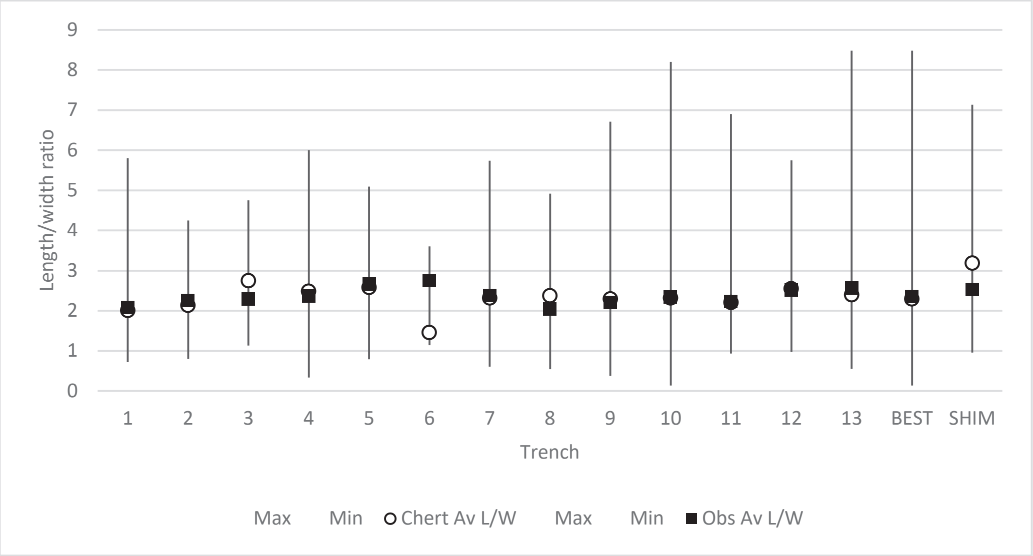


Figure 20.17. Blade width–length ratios for Bestansur and Shimshara blades, chert and obsidian separately.

stage but never did. Alternatively, these cores were for specialised production of flakes and flake tools, which do occur in small quantities at Bestansur, and are paralleled by a few such cores at Early Neolithic Ganj Dareh in the Iranian high Zagros (Nishiaki 2016: fig. 3: 1–2).

Obsidian cores were found at seven different trenches at Bestansur, suggesting that small-scale opportunistic obsidian knapping was widespread across the settlement. This appears to contrast with other Early Neolithic sites of the Zagros, such as Tepe Guran where there is no evidence for onsite obsidian knapping (Mortensen 2014: 40). Very unusually, additional blade production in obsidian is attested at Shimshara by the re-use of broken Çayönü tools as a raw material from which to knap thin, fine blades (Fig. 20.50: 1–2), once more attesting the high value attached to obsidian, here used as a recyclable resource. Otherwise in the Shimshara assemblage only one bladelet core and six core trimming elements, all of obsidian, were found (Table 20.8).

It is notable that the same basic technology of tool production is employed in both chert and obsidian at Bestansur, both heavily reliant on pressure flaking of blades and bladelets from ever-finer cores. The same knappers may have worked both chert and obsidian, with the probable exception of Çayönü tools. As discussed above, the differences in size distributions of blades in chert as against obsidian are likely to result from knappers' concerns to maximise the use of valued obsidian resources, rather than a basic technological variability in the treatment of

Table 20.8. Distribution of cores and core rejuvenation flakes/core trimming elements from Bestansur and Shimshara.

Bestansur	*Blade cores*		*Flake cores*		*Core trimming elements*		
Trench	*Chert*	*Obsidian*	*Chert*	*Obsidian*	*Chert*	*Obsidian*	*Total*
1	2	0	0	0	1	0	3
2	2	2	0	0	0	0	4
3	0	0	0	0	0	0	0
4	2	1	0	0	1	1	5
5	0	0	1	0	0	1	2
6	1	0	0	0	0	0	1
7	9	0	3	1	4	1	18
8	8	0	0	0	0	1	9
9	4	2	2	0	5	1	14
10	91	8	18	0	25	6	148
11	6	3	1	0	2	0	12
12	0	0	4	0	0	0	4
13	2	1	1	0	0	0	4
Shimshara	0	1	0	0	0	6	7
Total	127	18	30	1	38	17	231

these raw materials. Chert and obsidian technological compatibility in the Neolithic of Bestansur and Shimshara stands in contrast to Later Neolithic instances, such as Salat Cami Yanı in southeast Anatolia where chert and obsidian were knapped in completely different ways (Maeda 2011). The value of obsidian at Salat Cami Yanı is illustrated in the average weights (total weight divided by count) of obsidian tools and of obsidian pieces of debitage as against their chert counterparts. Similar variations in extravagance of chert versus obsidian production have been noted at other Neolithic sites distant from obsidian sources (Maeda 2011: 325).

In situ evidence for specific knapping episodes at Bestansur comes principally from Trench 7 on the western side of the mound, in an external area. Small distinctive deposits of associated knapping material on surfaces include a group of debitage fragments of an unusual red chert from Context 1225 in Space 18 (Fig. 20.23). It has been suggested (Pullar 1975; Kozlowski and Aurenche 2005: 83) that red cherts, such as those used here, were especially valued in the Early Neolithic of the Zagros and may have been traded across the region. This deposit of red chert at Bestansur is markedly different in colour from the cherts commonly employed at the site and shows evidence for careful knapping. In upper levels of Trench 7, in Context 1221, a collection of obsidian fragments of a distinctive fine-grained material indicates *in situ* working of obsidian (Fig. 20.24).

Within an open area of Trench 7, the earliest detected feature is the deposition of a discrete cluster of lithic debitage, Context 1172 (Figs 20.25–20.26). This deposit, which contained 838 fragments of chert, may have been placed in a pit/container under a fugitive surface, although during excavation the putative surface and pit were not visible. The lithics were concentrated in an area 30 × 20 × 5–8cm in dimension. Chert pieces in this deposit, which weighed 182.07g in total, comprise a single exhausted chert core, a single chert core trimming element, plus 217 unretouched blade fragments and 619 fragments of debitage of some four-five differing chert types. The inclusion of the unretouched blade fragments in this clearly intentional deposition of debitage from an episode of chert knapping reinforces the argument that unretouched blades at Bestansur are largely the waste product of tool manufacture. The delicate size of the core and the blade debitage from Context 1172 indicate the production here of extremely fine bladelet and micro-bladelet based tools by a highly dextrous knapper. This distinctive deposit is Bestansur's modest parallel for the astonishing "thick concentration of flint microblades and thousands of flint chips" (20,000 in all) over an area of 1 × 3m in the Bus Mordeh phase at Ali Kosh on the Deh Luran plain (Hole *et al*. 1969: 36), dated to *c*. 7400 BC, clearly debitage from major episodes of knapping.

On the east side of the mound in Trench 10, the large quantities of chert debitage (*c*. 2000 pieces of highly varied chert types) and five bullet cores recovered from Context 1752 in Space 27, an external area, come either from *in situ* chert knapping or from discard down the slope of the mound from knapping activities taking place higher up the mound slope. The low counts of cores from Trenches 12/13, by contrast, suggest that chert and obsidian knapping did not take place in or near the excavated parts of the settlement here. The persistent conduct of chipped stone tool manufacture, and other activities, at distinct locations around the settlement at Bestansur suggests the existence of 'landscapes of action' or 'taskscapes' (Ingold 1993; Robb 2013) as socially constructed spaces within which particular activities were recurrently carried out, contributing to the construction and maintenance of Neolithic society at the site.

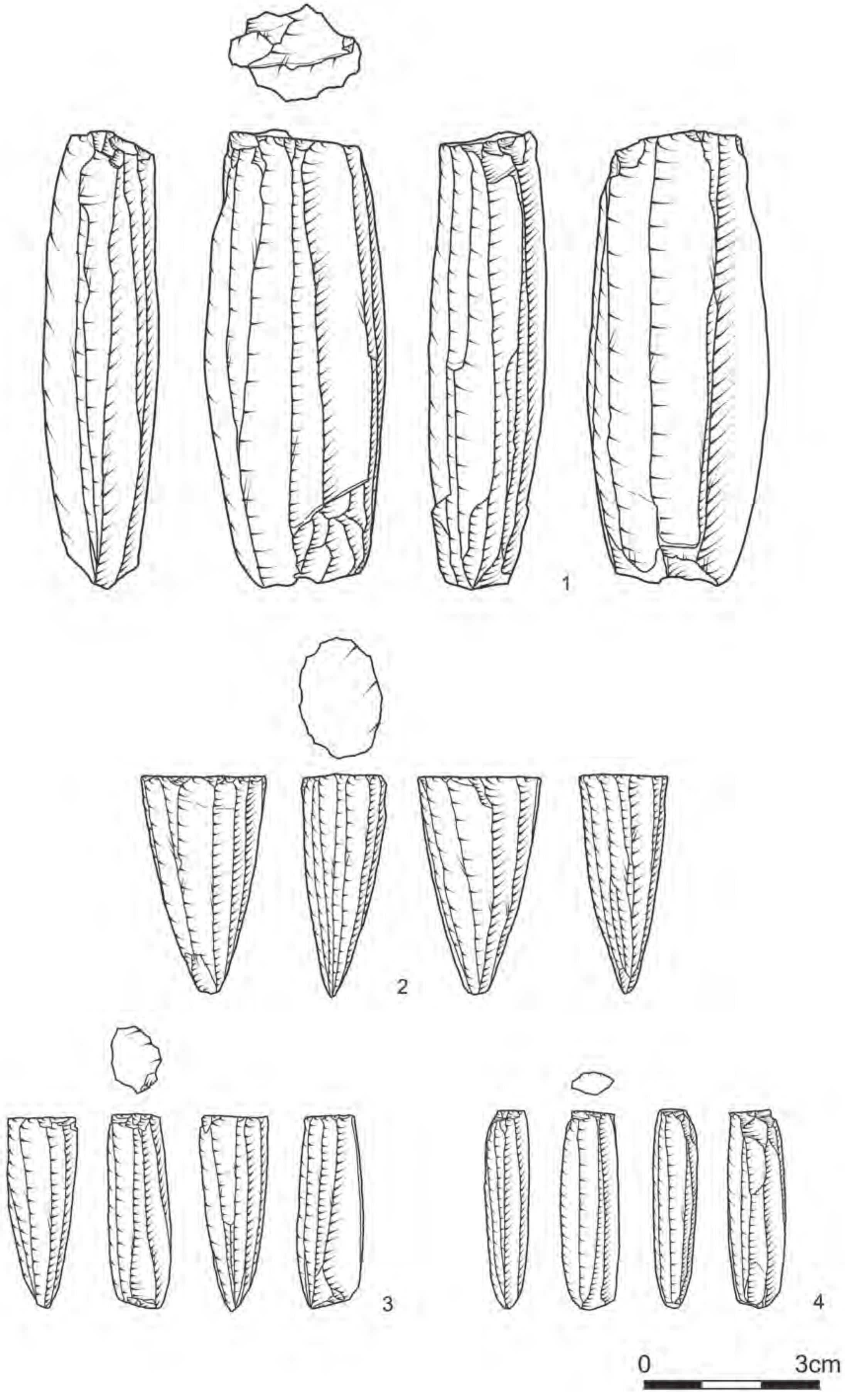


Figure 20.18. Chert cores from Bestansur: 1) T10 C1758 Tool 5949, core, chert (C8); 2) T10 C1758 Tool 5887, core, chert (C15); 3) T10 C1752 Tool 6111, core, chert (C12); 4) T10 C1738 Tool 5850, core, chert (C12).

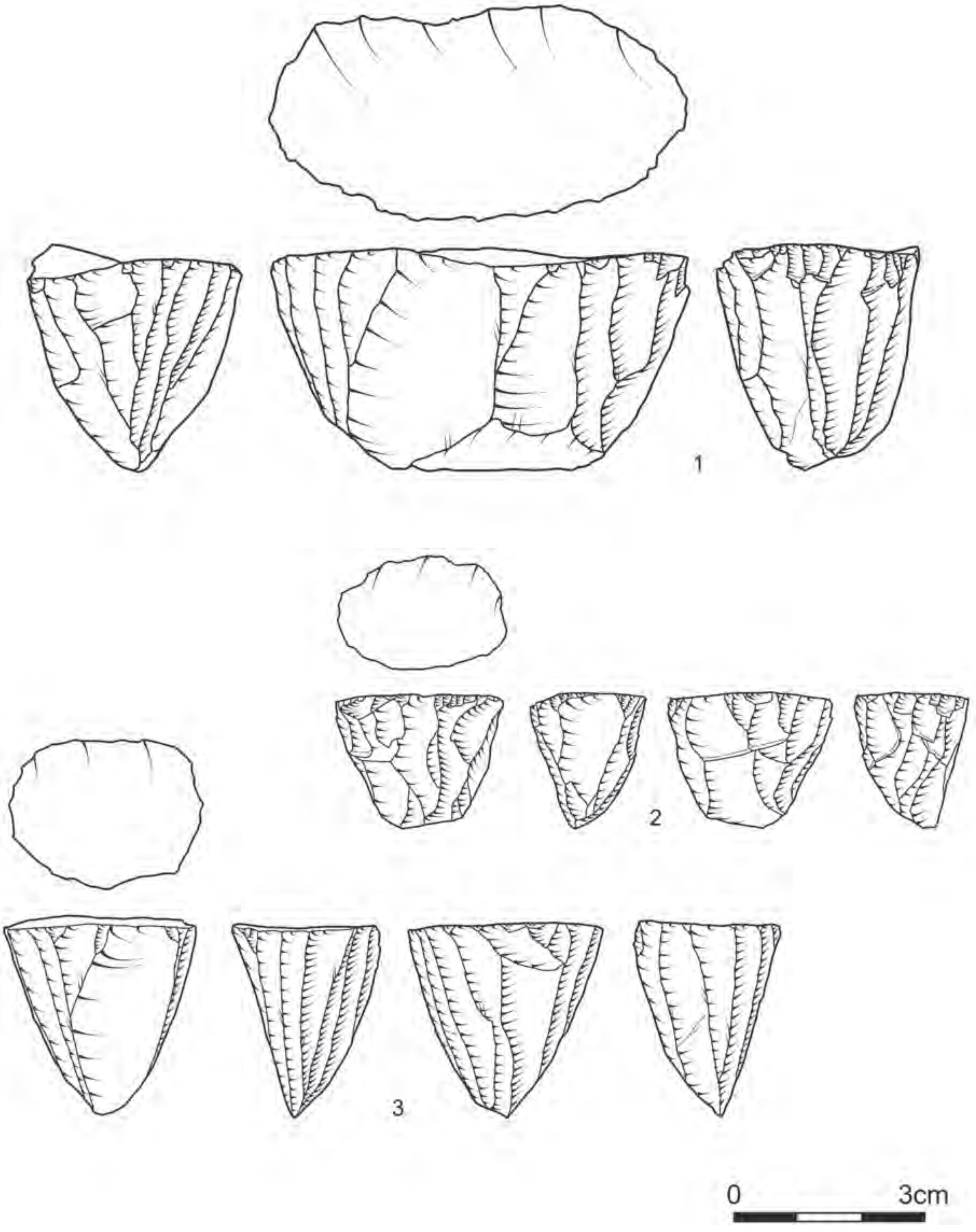


Figure 20.19 Chert cores from Bestansur: 1) T10 C1758 Tool 5948, core, chert (C4); 2) T10 C1751 Tool 5897, core, chert (C12); 3) T10 C1599 Tool 6810, core, chert (C3).

Technological structure of the Bestansur and Shimshara chipped stone assemblages

While there are significant differences between them, the Bestansur and Shimshara chipped stone assemblages, considered *en masse*, can both be characterised as typical Early Neolithic assemblages of the EFC. Kozlowski's ambitious analyses of chipped stone assemblages from this broad region identified a M'lefaatian tradition, with an emphasis on blades and production of a repertoire of tool types on locally available cherts with varying usage of imported obsidians (Kozlowski 1994; 1996; 1998; 1999: 51–75; Kozlowski and Aurenche 2005). Major excavated sites of the M'lefaatian lithic tradition span much of the

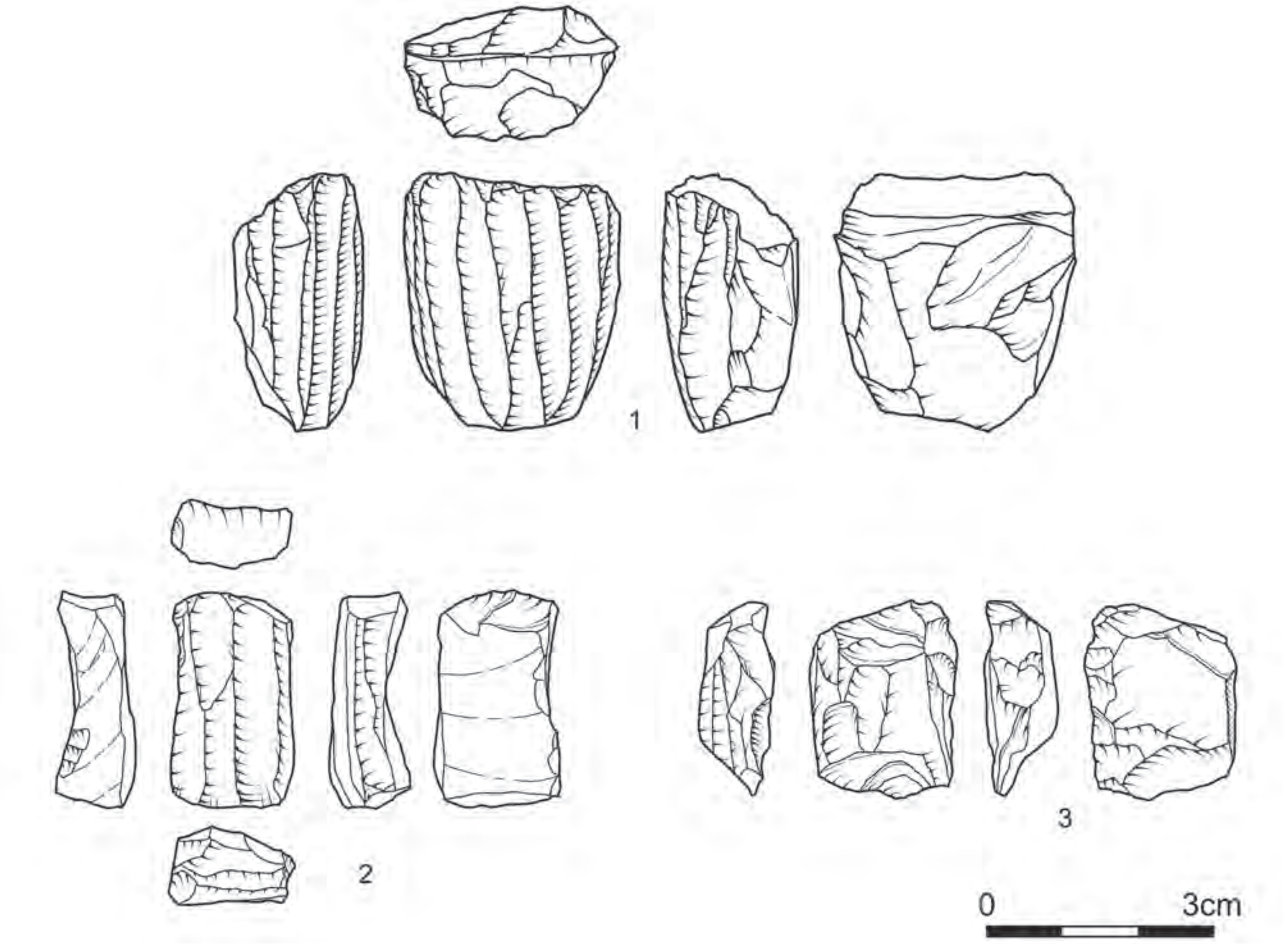


Figure 20.20. Obsidian cores from Bestansur and Shimshara: BEST: 1) T4 C1065 Tool 331, core, obsidian (O1); 2) T10 C1752 Tool 5935, core, obsidian (O1). SHIM: 3) T1 C1634 Tool SHIM387, core, obsidian, black (greenish).

Figure 20.21. Cores from mixed fill Context 1317, Space 29, Trench 10, Bestansur.

Figure 20.22. Cores from Space 53, Building 9, Trench 10, Bestansur.

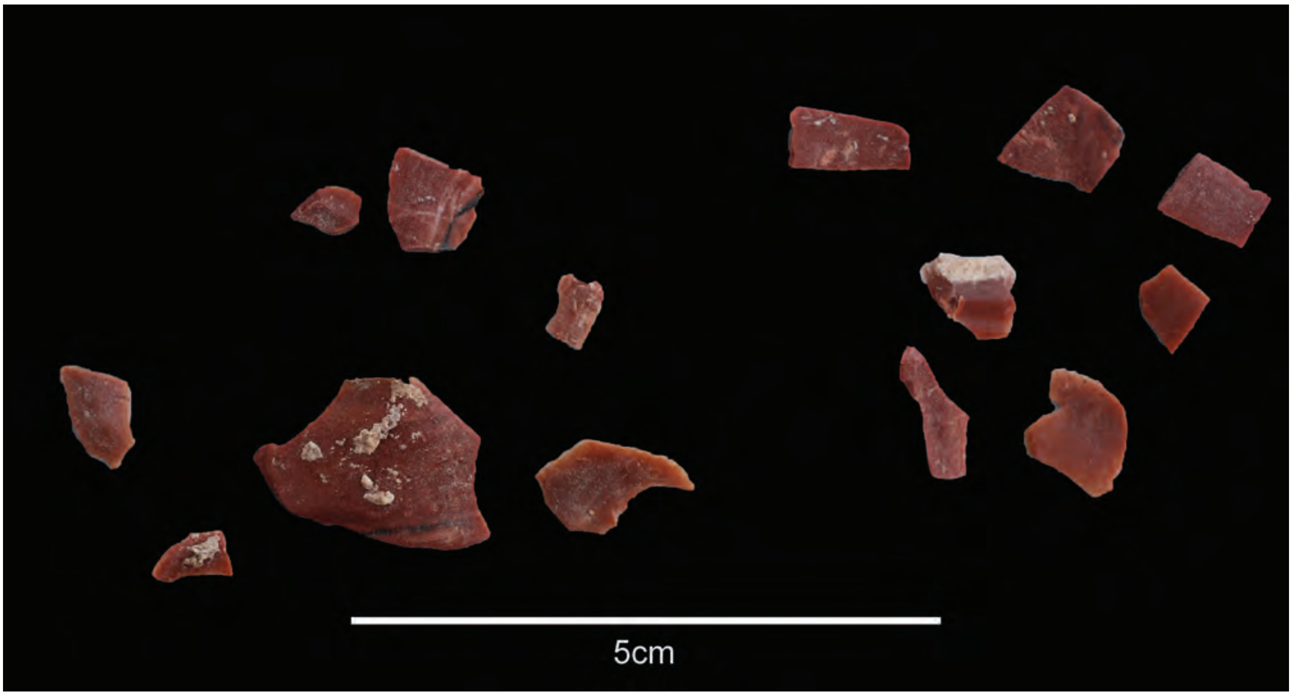


Figure 20.23. Red chert knapping debitage from external occupation residues C1225, Sp18, Trench 7, Bestansur.

central Zagros region of western Iran and eastern Iraq, including Jarmo, Shimshara, Asiab, Sarab, Ganj Dareh, Abdul Hosein and Tepe Guran, spanning approximately 8250–6500 BC (Kozlowski 1996: 182). The wide geographical and chronological spread of the M'lefaatian lithic tradition is testimony to its success in providing a chipped stone tool-kit capable of dealing with a wide range of practical requirements during the transition from hunter-gatherer to farmer-herder life-styles in this region.

The overall structure of the Bestansur and Shimshara assemblages from all trenches is broadly similar with regard to the relative proportions of cores, debitage (here including unretouched blades), retouched blades and retouched tools (other than blades) (Fig. 20.27). These proportions are similar to those described by Kozlowski (1994: 155; 1999: table 9) for M'lefaatian assemblages from a range of sites in the central and south Zagros. Figure 20.28 demonstrates the structural similarity of the

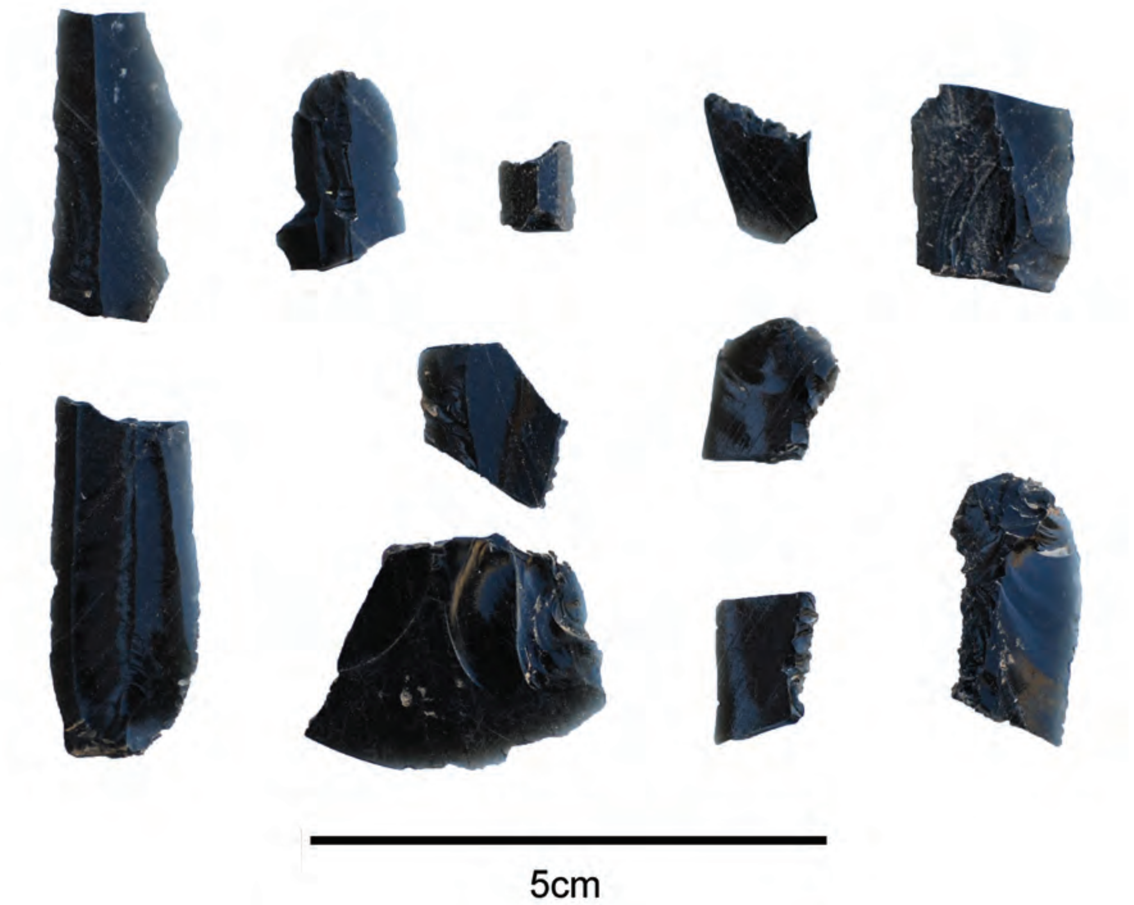


Figure 20.24. Obsidian knapping debitage from external occupation residues C1221, Sp18, Trench 7, Bestansur.

Figure 20.25. Chert debitage in situ in external occupation residues Context 1172, Space 11, Trench 7, Bestansur.

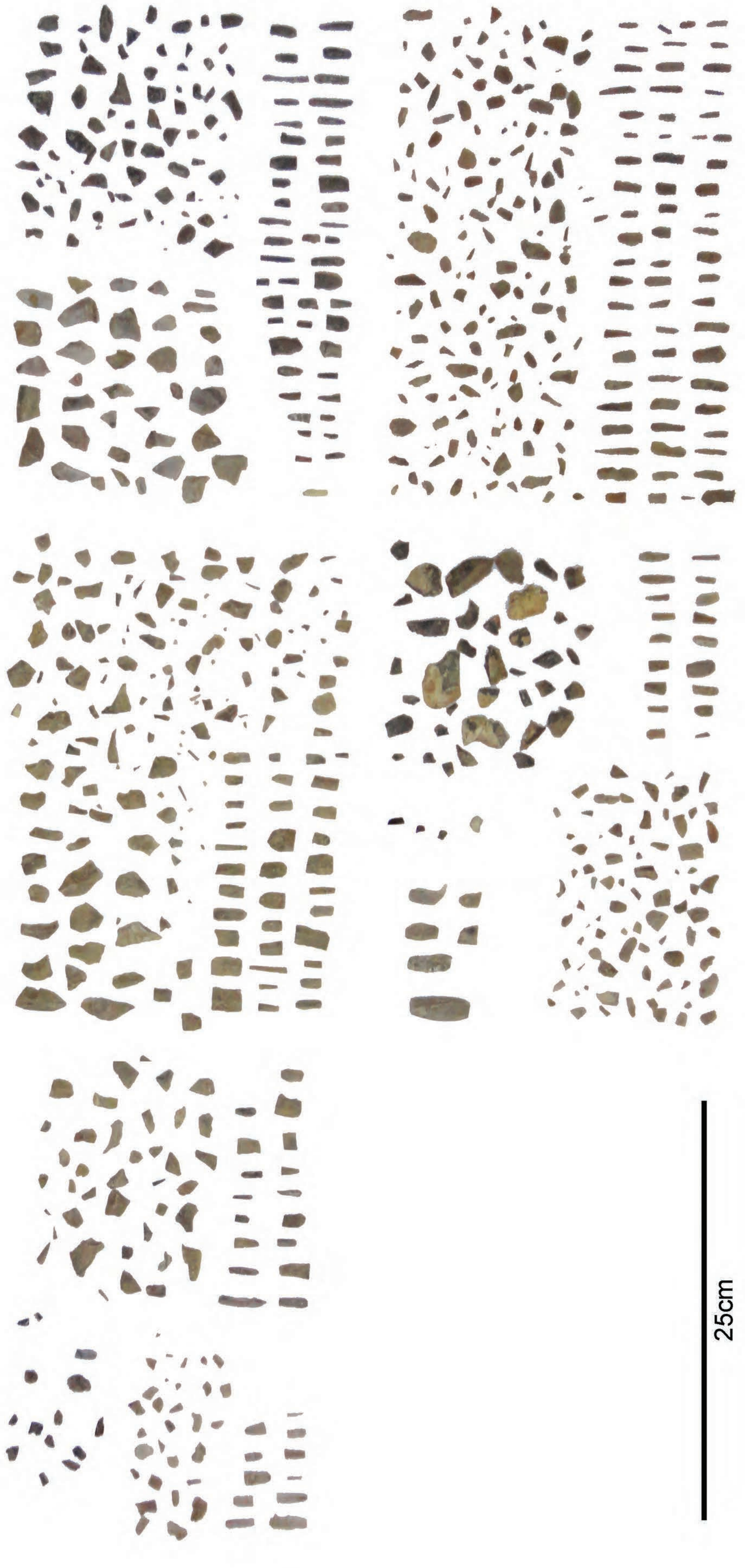


Figure 20.26. Chert debitage from external occupation residues Context 1172, Space 11, Trench 7, Bestansur.

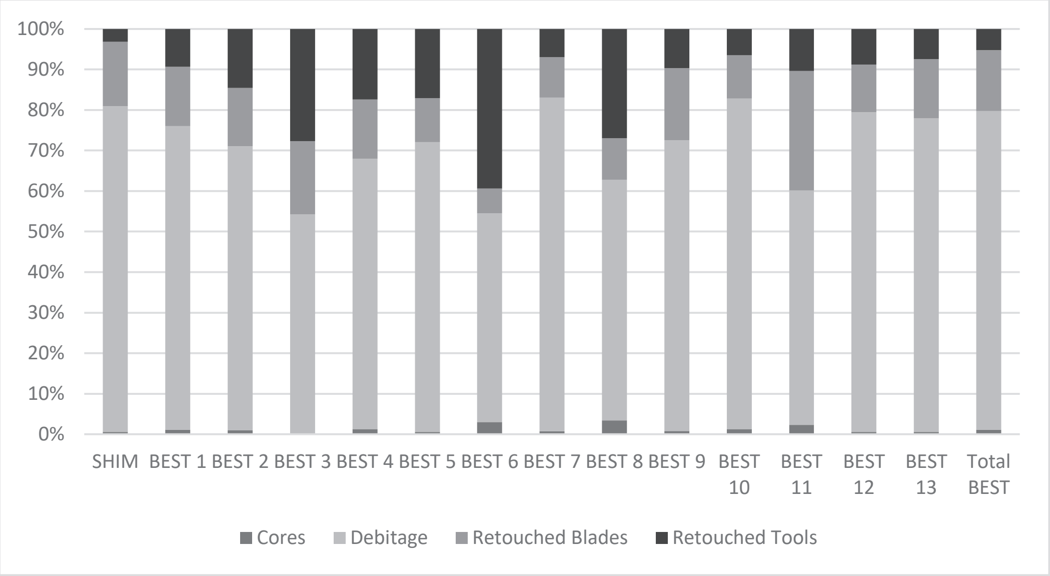


Figure 20.27. Technological structure of Bestansur and Shimshara chipped stone assemblages.

Bestansur and Shimshara site assemblages to those recorded from other sites of the Neolithic Zagros such as Jarmo, Abdul Hosein, Tepe Guran and Ali Kosh in particular based on tool proportions. Kozlowski (1999: 65) interprets this overall structure as indicative of *in situ* lithic production over extended periods of time in permanently settled locales largely using locally available raw materials. This interpretation fits with Mortensen's observation that chipped stone production in the Hulailan valley in the Iranian central Zagros shifted from being widely distributed across the entire landscape in the Epipalaeolithic to being focused on individual household production within settlements during the Neolithic, a true "domestication of flint" (Mortensen 2014: 123).

Within this model, the complete *chaîne opératoire* is carried out in one place, the 'home' site, with acquisition of local raw materials and full processing on site. According to Kozlowski (1994; 1999: 30–31, 65), 'home' lithic assemblages are characterised by very high proportions (>50%) of debitage, high proportions (23–45%) of retouched blades, moderate proportions (5–12%) of retouched tools (other than blades), and small proportions (0.5–4%) of cores. As Fig. 20.28 demonstrates, the assemblages from both Bestansur and Shimshara fit the 'home' production model extremely well.

Note that the new evidence from Shimshara, including materials recovered from sieving and flotation heavy residues, aligns the site assemblage more comfortably with other contemporary assemblages than was suggested by the low debitage attribute of the Shimshara chipped stone from the 1950s excavations (Mortensen 1970; Kozlowski 1999: 65–66). Taken in the round, the composition and attributes of the Bestansur and Shimshara lithic assemblages fit well within Kozlowski's (1999: 30) definitions of 'hunter', 'hunter-agricultural' and 'transitional' industries.

Making a living: visible evidence for how tools may have been used

The field of analysis of chipped stone tools in terms of their possible uses has greatly expanded in recent decades (van Gijn 1989; 2010; Odell 2001), comprising study of wear traces on the edges and facets of lithic tools, such as nibbling, rounding, striations and polish or sheen. Survival of organic residues on chipped stone tools, such as blood and animal tissue, is extremely rare in any context. Van Gijn's exhaustive study of Neolithic and Bronze Age lithics from the Netherlands, for example, failed to identify any definite organic traces on lithic tools, finding solely mineral traces of materials such as tar (from birch bark), ochre and pyrites (van Gijn 2010: 28). Identifications of blood residues of humans, wild cattle and sheep on stone tools and slabs from Aceramic Neolithic Çayönü in Southeast Anatolia (Loy and Wood 1989) have been cautiously received (Cattaneo *et al*. 1993).

It is also important to stress that while a chipped stone tool may have been made with a specific purpose in mind, its life history may often have been more complex, with successive episodes of activity perhaps far removed from original design. Cores can become scrapers, scrapers become barbs, and barbs become micro-points, for example. But the evidence from Bestansur and Shimshara in this regard is slight: most tools appear to have been made and used with a single specific function in mind, although further use-wear studies might affect this picture. Direct evidence for the working lives of the Bestansur and Shimshara stone tools takes the form of impacts on

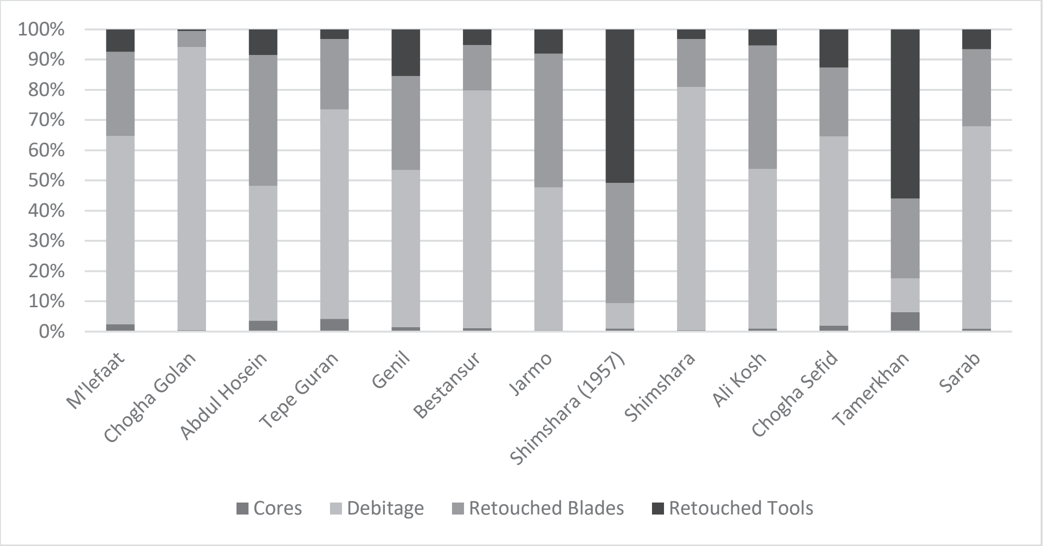


Figure 20.28. Technological structure of Bestansur and Shimshara chipped stone assemblages compared to other Neolithic sites of the Zagros region.

working edges, striations on planar surfaces, patches of silica sheen on blade edges and surfaces, and traces of fixative on blade planes for adhesion to hafts. We discuss each of these forms of evidence in turn.

Impacts on working edges

At the macroscopic scale, the commonest form of edge impact detectable on our assemblages is that of nibbling. By nibbling we mean the presence of small-scale irregular chipping along the edges of, usually, potential cutting tools. Nibbling is common on blade edges at Bestansur and Shimshara, as illustrated in Figure 20.29.

The problem lies in determining whether or not edge nibbling is the result of deliberate and specific tool preparation and/or use, or of accidental damage during knapping or use to otherwise unretouched blades (whether as tools or as elements of debitage), or of post-depositional impacts on blade edges (Anderson 1994: 61–62; van Gijn 2010: 44) that have no bearing on the blade's working life. Anderson's (1994) detailed study of retouch types on sickle blades and Çayönü tools divides them into 'preform' where edge retouch is part of the tool design and therefore occurs before tool use, 'evolutive' where retouch is carried out after initial use in order to resharpen and strengthen tool edges and 'transformative' where the tool is transformed by retouch into a different kind of tool (e.g. a cutting blade becoming a blade-end scraper). All three classes of retouch are well attested in the Bestansur and Shimshara assemblages, although it is often impossible to distinguish between them.

The field of use-wear analysis is heavily dependent on comparison of archaeological evidence with data obtained through experimental investigation or replication studies, principally in the form of using modern lithic tools to cut, scrape, pierce and polish items of stone, wood, plant, flesh, bone, antler and hide. As van Gijn (1989: 24–25; 2010: 30–31) and Andrefsky (2005: 7–10) point out, we need to treat such analogies with caution, given both our own shortcomings in appropriate skills and contextual knowledge, as well as the often similar use-wear traces generated by experimental usage of tools on a range of materials such as bone, antler and hard woods. While replication studies in association with use-wear analysis can provide pointers to possible uses of ancient tools, there is still considerable doubt about the efficacy of such approaches in advancing understanding of past lithic uses. Analyses need to be highly targeted to specific questions (van Gijn 1989: 147; Andrefsky 2005: 198; Smith 2007). In future studies we plan to conduct a systematic programme of microscopic use-wear analysis of the Bestansur and Shimshara lithic assemblages, addressing specific issues identified during the current analysis, as highlighted throughout this chapter. For the present, combining the input from experimental analogy and direct observation of Early Neolithic lithic tools, including above all contextual analysis, we aim here to delineate areas of activity undertaken by the occupants of Bestansur and Shimshara.

Striations on planar surfaces

The most common form of this type of use-wear in Early Neolithic assemblages occurs on so-called Çayönü tools, as has long been noted (Redman 1973; 1982; Anderson 1994). The wear marks take the form of distinctive fine parallel striations on the dorsal or ventral faces of these tools, which are always of obsidian (Fig. 20.30). Most interpretations agree that the striations are caused by use of an abrasive

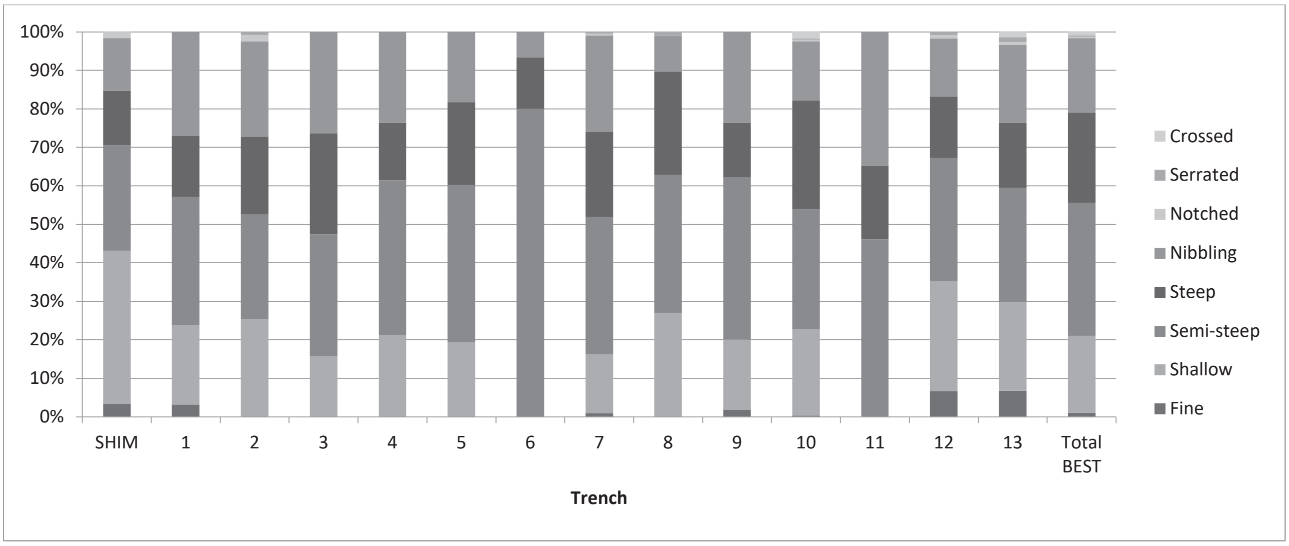


Figure 20.29. Distribution of retouch types at Bestansur and Shimshara.

powder or fine grit, hard enough to incise the obsidian surfaces, probably employed in polishing fine stone artefacts such as alabaster bracelets and bowls. Small quantities of these bracelet fragments occur at Bestansur and Shimshara, as at Early Neolithic sites more broadly (Chapter 21; Kozlowski and Aurenche 2005: 26–27, figs 5.3.1–5.3.4). Çayönü tools are discussed fully below.

Silica sheen on blade edges and surfaces

Silica sheen is visible on significant numbers of chert blades from Bestansur and Shimshara. Sheen is never visible on obsidian blades due to the nature of the raw material. Of the 123 blades observed to have silica sheen along the cutting edge, a sample of 35 were selected for pXRF analysis, for assessment of detectable residues (Table 20.9).

In order to isolate the chemical signatures of the tool material from the sheen, standard chert readings of 8mm on the dorsal and ventral surfaces of the tool were averaged to establish a baseline for the raw material. Further readings isolated to 3mm were taken along the blade edge, where sheen was visible, and on any remaining hafting residues. The selected blades provided a cross-section of chert materials, as well as retouched, notched and serrated blades. Values for blades that were wet-sieved, washed by hand and unwashed were compared, with the result that the washing of blades does not appear to affect the adhering substances. Three features may be observed in the results of the analysis of sickle sheen on the edges of blades: elevated silicon values, reduced detection of calcium in the chert, and a fivefold increase in the presence of strontium (Table 20.10, Fig. 20.31).

The transferral of silicon and strontium from the plant cutting onto the surface of the blade, alongside the reduced calcium values, appears to be preserved and can therefore be tested for, even when invisible to the naked eye. These results are not consistent in every case, as silicon proportions vary across cherts and throughout the fabric of each blade itself, but on average, silicon values were raised by 22% in the area of visible sheen, calcium values were lower by 31%, and strontium values were 600% higher.

Hafting residues

As discussed above, we envisage many Bestansur and Shimshara lithics as components of compound tools and implements. Given their generally small size, most lithic tools must have been affixed at some stage to a haft or handle of bone, antler or wood. In view of the rarity of evidence for traces of a fixative substance on the Bestansur and Shimshara lithic tools, we assume that the vast majority of them were attached to their hafts and handles by means of twine or sinew or slotted into neat grooves and notches in their handles without the need for any fixative or binding (Keeley 1982: 799). A rare complete crescentic bone haft from Zawi Chemi Shanidar was clearly designed to hold microlithic inserts, with a central groove ranging from 1–3mm in width, and with no traces of fixative (Solecki and Solecki 1963).

For our assemblages, the sole instances of visible hafting residues are on blades with sickle sheen (Fig. 20.32). Post-depositional manganese staining has been identified through pXRF analysis of faunal remains at Bestansur and is a known issue regarding stains on lithics at sites such as WF16 in Jordan (Smith 2007: 301). The dark stains observed along the centre of sickle blades at Bestansur correspond with manganese readings in seven of the 15 samples analysed, but in only two examples is the proportion of manganese higher than that of sulphur. This indicates that the presence of manganese should not necessarily preclude

Figure 20.30. Multiple use-wear striations on ventral surface of Çayönü tool from Shimshara (left) and dorsal surface of Çayönü tool from Bestansur (right).

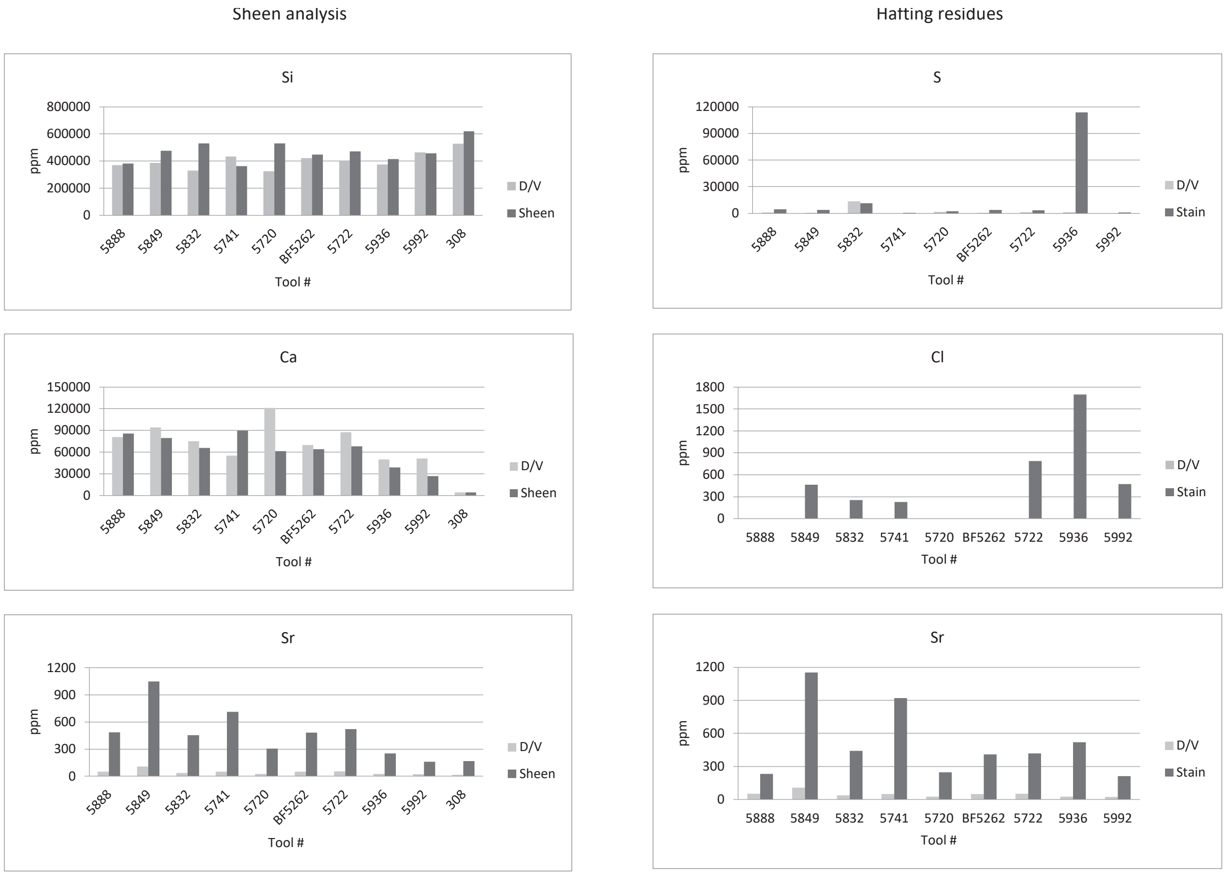


Figure 20.31. Comparison of pXRF chert results with a) sheen and b) hafting residue spot analysis ('D/V' = average of results across dorsal and ventral surfaces, 'Sheen' = silica sheen, 'Stain' = stains or residue from hafting fixative).

Table 20.9. Blades with silica sheen and/or fixative selected for pXRF analysis.

Tool	*Trench*	*Context*	*Description*	*Colour*	*Sheen*	*Fixative*
Bestansur						
2567	10	1315	Blade	C4	Y	
2643	9	1305	Denticulated blade	C2	Y	Y
3101	9	1344	Blade	C2		Y
3102	9	1344	Blade	C2		Y
3191	10	1331	Serrated blade	C13	Y	
3489	10	1316	Blade	C13	Y	
3540	9	1340	Serrated blade	C8	Y	Y
3593	10	1329	Serrated blade	C12	Y	Y
3641	10	1412	Blade	C8		Y
3645	10	1412	Blade	C13		Y
3705	10	1412	Blade	C4	Y	Y
3711	9	1347	Blade	C8		Y
3821	13	1370	Blade	C4	Y	Y
3832	13	1373	Blade	C3		Y
3848	13	1375	Blade	C13		Y
3863	13	1377	Serrated blade	C2	Y	Y
3916	10	1422	Blade	C4	Y	Y
3917	10	1422	Serrated blade	C8	Y	Y
3918	10	1422	Serrated blade	C8	Y	Y
3919	10	1422	Blade	C8	Y	Y
4545	10	1534	Blade	C6	Y	
4783	10	1538	Blade	C4		Y
4813	10	1620	Blade	C3	Y	Y
4976	10	1413	Serrated blade	C3	Y	Y
4994	10	1413	Serrated blade	C13	Y	Y
5122	10	1405	Blade	C13	Y	Y
5125	10	1405	Blade	C3		Y
5130	10	1405	Serrated blade	C10	Y	
5176	10	1409	Blade	C3	Y	Y
5424	13	1578	Serrated blade	C3	Y	Y
5624	10	1721	Serrated blade	C3	Y	Y
5720	10	1739	Blade	C4	Y	Y
5722	10	1724	Blade	C2	Y	Y
5741	10	1736	Blade	C6	Y	
5832	10	1738	Blade	C7	Y	Y
5849	10	1738	Blade	C15	Y	Y
5888	10	1758	Notched blade	C5	Y	
5936	10	1752	Blade	C7	Y	Y
5992	10	1755	Point	C2	Y	Y
Shimshara						
308	2	1652	Blade	C12	Y	

the possibility of the presence of bitumen. Bitumen sources are known in the foothills of the central Zagros, and its usage has been noted at Early Neolithic sites such as Ali Kosh and Chagha Sefid (Gregg *et al.* 2007: 138). Identification by pXRF of elevated levels of sulphur, chlorine and strontium (Table 20.10, Fig. 20.31) indicate the application of bitumen or pitch to the tools, for the purpose of hafting the blades. Present in very small quantities, it is possible to observe significant elevation of these trace elements in areas where dark residues were visibly present on the blades, with sulphur and chlorine values five times higher in the areas of residue and strontium ten times higher than the averages across the dorsal and ventral surfaces. Bitumen sources are common in eastern Iraq, including a major occurrence in the Dokan area (Karim and Taha 2009) 30km north of Bestansur.

Table 20.10. Proportional changes in elemental measurements (pXRF) of residues compared with chert.

% Change	*Silica sheen*	*Bitumen*
Al	–8	62
Ca	–31	54
Cl	1048	696
Fe	–4	75
K	–4	46
Mn	36	126
P	10	212
S	–66	606
Si	19	–30
Sr	542	730
Ti	–27	30

The repeated co-occurrence of hafting residues and silica sheen on blades demonstrates the manufacture of a specialist tool for specific plant-cutting purposes, as also attested at Chogha Golan (Zeidi and Conard 2013: 323), Jarmo (Hole 1983: 264), Halula (Borrell and Molist 2007: 62), Dja'de (Pichon 2017) and other Neolithic sites (Copeland and Verhoeven 1996). These tools represent a widespread activity across different sectors of the community, as they have been identified across three trenches (9, 10 and 13) at Bestansur. Blades with sheen were often deposited in clusters, with 43% of all sickle and hafted blades coming from the external areas to the south of Building 5 in Trench 10; four identical blades were all located in the fill deposit (C1422) adjacent to Wall 12 in Trench 10. Based on the similarities in the pXRF elemental composition of the chert, it is highly likely that the four blades from C1422 were used for the same sickle

Figure 20.32. Hafting residues on dorsal and ventral surfaces of a blade with sickle sheen from Bestansur (Fig. 20.36:2).

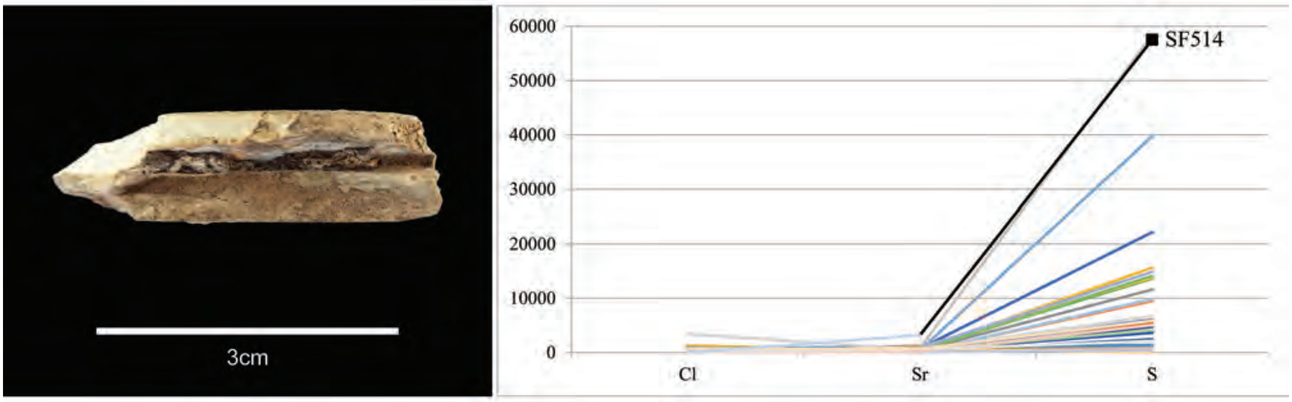


Figure 20.33. Bone haft, SF514, with bitumen residue, from external occupation residues Context 1730, Space 43, Trench 10, plus pXRF analysis of sickle blade hafting residues.

and struck from the same core, as may also be the case with the blades from C1412. From the adjacent open area Space 44, a fragment of bone sickle haft was recovered from the south section (SF514), with a smooth external surface and grooved interior with black residue to secure chert blades (Fig. 20.33; see Chapter 21). pXRF analysis of the black residue lining the central groove has revealed that this bitumen residue corresponds with the residues analysed on sickle blades. The high sulphur content on the bone haft is similar in signature to that of Tool 3916, one of a set of four sickle blades excavated from an adjacent context (Fig. 20.34). This is the only fragment of a haft recovered from Bestansur, 2012–2015, and it may be that bone hafts were less common than those made from more perishable materials, such as wood. A remarkable example of an intact bone haft was found as a grave good in the so-called Proto-Neolithic cemetery in level B1 of Shanidar Cave, tentatively dated to *c.* 10,500 BC (Solecki and Solecki 1963; Solecki *et al.* 2004: fig. 45c). The Shanidar haft is perforated at one end, for attachment to a belt perhaps, and contains a single chert blade fixed into the thick end of the haft with a lavish application of bitumen. The haft at Bestansur is similar in all respects to a PPNB example from Yiftahel in the southern Levant (Marder *et al.* 2008: 26).

This analysis reveals the potential for a greater in-depth study of the residues on sickle blades. It may also be possible to extract phytoliths from the silica sheen residues on these blades (Kealhofer *et al.* 1999; Hart 2011). Experimental analyses of sickle blade residues have been successful in illustrating the potential for deriving a wealth of information from these tools (see, for example, Evans and Donohue 2005; Goodale *et al.* 2010; Pichon 2017).

Situating chipped stone tools in their working lives

Considering the various forms of evidence adduced above, what can we say about the working lives of the Early Neolithic chipped stone tools from Bestansur and Shimshara? It may be most useful to approach this question through a series of episodes which we can be sure of having significance for the Neolithic inhabitants of these sites. Here we follow van Gijn's (2010) exemplary work in situating flint tools within the contexts of food and craft within their social, economic, cultural and political contexts. At the same time we appreciate that many tools may have fulfilled roles which transcend or combine these heuristic categories, and that chipped stone tools may have played only minor or non-existent parts within many aspects of the activities discussed below.

Chipped stone tools and food

A major project aim is to investigate the early stages in a complex transition from food procurement through hunting and gathering to food procurement through herding and cultivation. How do we situate lithics within this transition, and what was their contribution to this major episode of change? Can we distinguish differing sets of activities at Bestansur and Shimshara that may inform us on changes and variability through time and/or space in the Neolithic of the EFC? In approaching these questions, we have the opportunity to delineate cultural preferences and traditions in food selection, procurement, preparation and consumption, through rich contextualisation of chipped stone tools within their excavated contexts, spaces and buildings.

Food procurement: plants

The role of chipped stone tools in gathering and processing of wild vs domesticated plants in the Neolithic is currently hard to articulate based on analysis of chipped stone tools in isolation. The aim in this research, however, is to study lithics in association with other ecological and economic data in order to investigate the transition to agriculture and

Figure 20.34. Group of four chert blades (unwashed) with sickle sheen and bituminous fixative (Tools 3916, 3917, 3918, 3919), from external occupation residues Context 1422, Space 29, Trench 10, Bestansur.

indications of food procurement and consumption as discussed throughout this volume and synthesised in Chapter 24.

Sickle blades have long been regarded as fundamental to the transition to fully agricultural lifestyles in the Neolithic of Southwest Asia (Hillman and Davies 1990), and there has been considerable research into modes and means of possible sickle use and their use-wear implications, and into the distinction between the use of blades for harvesting reeds and grasses vs domesticated cereals (Bettison 1985; Anderson 1994; 1999; Quintero *et al*. 1997; Goodale *et al*. 2010; Vardi and Gilead 2013; Pichon 2017). Sickle blades are generally identified as blade tools with evidence for significant use-wear and sickle sheen on at least one edge. It is notable that sickle blades typically form a small proportion of Neolithic tool assemblages (Maeda *et al*. 2016): in the southern Levant, for example, sickle blades do not exceed 5% of the total tool assemblage at a wide range of Early Neolithic sites (Goodale 2010: table 1). The percentages of sickle blades in the Bestansur and Shimshara retouched tool assemblages are comparable, at 3.96% and 5.96% respectively, matching well with proportions from other Zagros sites such as Jarmo at 5.9% (Hole 1983: table 6, 244), Abdul Hosein at 4.9% (Pullar 1990: 108) and Chogha Golan at 1.2% (Zeidi and Conard 2013: 323). The higher proportion of sickle blades at Shimshara over Bestansur may be indicative of the later date of most of the excavated Shimshara deposits, as sickle blades increase in proportion through the Neolithic, in correlation with increased cultivation of domesticated cereals (Fig. 20.35; Maeda *et al*. 2016). This trend is attested in the more than 2000 year occupation span of the Early Neolithic at Sheikh-e Abad, for example (Vahdati Nasab *et al*. 2013b: 120), in the deep Neolithic sequence at Tepe Guran (Mortensen 2014: fig. 54), in later Neolithic assemblages such as Tall-i Jari B in Fars where sickle blades comprise 22% of the tools (Nishiaki 2013b: 357), and in the long sequence of Neolithic sites on the Deh Luran plain in Khuzestan (Hole *et al*. 1969: 81, table 3; Hole 1983: 244; 1994: 102).

Experimental analysis of the thickness of sickle blades suggests these tools were intended to have long use-lives, able to last for several harvesting or gathering seasons (Goodale *et al.* 2010), which may help explain their apparently low representation in overall tool assemblages. Furthermore, the fact that

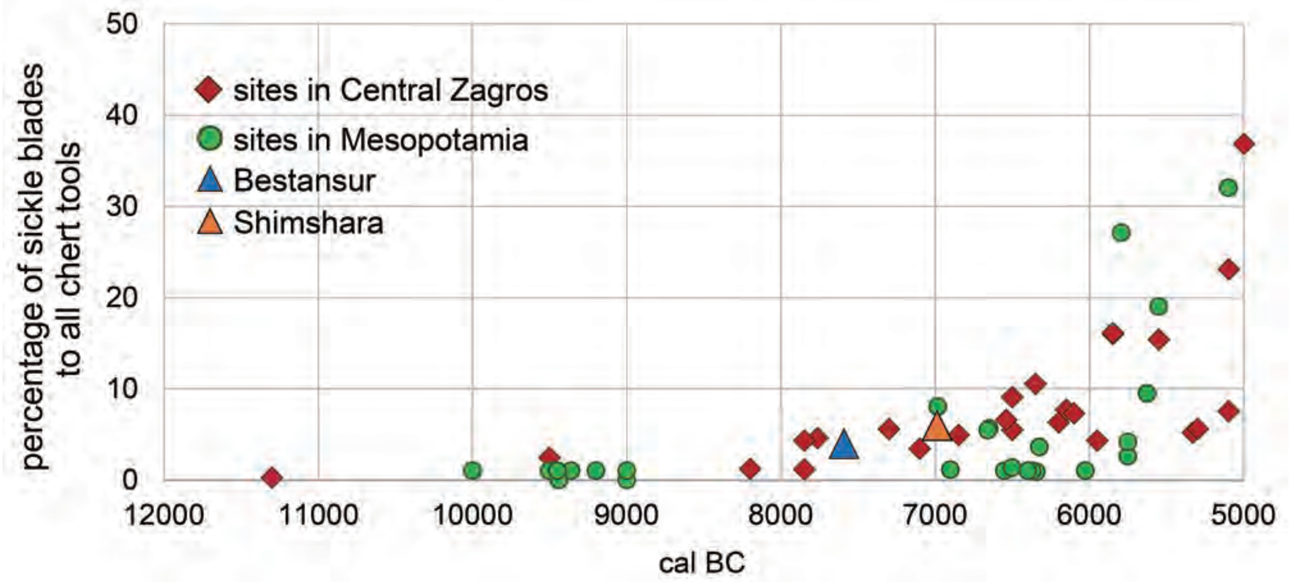


Figure 20.35. Percentages of sickle blades within lithic assemblages at Neolithic sites of Mesopotamia and the Zagros region.

sickle blades always appear to have been hafted may also have been a factor in their curation and retention through long periods of use, given the investment of time and skill in manufacturing the handle and setting the chipped stone components within it (Bleed 1986). As discussed above, sickle sheen on chert blades may be caused by a wide range of activities, not solely cereal harvesting, and the sheen is produced after only a few hours of plant cutting (Quintero *et al.* 1997). It is likely that the Bestansur sickle blades, all of distinctive chert and almost always with hafting residues, were employed either in gathering of cereals and grasses (wild and/or cultivated) or of cutting of reeds for use in craft and perhaps construction, or both. Here then, we have a tool that may have been involved in spheres of food procurement and craft activity. It is also likely that sickle blades were used to harvest plant materials for animal, as well as human, consumption. Investigation of correlations of sickle blade frequencies with evidence for exploitation of domesticated cereal crops at Neolithic sites across Southwest Asia demonstrates that sickles were used for millennia prior to the intensive cultivation of cereals (Maeda *et al.* 2016), suggesting that sickle blades were originally developed for a wide range of plant-related activities, including cutting of grasses, reeds and sedges for basketry, matting and thatch, and only later co-opted into the arena of intensive cereal harvesting (Fuller 2007b).

In their detailed studies of sheen on chert blades, Anderson (1994), van Gijn (2010: 63–72) and Pichon (2017) stress that sheen may result from repeated contact of the blade with a range of materials, including soft stones, soil, hides treated with ochre, hair and leather-hard clay. While high-powered microscopy may succeed in distinguishing traces of these materials on chert edges, in the case of the Bestansur and Shimshara sickle blades the uniformity of form of the blades and the consistent evidence for their hafting combine to suggest a single major function for these blades in gathering or cutting plants. Further study of the micro-use wear patterns on blade surfaces may assist in determining the precise usage of these blades, including the extent to which they were used for gathering wild plants, such as seed heads of grasses or stands of reeds (Juel Jensen 1994).

Blades with sickle sheen are found widely distributed across the trenches at Bestansur and Shimshara (Figs 20.36–20.37; Table 20.11). They tend to be substantial blade fragments, their average weight of 2.60g significantly exceeding the average weight for all Bestansur retouched tools of 1.63g. At both sites, blades with sickle sheen are made from distinctive cherts, with mottled pale grey and mid-grey–brown cherts very commonly used. Many of the sickle blades show evidence for multiple episodes of retouching and reworking of blades, suggesting persistent usage. The often heavy retouching, occasionally to create serrated edges, suggests that these blades were required to cut through tough stands of plant matter, which may in these serrated types indicate use to cut reeds and rushes rather than cereals (Pope 2010: 179). Experimentation with such serrated/denticulated blades has revealed some practical problems harvesting cereals as stems periodically get caught in the blades' teeth (Vardi and Gilead 2013: 389), which would not apply in the case of reed cutting. Moreover, Anderson's (1994: 63) study of micro-wear traces suggests that many blades with sickle sheen from Early Neolithic sites in Southwest

Table 20.11. Trench by trench distribution of sickle blades at Bestansur and Shimshara.

Trench	*No. sickle blade frags*	*Average weight (g)*	*Average length/width ratio*
Bestansur			
1	1	0.66	2
2	4	3.32	2.36
3	1	1.7	3.8
4	7	1.68	2.55
5	2	3.11	1.68
7	13	2.01	2.52
8	5	2.46	1.86
9	24	2.08	2.16
10	87	2.8	2.45
12	7	2.69	2.27
13	8	2.66	2.04
Total	159	2.6	2.34
Shimshara	22	2.52	3.91

Asia were used to harvest reeds rather than cereals or grasses.

At Bestansur, in the Neolithic levels, sickle blades most commonly come from *in situ* external area occupation deposits (52.08% or 83/159), particularly from the sloping external strata of Trench 10 where they occur along with animal bones, ash, burnt stones and discarded edible snail shells. Significant numbers also come from within buildings (13.83% or 22/159), especially in Building 5, Trench 10 (Table 20.12). They are also found in Iron Age and later contexts, and in mixed and topsoil contexts (30.21% or 48/159). It is probable that the majority of recovered sickle blades were detached from hafts after breakage and abandoned in external areas of the sites during renewal of sickle tools, as supported by the context find spots and by the fact that almost all sickle blades are truncated/broken at one or both ends, thus in agreement with Keeley's (1982) proposal regarding the likely archaeological contexts of hafted tools. It is furthermore probable that considerable quantities of broken sickle blades would be discarded in the field, close to the point of use, which may help account for the low representations of sickle blades in assemblages recovered from settlement sites.

The Shimshara sickle blades (Fig. 20.37) differ from the Bestansur ones (Fig. 20.36) in three respects. They tend to be longer and thinner (Table 20.11), with an average length/width ratio of 3.91 as against 2.34 for the Bestansur sickle blades. They are frequently curved along their length, whereas the Bestansur examples are generally flat. Finally, fewer Shimshara sickle blades (9.09% or 2/22) have traces of fixative on their surfaces, compared to the Bestansur blades (38.31% or 61/159), which may relate to differential access to suitable bituminous sources or to differing modes of hafting.

Table 20.12. Context types with sickle blades at Bestansur and Shimshara.

Context type	*Sickle blades*	
	Bestansur	*Shimshara*
Topsoil	22	10
Wash/mixed	11	5
Late deposit/pit with pottery	15	–
Occupation, internal, Neolithic	22	–
Occupation, external, Neolithic	83	7
Shell midden, external, Neolithic	4	–
Wall, Neolithic	2	–
Total	159	22

Food procurement: animals, fish, birds

Hunting of living, moving prey is often seen as an activity most effectively conducted through use of chipped stone tools and weapons. In fact, it is perfectly possible to hunt a wide range of living creatures, large and small, by land, water and air, without using any stone implements, relying entirely on weapons of shaped and sharpened bone, antler, reeds and wood, and nets and traps often set by children (Bolger 2010). Conspicuously lacking in the Bestansur and Shimshara assemblages are clear instances of projectile points, such as the Byblos, Nemrik, El-Khiam and tanged points which typify approximately contemporary assemblages in Early Neolithic sites to the northwest and west across the Mesopotamian steppe and beyond (Kozlowski and Aurenche 2005: 22, figs 1.1.1–1.1.19; Borrell and Štefanisko 2016). Projectile points, generally speaking, are restricted to the steppe lands and do not feature in the upland assemblages of the Zagros chain (Hole 1996: 7).

In keeping with assemblages at other sites of the EFC (Kozlowski and Aurenche 2005: 22, figs 1.2.1–1.2.12), the Bestansur and Shimshara assemblages have significant quantities of small chert and obsidian tools (Fig. 20.38) such as nibbled and backed bladelets and diagonal-ended bladelets, as well as small quantities of crescents and trapezes, which may have served as points and barbs in composite tools and weapons suitable for hunting game (Hole 1983: 239, 258; Voigt 1983: 243; Aurenche and Kozlowski 2011: 453). They may also have been set as harpoon barbs for catching fish, although it is likelier that most fishing was carried out with weighted nets and traps. Use of nets is supported by significant quantities of pierced net-sinkers from Trenches 7 and 12–13 (Chapter 22) as well as by impressions of netting on the base of a possible Late Neolithic storage vessel from surface collection at Bestansur (Nieuwenhuyse *et al.* 2012). The majority of hunting implements may have been lost off-site and therefore do not feature in our recovery. As van Gijn (2010: 56) suggests, hunting points and barbs recovered on sites are most likely to have been discarded there during repair, retooling and rehafting, as we also suspect for the sickle blades.

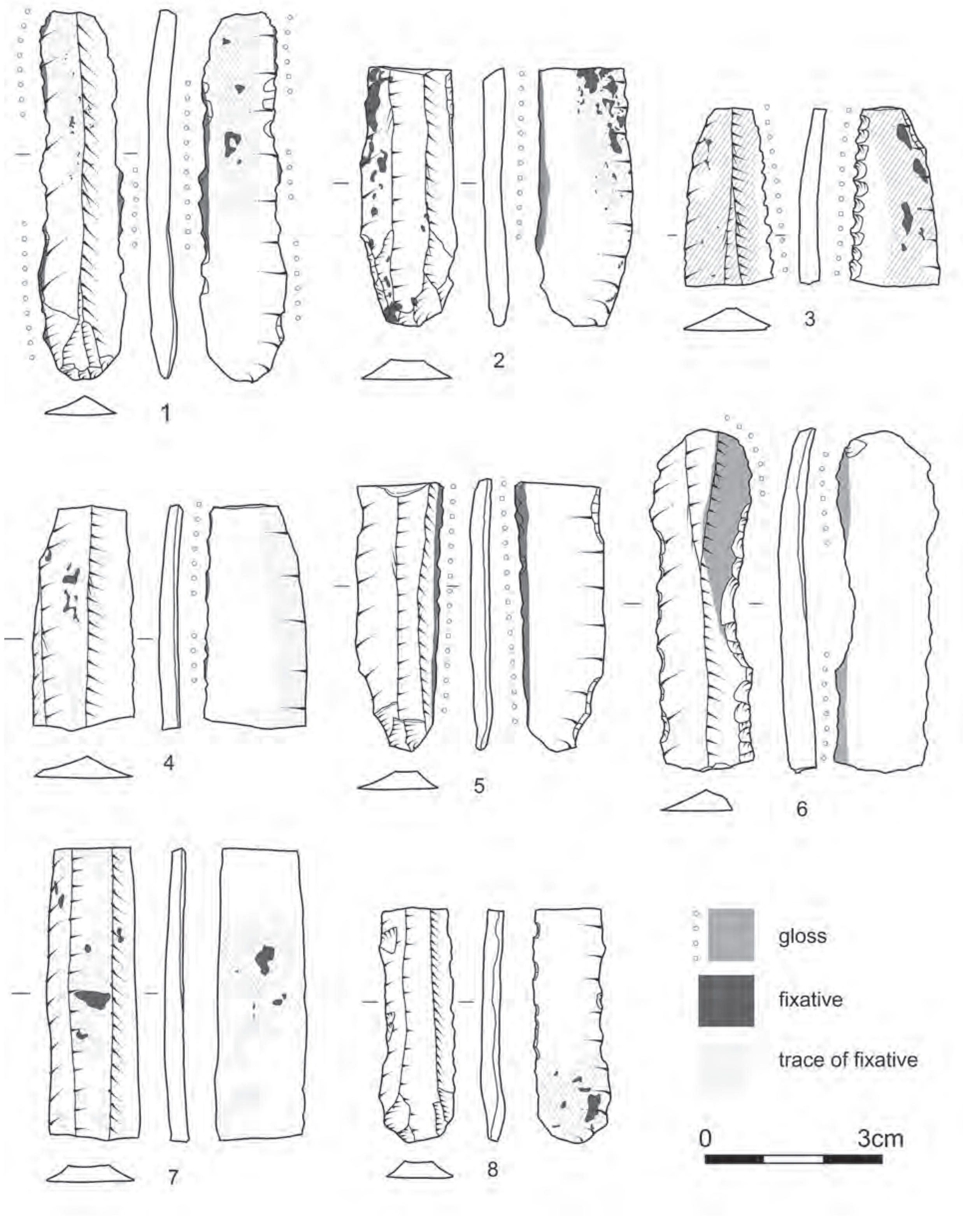


Figure 20.36. Chert blades with sickle sheen and/or fixative from Bestansur: 1) T10 C1540 Tool 6943, sickle blade, chert (C3); 2) T10 C1752 Tool 5936, sickle blade, chert (C7); 3) T10 C1721 Tool 5624, sickle blade, serrated, chert (C3); 4) T10 C1755 Tool 5999, sickle blade, chert (C2); 5) T13 C1578 Tool 6291, sickle blade, chert (C7); 6) T13 C1373 Tool 6739, sickle blade, chert (C2); 7) T10 C1775 Tool 6081, sickle blade, chert (C2); 8) T12 C1528 Tool 6510, sickle blade, chert (C6).

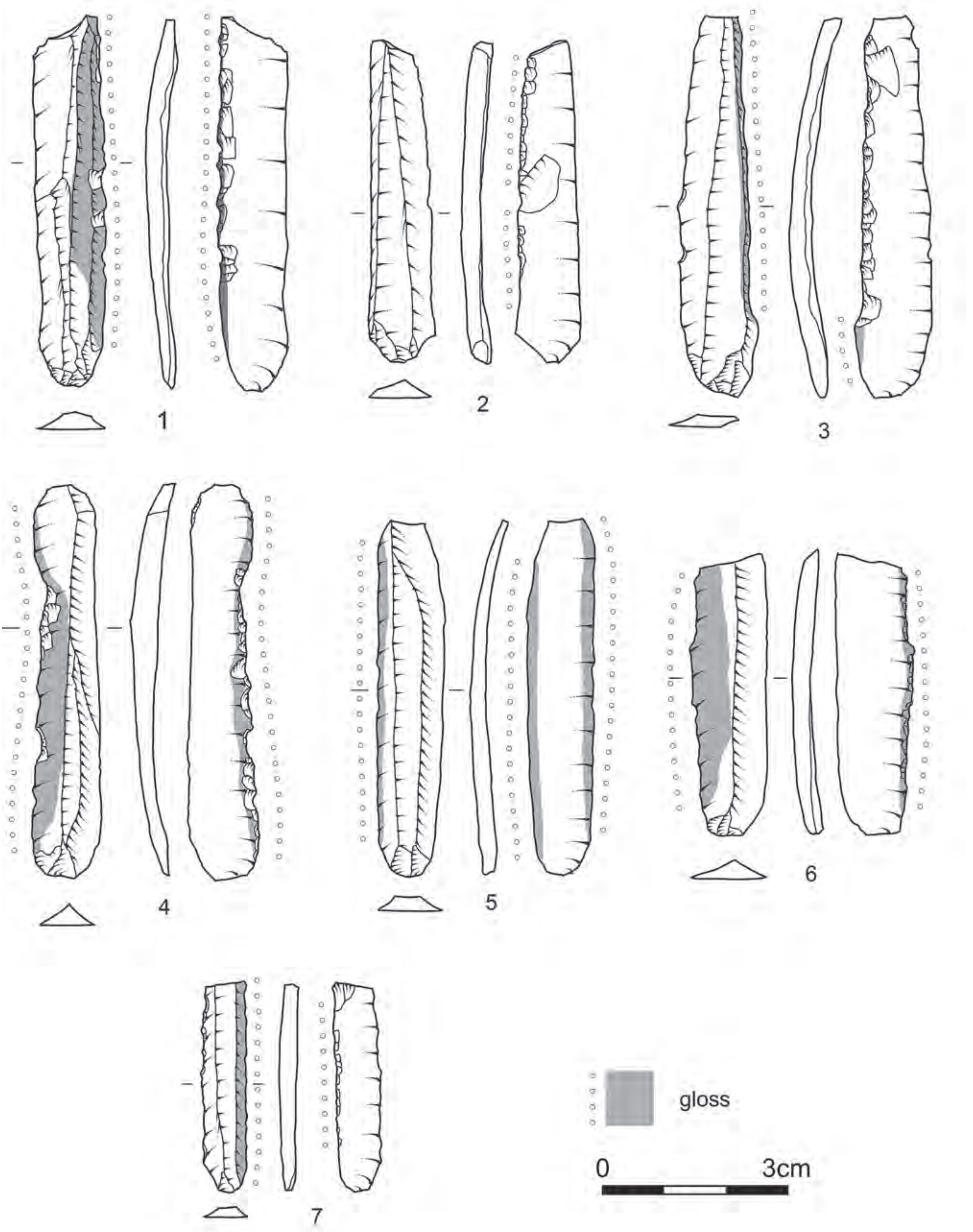


Figure 20.37. Chert blades with sickle sheen from Shimshara: 1) T1 C1632 Tool SHIM334, sickle blade, chert, mid-brown; 2) T1 C1632 Tool SHIM335, sickle blade, chert, mid-brown; 3) C1660 Tool SHIM407, sickle blade, chert, mid-grey; 4) T2 C1659 Tool SHIM432, sickle blade, chert, dark brown; 5) T2 C1636 Tool SHIM483, sickle blade, chert, pale grey; 6) T2 C1659 Tool SHIM433, sickle blade, chert, mid-grey/brown; 7) T1 C1653 Tool SHIM310, sickle blade, chert, pale grey.

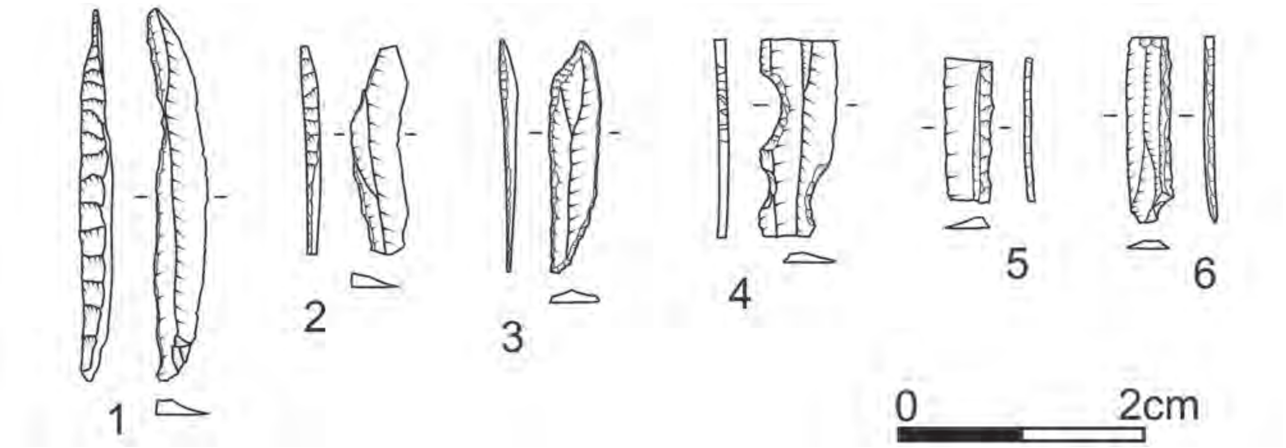


Figure 20.38. Chert microtools from Bestansur and Shimshara. BEST: 1) T10 C1781 Tool 7046, blade, backed, chert (C3); 2) T10 C1781 Tool 7061, crescent/lunate, chert (C1); 4) T13 C1579 Tool 6377, blade, notched, chert (C7); 5) T10 C1781 Tool 7111, blade, backed, chert (C3). SHIM: 3) T2 C1659 Tool SHIM452, diagonal-ended blade, chert, green/grey; 6) C1635 Tool SHIM521, diagonal-ended blade, chert, mid-grey.

Potentially the most significant tool in this regard is the diagonal-ended blade or bladelet. These tools are found at both sites, in large numbers at Bestansur and, unlike sickle blades or Çayönü tools, can be made of either chert or obsidian (Figs 20.39–20.41; Tables 20.13–20.14). Diagonal-ended bladelets are delicate, small artefacts, with an average weight of 0.51g at Bestansur, much less than the average for all retouched tools at 1.63g. According to Binder's classification by width of blade sizes (see above), the Shimshara diagonal-ended bladelets break down to three micro-bladelets and four bladelets, while the Bestansur examples break down to 121 micro-bladelets, 30 bladelets and only four blades. Of the 155 Bestansur examples, 59 were recovered from flotation heavy residues, 25 from dry-sieving and 71 were hand-picked from deposits during excavation. These fine tools were made by pressure flaking of a blade from a bladelet core, followed by oblique truncation of the proximal end of the blade and subsequent retouch along the diagonal fracture in order to strengthen the resulting edge, usually giving a mildly concave shape to the diagonal end culminating in a sharp tip (Fig. 20.40). The distal ends are often deliberately snapped. The vast majority of Bestansur examples have the tip of the proximal truncation on the left-hand side when viewed with the truncation at the top and the dorsal face uppermost (Fig. 20.39). By contrast, at least some of the Shimshara examples have the tip on the right-hand side, a distinction which may relate to handedness of the knapper(s) or to cultural preferences in knapping technology.

We envisage diagonal-ended bladelets as being slotted into a shaft at an angle so that the retouched tip served as a barb or being inserted into the tip of a shaft as a point. Multiple bladelets might be attached to a single shaft (Fig. 20.41). Examples from Jarmo have traces of bitumen fixative probably for this purpose (Hole 1983: 238). On the basis of experimental studies, Yaroshevich *et al.* (2010: 387) argue that during the Natufian in the WFC a decline in the use of geometric microliths and their replacement by a single standardised lunate shape, used as arrow tips, indicates "a demand for flexible, light and efficient projectiles requiring low time and labor investment for preparation and retooling". These requirements and properties can equally be assigned to the diagonal-ended bladelet.

By far the most common context type for diagonal-ended bladelets is external occupation deposits (56.82% or 88/155), in particular in Trenches 7 and 10 (Table 20.14). How did significant numbers of these delicate small tools end up liberally distributed through occupation debris and on living surfaces in Neolithic external contexts? A likely answer is that they arrived at the site embedded in the carcasses of hunted game and were then discarded onsite in the process of butchery and disposal of animal remains. The majority of diagonal-ended bladelets have broken tips or edges, likely to have occurred during impact.

There is also a chronological aspect to the preponderance of diagonal-ended bladelets and the rarity of geometric microliths such as trapezes and crescents at Bestansur (Table 20.13). At Jarmo diagonal-ended bladelets are found only in the earlier levels while geometric microliths come almost exclusively from Jarmo's later Neolithic levels (Hole 1983: 239), and from late Aceramic Neolithic sites in Southeast Anatolia (Cauvin and Balkan 1985: 69), northern Syria (Nishiaki 1993: 148) and northwest Iran (Kozlowski 1999: 53). An identical pattern can be seen at the Deh Luran sites in Khuzestan, with diagonal-ended bladelets in the Early Neolithic phases replaced by geometric microliths in the later phases (Hole *et al.* 1969: 77–78; Hole 1977: table 37, 160). The Bestansur pattern fits with the radiocarbon chronology, which

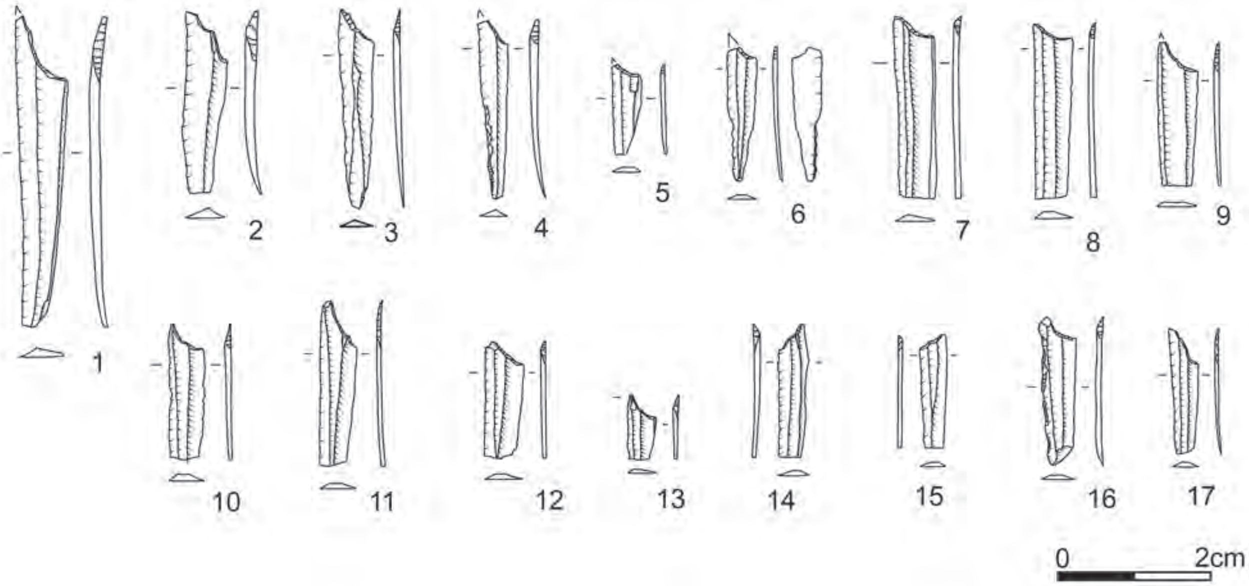


Figure 20.39. Diagonal-ended bladelets from Bestansur and Shimshara. BEST: 1) T10 C1784 Tool 6174, diagonal-ended blade, chert (C1); 2) T13 C1494 Tool 6777, diagonal-ended blade, chert (C7); 3) T10 C1721 Tool 5625, diagonal-ended blade, chert (C2); 4) T13 C1581 Tool 6303, diagonal-ended blade or point/awl, chert (C2); 5) T12 C1526 Tool 6387, diagonal-ended blade, chert (C6); 6) T12 C1514 Tool 6446, diagonal-ended blade or point/awl, chert (C2); 7) T10 C1625 Tool 6850, diagonal-ended blade, chert (C2); 8) T10 C1773 Tool 6080, diagonal-ended blade, chert (C8); 9) T12 C1523 Tool 6480, diagonal-ended blade, chert (C8); 10) T10 C1755 Tool 5995, diagonal-ended blade, chert (C13); 11) T10 C1750 Tool 5812, diagonal-ended blade, chert (C1); 12) T10 C1756 Tool 5790, diagonal-ended blade, chert (C14); 13) T12 C1528 Tool 6392, diagonal-ended blade, chert (C10); 14) T9 C1352 Tool 6668, diagonal-ended blade, chert (C1); 16) T12 C1488 Tool 6763, diagonal-ended blade, obsidian (O1); 17) T10 C1539 Tool 6883, diagonal-ended blade, obsidian (O1). SHIM: 15) T2 C1659 Tool SHIM441, diagonal-ended blade, chert, pale grey.

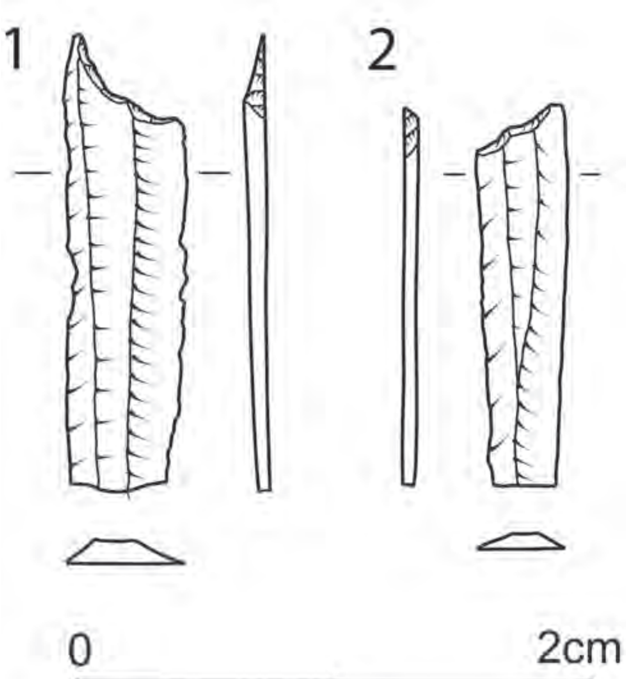


Figure 20.40. Diagonal-ended bladelets from Bestansur and Shimshara. BEST: 1) T10 C1755 Tool 5995, diagonal-ended bladelet, chert (C13). SHIM: 2) T2 C1659 Tool 441, chert, dark beige.

suggests contemporaneity of Bestansur with, and predating of, the earliest levels at Jarmo (Chapter 11). A related aspect is the complete absence at Bestansur and Shimshara of the so-called 'side-blow blade-flakes' which are common at Jarmo and other sites of very late Aceramic Neolithic and Pottery Neolithic date (Hole 1983: 247–248; Nishiaki 1993: 145; 1996).

Finally, in two cases we have evidence for pointed tools in close association with human remains at Bestansur. In Trench 7 a distinctive chert point or drill, slightly shouldered like an El-Khiam point (Kozlowski and Aurenche 2005: fig. 1.1.5), was found adjacent to the skull of an adult male buried with an adult female (Fig. 20.42; Chapter 19).

Secondly, in Trench 10 a fine specimen of a diagonal-ended blade, in two joining pieces of white chert, was found in close proximity to bone mass SK1784 in Space 50, remains of at least one adult female (Fig. 20.43). This tool appears to have been deliberately broken, or 'killed', before being deposited with the human bone mass, or was possibly broken on impact. A good contemporary parallel comes from Tepe Guran, trench G III, where a broken backed bladelet, "possibly deriving from an arrow" (Mortensen 2014: 39), was found adjacent to the head of a single adult male. In all cases we cannot be certain that these stone tools were components of weapons that may have

Table 20.13. Trench by trench distribution of diagonal-ended bladelets and geometric microliths at Bestansur and Shimshara.

Trench	*Diagonal-ended bladelets*		*Average weight (g)*	*Average length/ width ratio*	*Geometric microliths*
	Obsidian	*Chert*			
Bestansur					
2	4	–	0.15	2.58	–
3	1	2	1.18	2.15	–
4	10	5	0.57	2.64	1
5	2	–	0.34	2.94	2
6	1	–	0.5	2.63	1
7	13	9	0.57	2.92	1
8	2	7	0.83	2.51	1
9	6	9	0.16	3.42	3
10	7	59	0.29	3.37	8
11	1	2	1.31	4.01	–
12	1	8	0.1	3.47	–
13	–	6	0.15	3.3	–
Total	48	107	0.51	3	17
Shimshara	4	3	0.47	3.01	1

Table 20.14. Context types with diagonal-ended bladelets at Bestansur and Shimshara.

Context type	*Diagonal-ended bladelets*	
	Bestansur	*Shimshara*
Topsoil	22	1
Mixed, disturbed	9	4
Late deposit/pit with pottery	11	–
Occupation, internal, Neolithic	16	–
Occupation, external, Neolithic	88	2
Wall/packing, Neolithic	7	–
Human burial, Neolithic	1	–
Fire installation, Neolithic	1	–
Total	155	7

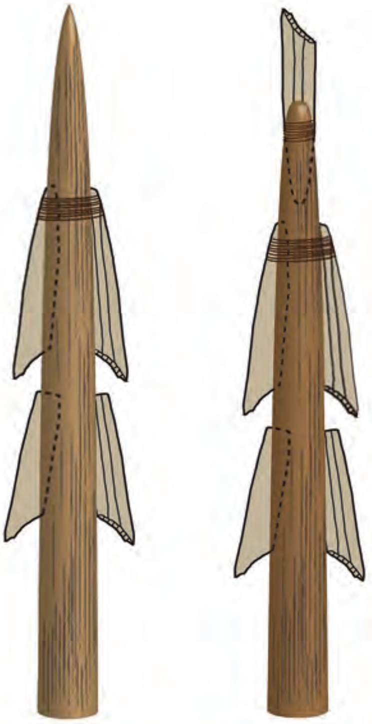


Figure 20.41. Reconstruction drawing of possible use of diagonal-ended bladelets as barbs and points on arrows.

been involved in harming, even fatally wounding, the humans represented by the associated bones, rather than deposited as a grave good or accidentally interred with the deceased, but the former interpretation is more likely and violence in the Neolithic is attested at other sites (Rollefson and Kafafi 1996; Bocquentin and Bar-Yosef 2004; Knüsel *et al.* 2019). Similar doubts are expressed in van Gijn's (2010: 116) discussion of flint arrowheads found in Dutch Neolithic human burials. But they remind us to be aware that tools used for hunting animals may equally have found use in inter-human conflict and combat.

Food processing, preparation and consumption

Many Neolithic tools may have performed important roles in the preparation of hunted prey of all types. Gutting and filleting of fish, for example, could be performed by razor-sharp obsidian blades set in wooden hafts. The types of fish attested at Bestansur, however, would need only minimal preparation before consumption (Chapter 15), which may or may not have involved chipped stone tools. Stone tools would be commonly used in butchery of animals for food preparation, including cutting of the skin, dismembering, gutting and filleting of animals of a wide range of sizes, from small birds to very large mammals. Experimental work on animal butchery with chert tools suggests that diagnostic use-wear traces are extremely difficult or impossible to detect (van Gijn 2010: 63). A small quantity of animal bones from Bestansur has traces of cutting with sharp implements, but usually the skills of the Neolithic butchers show through in their ability to fillet meat

Figure 20.42. Shouldered chert point (Tool 1350) adjacent to skull of adult male, external burial fill Context 1224, Space 22, Trench 7, Bestansur.

Figure 20.43. Diagonal-ended blade (Tool 6174) adjacent to bone cluster SK6 in Context 1784, Space 50, Trench 10, Bestansur.

without touching the bone, and thereby blunting their tools. Hand-held ground-stone tools would be useful for smashing bones in order to extract marrow, as commonly attested at Bestansur (Chapters 15, 22).

We have good evidence for association of lithic tools with a favourite item of the Bestansur diet: land snails or *Helix salomonica*. In Trench 7 a clay-lined pit with multiple snail shells also included a heavily worked serrated chert blade, in two joining pieces, with thick traces of bitumen fixative and sickle sheen on both edges (Figs 20.44–20.45). Perhaps this tool was used in cutting of plant fuel, such as reeds, for burning in the clay-lined pit, or it could have been simply thrown into the fire pit as waste after breakage in activities taking place elsewhere in this open external area of the site. In Trench 5 to the north of Trench 7, chert and obsidian blades occur in significant numbers embedded within strata of discarded land snails (Fig. 20.46). Many of the Trench 5 blades are notched, perhaps to shape and sharpen wooden snail picks. Otherwise the blades here may have been used for prising open snails and extracting and slicing the edible parts after cooking.

Cherts and flints were of course used as strike-a-lights by many cultures through history. We know that the inhabitants of Bestansur were cooking edible land snails in clay-lined pits and that they had good control over fire, as attested by numerous fire installations throughout the site. We can assume that much of their daily diet, in particular the meat-based dishes, was prepared through heating in some form. Many of the Bestansur chert tools could be used as strike-a-lights in conjunction with another hard material, although it is not possible to identify a specific tool for this purpose such as the 'firestones' with patches of battering found at Umm Dabaghiyah and other Later Neolithic sites (Mortensen 1983: 212).

Figure 20.44. Clay-lined pit (Context 1218) filled with edible land snail, Helix salomonica, and two joining pieces of a chert serrated blade SF61 (one piece at top left by scale, other piece centre right), Space 17, Trench 7, Bestansur. Looking south, scale = 25cm.

Chipped stone tools and craft activities

The relationship between chipped stone tools and prehistoric craft activities can be difficult to articulate (Cahen *et al*. 1979) and, indeed, the very definition of ancient craft, as distinct from food gathering and preparation, for example, may often be impossible. Nevertheless, there are certain fields of activity undertaken by the Neolithic inhabitants of Bestansur and Shimshara that we can delineate as potentially significant for the interpretation of our chipped stone tool assemblages within a broad definition of craft production. Such a definition of craft includes the manufacture of tools of wood, bone and antler, of containers, clothing, mats or coverings made from organic materials such as hide, bark, wood, reed and fibre and of ornaments and special artefacts made of clay, stone, bone and shell.

A starting point may be to consider which of these materials are directly attested in the archaeological record at Bestansur and Shimshara and which of them might be indirectly inferred to have been present, and then to review whether and how they might have been worked using the attested chipped stone tools. Worked raw materials directly attested at Bestansur and Shimshara (Chapters 21 and 22) include a range of ground and polished stones, clay (generally unbaked, occasionally fire-hardened), animal bone, shell (river and marine) and reed (split-reed matting surviving in charred form and as articulated phytolith spreads). Worked raw materials indirectly inferred include, above all, those necessary for the production of clothing (hides and perhaps felt held together with twine, skin or sinews, but there is as yet no evidence for woven textiles), and of storage items, such as baskets (wood and /or split reeds and grasses?), and of cooking and eating utensils and dishes (wood, bone, antler?). Where might chipped stone tools fit into these loosely defined areas of craft activity, bearing in mind van Gijn's (2010: 77–78) warning that chert or obsidian

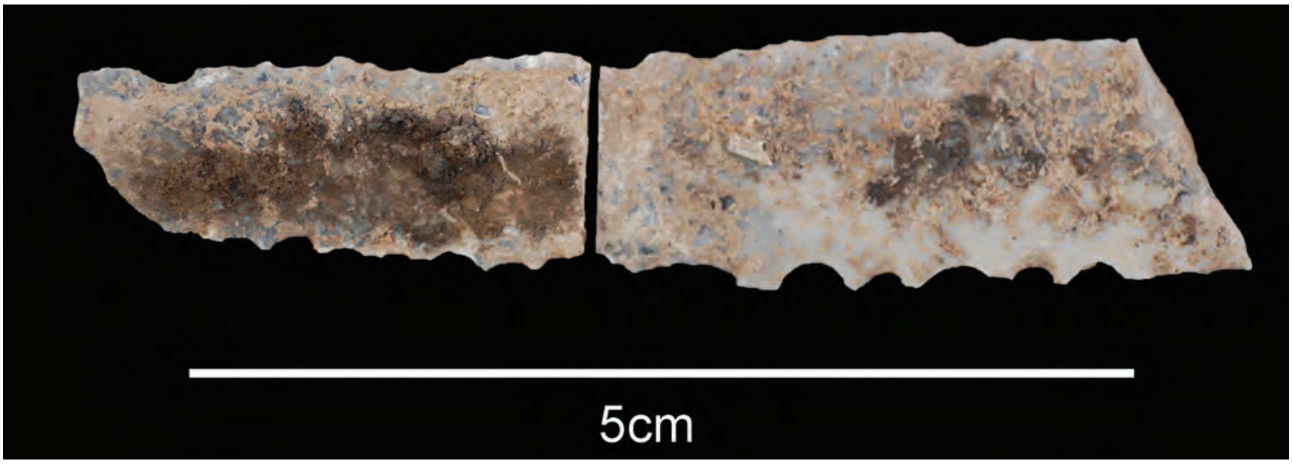


Figure 20.45. Chert serrated blade SF61 from clay-lined pit fill Context 1218, Space 17, Trench 7, Bestansur, showing heavy edge battering and thick traces of fixative.

Figure 20.46. Obsidian blade, SF13, embedded in strata of discarded snail shell, Helix salomonica, Context 1078, Space 7, Trench 5, Bestansur.

tools will only have been one component of complex tool-kits comprising implements made of multiple, often compound, and perishable materials? We here examine the materials in turn.

Antler and bone

Tools of bone are relatively common in Neolithic sites of the EFC, and Bestansur is no exception (Chapter 21). By far the commonest tool is the bone point, manufactured on the metapodia of deer, sheep or goat. Cutting of the blanks for these tools would have been performed using chipped stone blades, and such cut marks are occasionally visible on bone tools and shafts from our sites. Antler tools have not been identified at Bestansur or Shimshara.

Tools with obvious burin facets, used as engravers potentially for incising materials such as bone, antler, leather and shell, as well as burin spalls, are extremely rare at Bestansur and Shimshara, as at contemporary sites such as Abdul Hosein in the high Zagros (Mortensen 1970: 30–31; Pullar 1990: 110) and M'lefaat to the northwest (Kozlowski 1998: 197). At Bestansur only eight possible examples of burin tools were found (five from Trench 10 and three from Trench 11: see Table 20.19 below). There is probably a chronological attribute to this scarcity, since at Çayönü burin tools occur in the earliest levels (Redman 1982: 39), which pre-date Bestansur, but not in the later phases, contemporary with Bestansur. We lack evidence so far for incised and engraved decoration of bone or stone artefacts that may have been executed with burin tools.

Beads and ornaments of stone, bone, shell, clay

Significant quantities of beads were found in association with the multiple deposits of human remains in Trench 10, Building 5, Space 50, as well as occasionally elsewhere across the site (Chapter 21). Production of beads from stone, bone, shell and clay would have involved use of chipped stone tools in a range of tasks, including sharp blades for cutting the bead blank from a segment of raw material, and points, awls and drills for piercing a perforation through the blank in order to prepare the bead for stringing (González-Urquijo *et al*. 2013). The very fine size of most of the Bestansur beads indicates that much of the drilling could only have been performed by extremely fine points.

Chipped stone tools with points are relatively common in the Bestansur and Shimshara assemblages (Table 20.15). They range from micro-tools with fine points to sizeable shouldered drills and thick reamers used for expanding holes already made by finer tools (Fig. 20.47). The vast majority of pointed tools are made of chert (198/231 or 85.71%) rather than obsidian (33/231 or 14.29%), no doubt because chert piercers and points are less brittle than obsidian points. Shouldered drills, in particular, are always made from chert and generally from a tough, smooth-textured grey chert with pale mottling; 88% of drills at Jarmo were made of chert (Hole 1983: 241).

The distribution of pointed tools across context types at Bestansur (Table 20.16) once more shows a strong predominance of external Neolithic areas (109/231 or 47.17%) with modest indication of usage

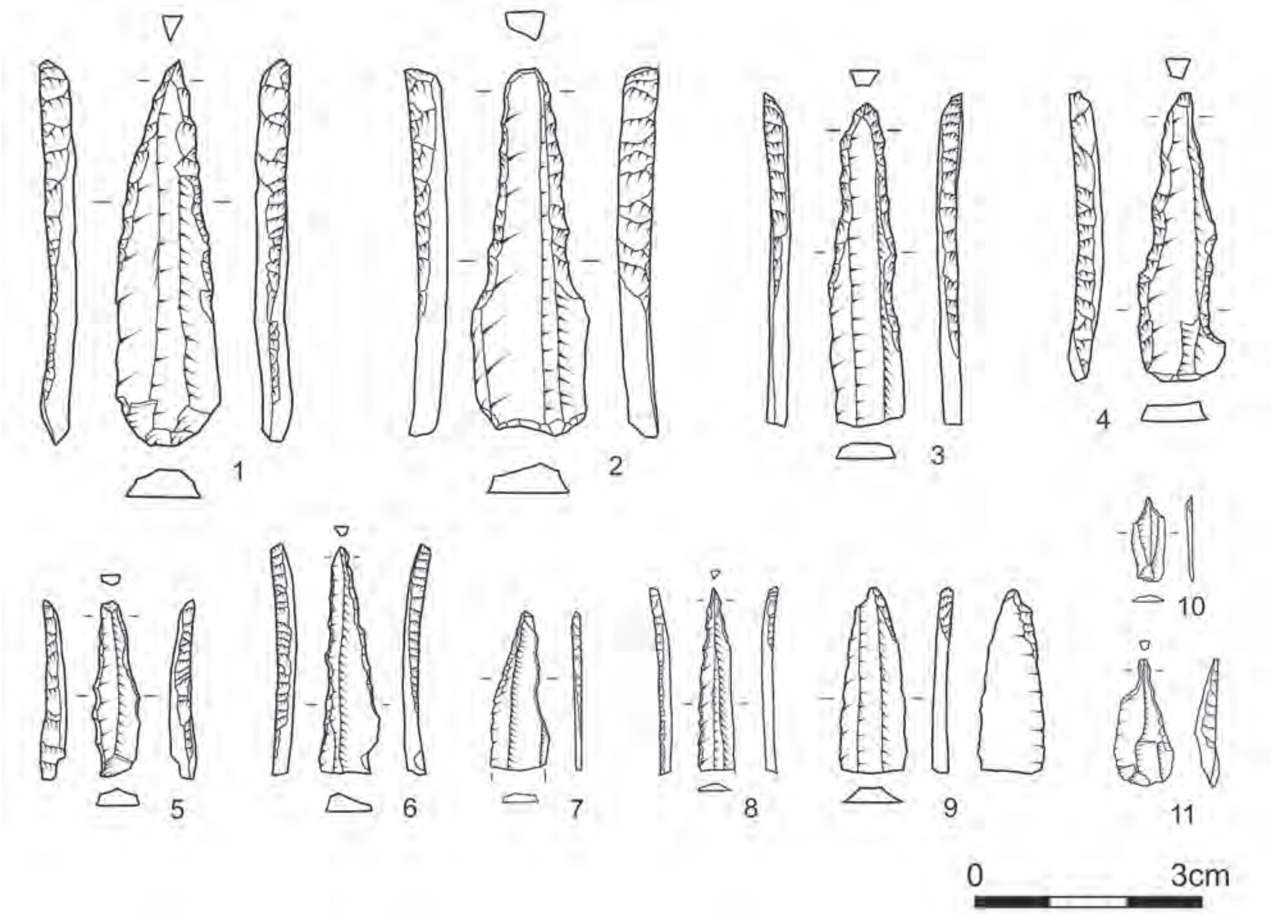


Figure 20.47. Pointed tools from Bestansur and Shimshara. BEST: 1) T13 C1572 Tool 6249, point/awl, chert (C3); 2) T10 C1720 Tool 5643, point/awl or reamer, chert (C4); 3) T13 C1575 Tool 6370, point/awl or reamer, chert (C10); 4) T13 C1581 Tool 6299, point/awl or reamer, chert (C7); 5) T13 C1521 Tool 6320, borer, chert (C4); 6) T10 C1620 Tool 6835, pointed tool, chert (C5); 7) T10 C1750 Tool 5813, point/awl, chert (C2); 8) T13 C1572 Tool 6248, point/awl, obsidian (O1); 10) T10 C1538 Tool 5837, point/awl or shouldered drill, chert (C4); 11) T10 C1538 Tool 7150, point/awl or shouldered drill, chert (C1). SHIM: 9) T2 C1658 Tool SHIM219, point/awl, obsidian, black (greenish).

in internal areas as well (16/231 or 6.93%). In addition to bead-working, pointed stone tools would have been used for a wide variety of craft activities, including piercing and stitching items of clothing, such as hides, to form skirts, capes and jackets for example. It is also possible that some of them were used as projectile points rather than as piercers or drills.

Polished stone bowls and bracelets

Highly distinctive objects of polished alabaster occur in small quantities at both Bestansur and Shimshara in the form of vessels and so-called bracelets (Chapter 21), as attested at a broad range of Neolithic sites across the Fertile Crescent (Voigt 1983: 236–237; Kozlowski and Aurenche 2005: 26–27). The most significant issue here is the potential use of so-called Çayönü tools in the production of these clearly high-status artefacts. Redman (1973: 258; 1982: 43–44) first suggested that Çayönü tools may have been used in conjunction with a grinding compound, hard enough to cause the characteristic planar striations, and a frame of some kind in order to shape and polish alabaster objects such as bracelets.

Çayönü tools are one of the most diagnostic tool types found at Bestansur and Shimshara (Figs 20.48–20.51). At Bestansur we found a total of 93 fragments of Çayönü tools (seven of them from Iron Age excavations in Trench 14 which otherwise does not feature in the analyses of this chapter), occurring in almost every trench, while from Shimshara we recovered 29 Çayönü tool fragments. No complete Çayönü tools were found. With an average weight of 1.17g and length of 2.04cm, Çayönü tool fragments from Bestansur are significantly smaller and more fragmented than those from Shimshara, whose average weight is 4.16g and length is 4.22cm, a fact which again attests the more lavish use of obsidian at Shimshara (Table 20.17). Indeed the Shimshara Çayönü tools are more substantial than the average Çayönü tool from Çayönü itself, at 3.3cm in length (Redman 1982: 43), although we lack the spectacular 20cm long examples also found at that site (Redman 1982: fig. 2.14). Typical examples

Table 20.15. Trench by trench distribution of pointed tools at Bestansur.

Chert/ obsidian Trench	*Awl/point/ borer/drill*		*Shouldered drill*		*Reamer*		*Totals*	
	C	*O*	*C*	*O*	*C*	*O*	*C*	*O*
1	6	–	–	–	–	–	6	–
2	2	3	6	–	–	–	8	3
3	1	–	–	–	–	–	1	–
4	7	2	5	–	–	–	12	2
5	2	1	5	–	–	–	7	1
7	7	4	5	1	–	–	12	5
8	4	–	4	–	–	–	8	–
9	19	2	6	–	3	–	28	2
10	69	16	17	–	5	1	91	17
11	3	1	1	–	–	–	4	1
12	5	1	1	–	–	–	6	1
13	13	1	–	–	2	–	15	1
Total	138	31	50	1	10	1	198	33

of these distinctive emblems of Early Neolithic material culture from Bestansur and Shimshara are depicted in Figures 20.48–20.51.

Previously called ‘beaked blades’ by some (Fujii 1988), Çayönü tools have a characteristic morphology, with thick blades showing steep, dense retouch on one or both edges and often with a flaring, rounded end. Many Çayönü tools have pressure-flaked retouch, which is rare among other types of Eary Neolithic chert and obsidian tools. In cross-section they are frequently angular and rhomboid or tunnel-shaped, occasionally wedge-shaped. In many cases the distinctive retouch along the edges of Çayönü tools took place after their initial use, as a means of re-establishing the tool edge to enable further use (Anderson 1994: 76). On their flat dorsal or ventral faces they almost always show clear use-wear traces in the form of radial or parallel lines etched into the obsidian, interpreted by Redman (1982) and Anderson (1994) as evidence for their use in shaping and polishing of stone objects such as marble bracelets and limestone plaques or bowls in a repetitive back and forth motion. Anderson’s (1994: 78) EDAX analyses of mineral residues trapped within the striations on Çayönü tools show elevated levels of sulphur and calcium, congruent with polishing of limestone or alabaster. In agreement with these results, our pXRF analysis identified elevated sulphur levels above 300–400 parts per million (ppm) on sampled Çayönü tools. At Shimshara, alongside high proportions of stone bracelets and bowls, elevated sulphur levels are evident on the Çayönü tools, matched with elevated calcium levels on SHIM Tools 253, 351, 352, and 390. Sulphur levels do not appear to have been significantly elevated on any of the Bestansur obsidian tools, but slightly elevated calcium levels are present on a small number of them. Levels of calcium on the surface of obsidian tools can also be elevated where patination has occurred and therefore not relate to use of the tools.

Table 20.16. Context types with pointed tools at Bestansur and Shimshara.

Context type	*Pointed tools*	
	Bestansur	*Shimshara*
Topsoil	43	1
Mixed, disturbed	11	6
Late deposit/pit with pottery	47	–
Occupation, internal, Neolithic	16	–
Occupation, external, Neolithic	109	5
Wall, Neolithic	2	–
Shell midden, Neolithic	2	–
Human burial, Neolithic	1	–
Total	231	12

Table 20.17. Trench by trench distribution of Çayönü tools at Bestansur.

Trench	*No. Çayönü tool frags*	*Average length (cm)*	*Average weight (g)*
Bestansur			
1	2	1.5	0.41
2	7	2.33	2.16
3	5	2.62	1.27
4	1	1.6	1.28
5	10	1.8	1.17
7	19	2.25	1.12
8	4	1.48	0.68
9	5	1.81	1.19
10	18	2.3	1.22
11	12	2.02	0.69
12	3	2.74	1.79
14	7	–	–
Total	93	2.04	1.17
Shimshara	*29*	*4.22*	*4.16*

Apart from size and shape, there are striking and consistent elements of difference in the manufacture and retouch of Çayönü tools from Bestansur as against those from Shimshara. At Bestansur, the retouch of the tool edges is always inverse, that is on the ventral face, while at Shimshara the retouch is always direct, that is on the dorsal face (Fig. 20.30). Furthermore, the heavily ground surface of the tool, usually with multiple fine striations, is almost always on the dorsal face at Bestansur (Fig. 20.48) but on the ventral face at Shimshara (Figs 20.30, 20.49–20.50). Thus, in each case the retouching of the tools’ edges took place from the grinding or polishing surface downwards, supporting Anderson’s (1994: 79) suggestion that the main purpose of the massive retouching was to sustain a suitably formed polishing surface. These technological distinctions fit with an observation made by Fujii (1988: 1; see also Nishiaki 1993: 147; adumbrated by Linda Braidwood’s comments in Hole 1983: 264, note 5) that Çayönü tools in the Zagros region tend to have inverse retouch while Çayönü tools in Anatolia more often have direct retouch,

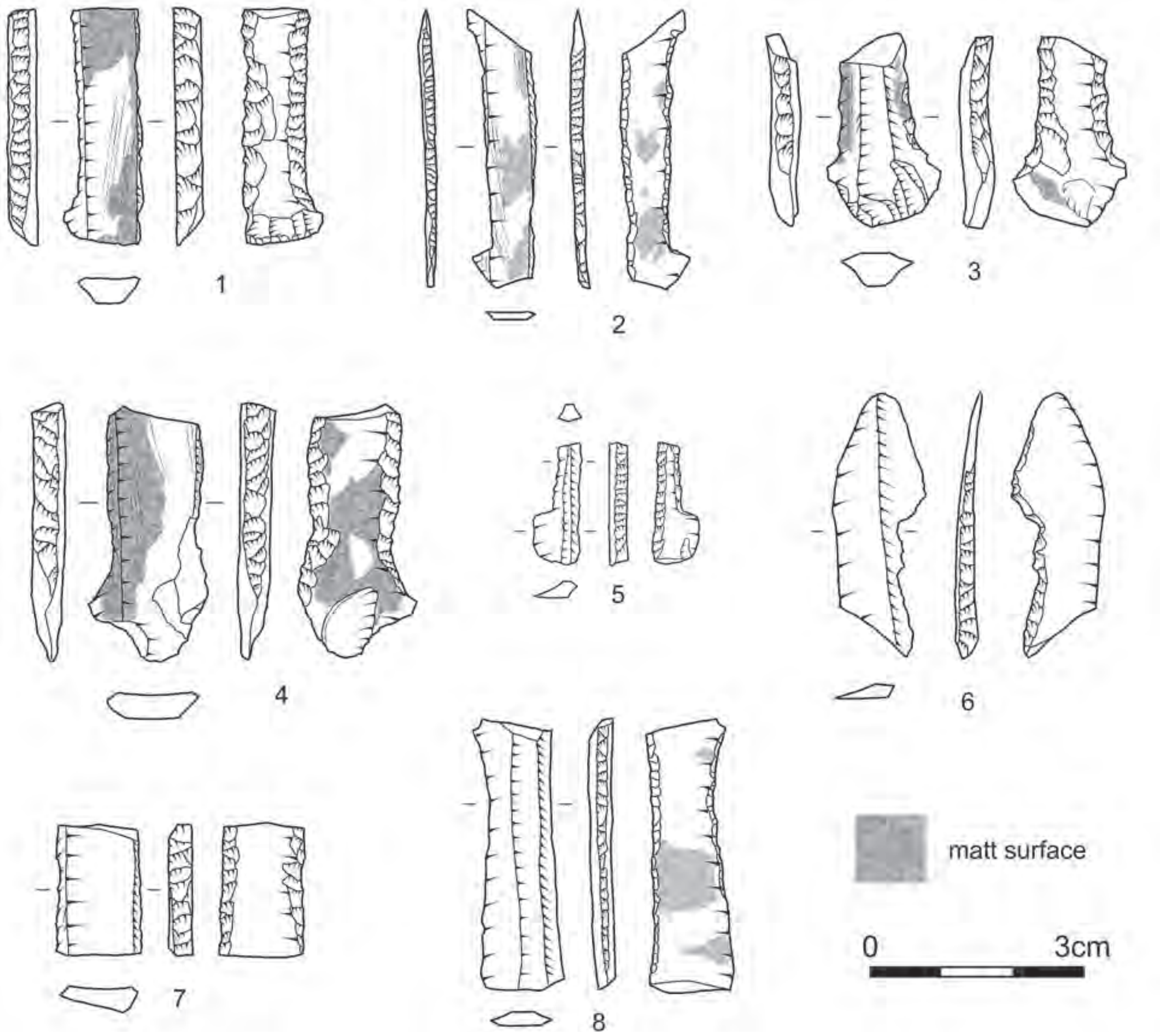


Figure 20.48. Çayönü tools from Bestansur, obsidian: 1) T2 C1030 Tool 153, Çayönü tool, obsidian (O1); 2) T12 C1512 Tool 6420, Çayönü tool, obsidian (O1); 3) T12 C1526 Tool 5430, Çayönü tool, obsidian (O1); 4) T10 C1549 Tool 7180, Çayönü tool, obsidian (O1); 5) T7 C1259 Tool 1524, Çayönü tool, obsidian (O1); 6) T10 C1557 Tool 7138, Çayönü tool, obsidian (O1); 7) T10 C1727 Tool 5777, Çayönü tool, obsidian (O1); 8) T5 C1074 Tool 502, Çayönü tool, obsidian (O1).

which suggests that Shimshara for this purpose lay within the Anatolian rather than the Zagros sphere. A single example from nearby Qalat Said Ahmadan matches the Shimshara style (Tsuneki *et al*. 2015, fig. 5.21:3). Çayönü tools from Çayönü itself conform to the Shimshara examples, with heavy striations on the ventral planes and direct retouch (Redman 1982: 42, figs 2.14–2.15), as do Çayönü tools from Cafer Höyük in southeast Anatolia (Cauvin and Balkan 1985: figs 3–4) and from Boytepe on the northern slopes of the Taurus (Balkan 1989: 88–89, fig. 2). In keeping with its location between the two zones, examples from Maghzaliya in the Sinjar region of upper Mesopotamia, where obsidian forms 75% of the Early Neolithic chipped stone assemblage, show an unusual mixture of both Anatolian-style direct retouch and Zagros-style inverse retouch, occurring in association with common fragments of polished marble bracelets and bowls (Bader 1993: 15–16, 37, fig. 2.25; Kozlowski 1999: pl. li).

By contrast, Çayönü tools from Jarmo (Hole 1983: 264, fig. 122: 11–25) resemble the Bestansur examples, with an average length of 2.16cm, ventral surface striations and inverse retouch. Rare Çayönü tools from Umm Dabaghiyah (Mortensen 1983: 210, fig. 4: k–l) also agree with the Bestansur/Jarmo pattern. Given that the obsidian for Çayönü tool manufacture at both Shimshara and Bestansur was coming from the same source, at Nemrut Dağ in east Anatolia, we interpret the observed variation in technological practice as indicative of differing local traditions in tool manufacture and use that may attest technical 'schools' of production at the regional scale. This inference has exciting implications for issues such as craft traditions, training and skills sharing in lithic technology within and across the Early Neolithic world.

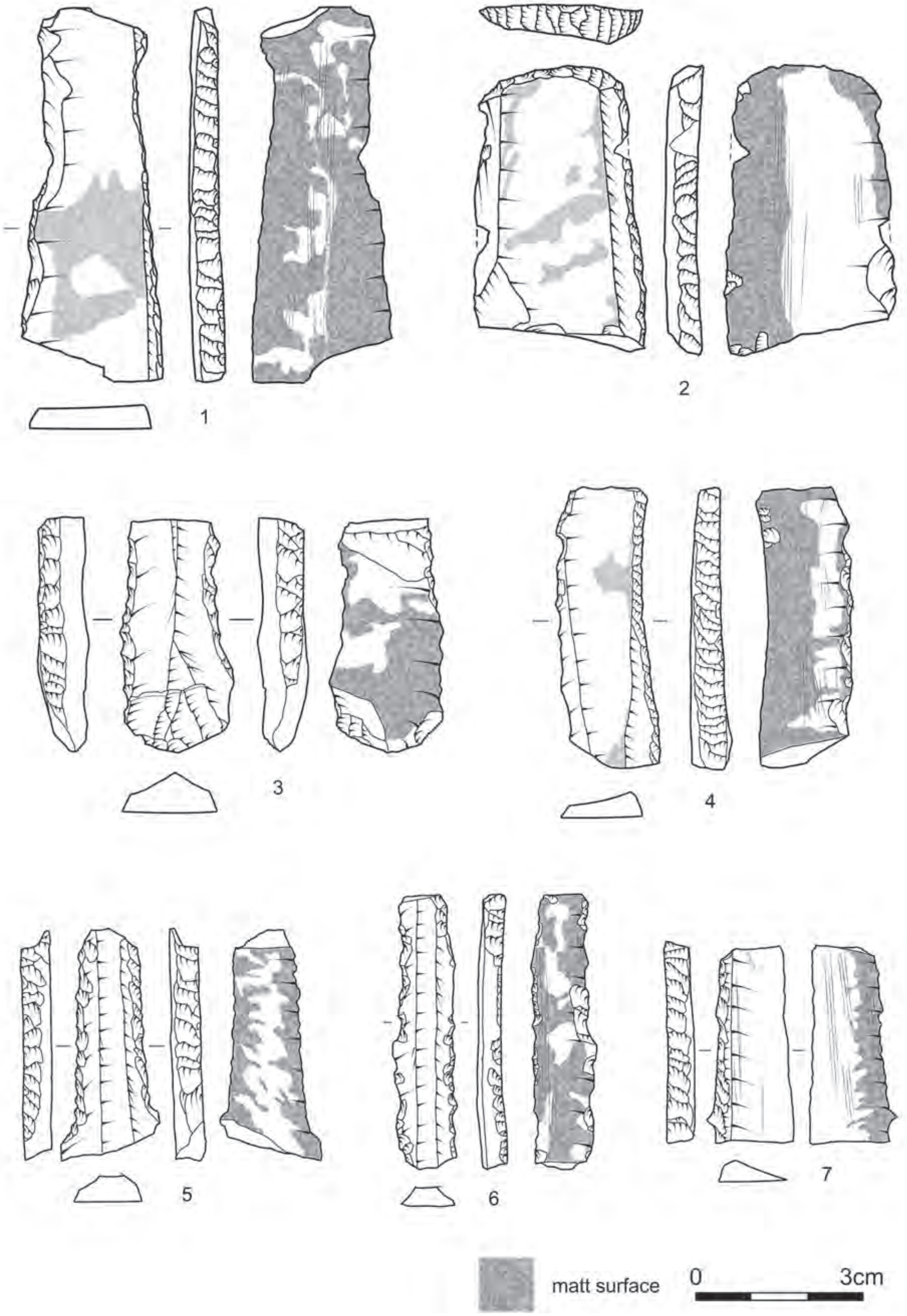


Figure 20.49. Çayönü tools from Shimshara, obsidian: 1) T2 C1636 Tool SHIM489, Çayönü tool, obsidian, black (greenish); 2) C1635 Tool SHIM522, Çayönü tool, obsidian, black (greenish); 3) T1 C1632 Tool SHIM352, Çayönü tool, obsidian, black (greenish); 4) T1 C1632 Tool SHIM350, Çayönü tool, obsidian, black; 5) T1 C1649 Tool SHIM398, Çayönü tool, obsidian, black (greenish); 6) T2 C1633 Tool SHIM284, Çayönü tool, obsidian, black (greenish); 7) T2 C1636 Tool SHIM488, Çayönü tool, obsidian, black (greenish).

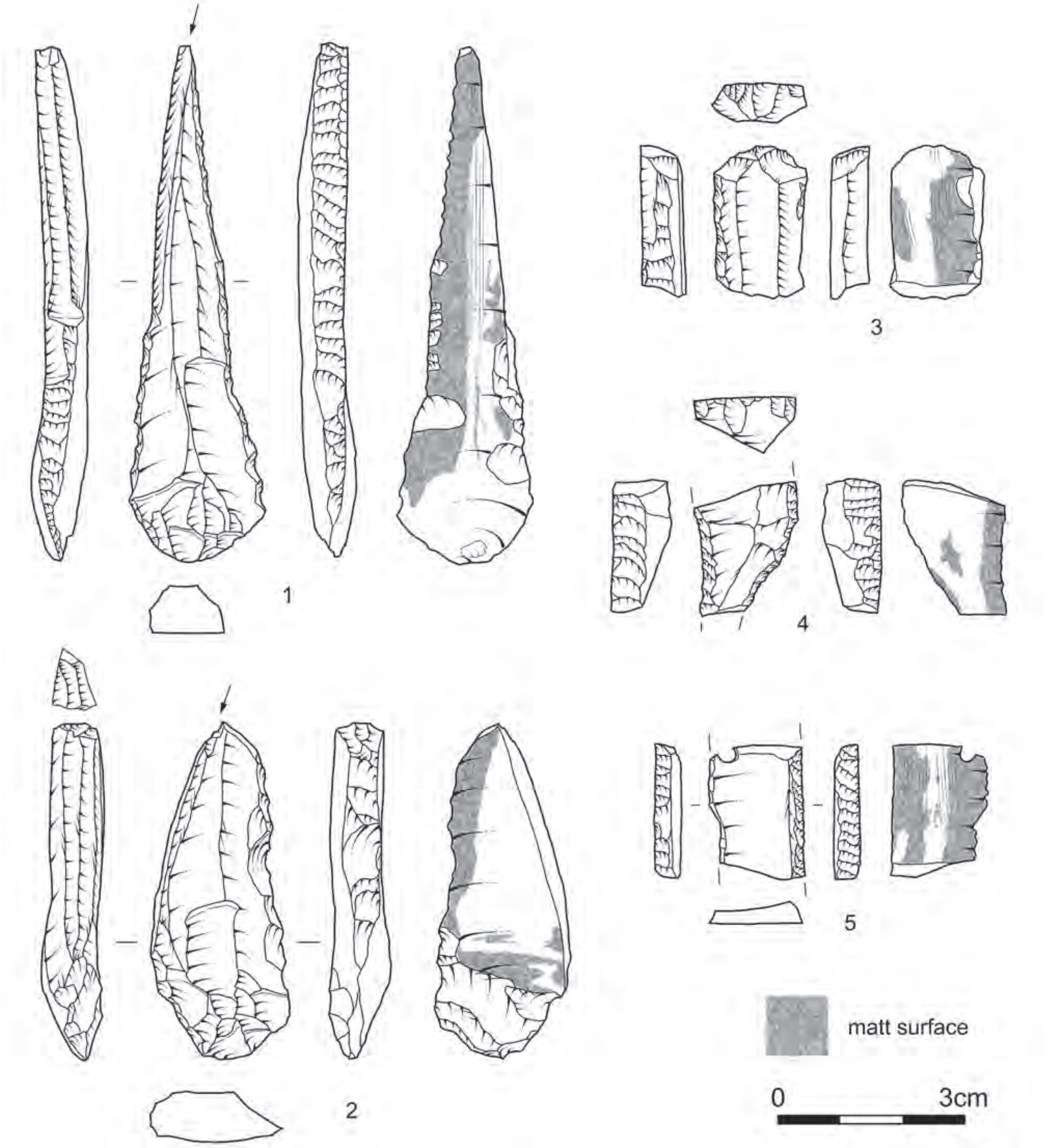


Figure 20.50. Çayönü tools from Shimshara, obsidian: 1) T1 C1653 Tool SHIM253, Çayönü tool, obsidian, black (greenish); 2: T1 C1632 Tool SHIM347, Çayönü tool, obsidian, black (greenish); 3: C1635 Tool SHIM568, Çayönü tool, obsidian, black (greenish); 4: T2 C1658 Tool SHIM220, Çayönü tool, obsidian, black (greenish); 5: T2 C1658 Tool SHIM221, Çayönü tool, obsidian, black (greenish).

What might a complete Çayönü tool have looked like? One clue is provided by an extraordinary find at Shimshara in the 1950s. In level 13, the earliest of the Pottery Neolithic levels, the Danish-Iraqi team recovered four pieces of heavily burnt obsidian, three of which joined together to form what they classified as a 'dagger', originally some 35.5cm in length (Mortensen 1970: 33–35, figs 30–31). The top 15cm of this tool are not distorted by fire and clearly reveal the item to be a Çayönü tool, with classic steep retouch along both edges and a flaring culmination at the bulbar end, which has been flattened by careful chipping, common on Çayönü tools. It is not possible to see on the photographs whether there

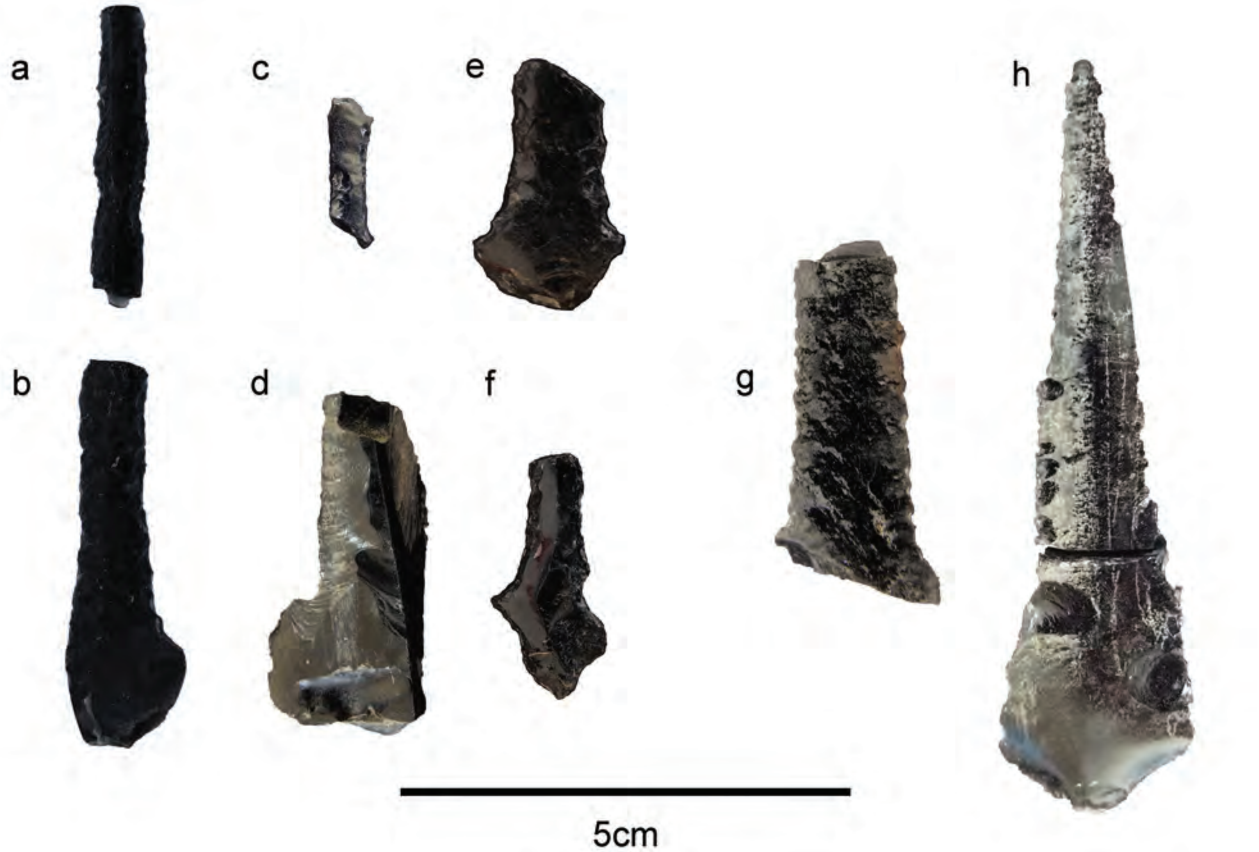


Figure 20.51. Çayönü tools from Bestansur and Shimshara. From Bestansur: a) SF58; b) SF59; c) Tool 2810; d) Tool 4546; e) Tool 5335; f) Tool 5430. From Shimshara: g) Tool 253; h) Tool 398.

are use-wear striations on the ventral surface. The distal end is warped by high-temperature burning and therefore difficult to apprehend, but it looks as though this end of the tool served as some form of handle or grip. The size and delicacy of this example, and of the 20cm long blades from Çayönü itself (Redman 1982: fig. 2.14), underline the dexterity and ambition of the obsidian knappers who fashioned these special objects. Several of the Çayönü tools from Shimshara show evidence for re-use either as cores from which to knap fine blades or as scrapers (Figs 20.49: 2; 20.50: 1–4).

There are some notable aspects of the findspots of Çayönü tools at Bestansur. As mentioned, they occur in almost every trench at the site (Table 20.17), which suggests widespread usage of these tools in all sectors of the settlement. When we examine the context types in which Çayönü tools were found, however, we see that almost exactly half of them (49.5% or 46/93) come from topsoil, 37.6% (35/93) of them from post-Neolithic or disturbed contexts, and only 12.9% (12/93) from secure *in situ* Neolithic deposits, as discussed below (Table 20.18). The fact that so many of these tools come from topsoil and post-Neolithic deposits strongly argues for a chronological aspect to this distribution, whereby Çayönü tools represent a now-eroded and ploughed-out level of Neolithic occupation which immediately post-dates the main levels of Neolithic settlement uncovered in our trenches so far. This interpretation is supported by the fact that other specific tool types at Bestansur, such as sickle blades and diagonal-ended bladelets, show a very different contextual distribution with much less emphasis on topsoil and late or disturbed contexts (see Tables 20.12, 20.14).

The 12 Çayönü tools from secure Neolithic deposits at Bestansur are found principally in external occupation and shell midden areas, in Trenches 4, 5, 7, 10 and 12, again supporting widespread usage. The only two fragments of Çayönü tools from within a building both come from Space 16 in Trench 7, a room remarkable for the large quantity of ground stone tools deposited on its floor (Chapter 22), an association which supports an interpretation of the use of Çayönü tools within an environment of stone-working. The contextual distribution of Çayönü tools from the limited excavations at Shimshara is similar to that of Bestansur, with approximately half of them (14/29) from topsoil, but a higher proportion (9/29) than at Bestansur from intact external Neolithic deposits. The evidence from both sites supports the notion that Çayönü tools appear late in the Early Neolithic period and that they were involved in craft activity with alabaster objects which took place almost

Table 20.18. Context types with Çayönü tools at Bestansur and Shimshara.

Context type	*Çayönü tools* *Bestansur*	 *Shimshara*
Topsoil	46	14
Wash/mixed	2	6
Late deposit/pit with pottery	26	–
Disturbed deposit, with pottery	7	–
Occupation, external, Neolithic	8	9
Shell midden, external, Neolithic	2	–
Occupation, internal, Neolithic	2	–
Total	93	29

exclusively in open external areas.

In the wider context, Çayönü tools appear in a broad band of territory spanning Southeast Anatolia, upper Mesopotamia and the central Zagros, and can be dated to the later eighth and early seventh millennia BC, contemporary with the Levantine Middle–Late PPNB (Cauvin and Balkan 1985; Nishiaki 1993: 146, fig. 6; Özdoğan and Balkan-Atlı 1994; Kozlowski and Aurenche 2005: fig. 1.3.4.2). At Çayönü itself these tools are associated in particular with the Cell Building and subsequent sub-phases (Redman 1982: 44; Caneva *et al.* 1994: 263; Özdoğan and Balkan-Atlı 1994, fig. 1), from *c.* 7600 BC onwards. There is a dramatic decrease in frequency and in size of Çayönü tools through the Pottery Neolithic levels at Çayönü (Özdoğan 1994: 271) and at other sites (Cauvin 1988; 1991b; Nishiaki 1993; Maeda 2011). At Jarmo the vast majority of Çayönü tools, 71 out of 87 in total, were found in the earlier levels (Hole 1983: 241), strengthening the interpretation that the main excavated phase at Bestansur pre-dates the earliest levels at Jarmo. The disappearance of Çayönü tools from later Neolithic sites is directly associated with a decline in evidence for manufacture of ground and polished alabaster artefacts.

Rokitta's study (summarised in Rokitta 2006) shows that the geographical distribution of Çayönü tools correlates well with that of obsidian from Southeast Anatolian, rather than Cappadocian sources, suggesting that Çayönü tools were being transported across the Taurus–Zagros zone, probably as shaped artefacts (but without retouch) along mainly riverine routes, along with blocks and nodules of pre-worked obsidian. She also found a strong correlation between the occurrence of Çayönü tools and ground and polished stone artefacts such as bowls, bracelets, rings and grooved stones, supporting the argument that Çayönü tools were exclusively used in their production. It is striking that the distribution of Çayönü tools across the central and Eastern Fertile Crescent matches well, in space and time, with that of alabaster 'bracelets with convex and profiled sections' as defined and mapped by Kozlowski and Aurenche (2005: figs 1.3.4.2 and 5.3.4), two examples of which were found at Bestansur (Chapter 21: SF187, SF336). A very similar example, but made of obsidian, was found in a high-status architectural context of eighth millennium BC date at Aşıklı Höyük in central Anatolia. Intriguingly, study of the surface striation patterns on the Aşıklı bracelet indicates that a polishing tool was used in conjunction with an abrasive in order to produce "concentric striations with consistent orientation" (Astruc *et al.* 2011: 3421). At Cafer Höyük in Southeast Anatolia, Çayönü tools occur in association with stone bracelets, including examples in red and white alabaster with flanged external profiles (Cauvin and Balkan 1985; Maréchal 1985; Cauvin *et al.* 2011: figs 36–37), as is also the case at Maghzaliya in upper Mesopotamia (Bader 1993: fig. 2.25: 23–24).

In sum, there can now be little doubt that Çayönü tools, probably mounted within a wooden frame, were used in the production and polishing of high-status marble or alabaster objects, bracelets in particular, during the last centuries of the Early Neolithic period and into the Pottery Neolithic. The widespread occurrence of Çayönü tools and alabaster bracelets across much of the Early Neolithic world indicates shared practices of adornment and status-marking that betoken trans-regional connectivity within a milieu of inter-community socio-cultural values. What is also beyond doubt is the fact that the manufacture of alabaster status items would have demanded many hours of expert engagement and sheer hard work in order to produce a single flanged bracelet, for example. Did expert stone-workers produce such items on demand for all segments of society and, if so, how were they rewarded or supported during their commitment of time and energy? The fact that Çayönü tools and polished stone artefacts such as bracelets occur together across the Neolithic world, even at desert outposts such as Umm Dabaghiyah, suggests that each community had the capability both to access the necessary raw materials – fine alabaster and obsidian – and to work those materials into the required final shape. This distribution pattern does not support the notion of specialist craft workers operating from regional centres, but rather a dispersed model of self-sufficiency and connectivity for each community, however modest in size.

Hides, reeds, wood, bark

In order to be suitable for use in clothing, hides need considerable processing (Audoin-Rouzeau and Beyries 2002; van Gijn 2010: 79–80). Initial cleaning of fresh hides can be carried out using a chert scraper, either held directly in the hand or mounted in a haft. Blade-end scrapers and side scrapers would both be suitable for this purpose. Once cleaned of fat and flesh, hides need to be dried by staking out or spreading on racks. Further processing, such as the removal of the epidermis containing the animal's hair, can also be conducted using chert scrapers, which may then bear distinctive use-wear traces (van Gijn 2010: 81). During the process of curing or tanning of hides vegetal or mineral substances may be worked into the hide as softening, toning or dyeing agents, including materials such as ochre. It is notable that splashes of red pigment occur at many points on the floors and walls of Bestansur rooms.

A wide variety of scraping tools is found at both Bestansur and Shimshara (Table 20.19; Fig. 20.52). Tools include blade-end scrapers, side scrapers, flake scrapers and thumbnail scrapers. Occasionally exhausted cores and core trimming elements were retouched and used as convenient scraping tools, as also at Çayönü (Redman 1982: 37). As Table 20.19 shows, scraping tools come predominantly from external areas of Trenches 7, 9 and 10, but significant numbers of scrapers from internal rooms of Building 5 suggest that some activity was taking place indoors.

Once dried and scraped clean, hides would need cutting and stitching into wearable items of clothing. Before the invention of scissors, which make ingenious use of the special human ability to oppose thumb against any or all of the other digits of the hand, the act of cutting would normally require the use of a resistant surface, such as a wooden plank or flat stone, upon which to place the material to be cut by a sharp blade. In Chapter 22 David Mudd makes the case for the large incised stone set onto the floor at the entrance to Space 40 in Building 5 (Fig. 20.53) as being used as a hide processing bench perhaps involving use of ochre (Dubreuil and Grosman 2009). The multiple cut marks, many of them deep, on the surfaces of this stone certainly support an interpretation that involves frequent sharp cutting of straight lines across and through substantial pieces of material, using a hard ruler of some kind to keep the lines straight. Cutting of hides fits this interpretation well. The holes drilled into the surface of the stone might also fit for aligning piercings of hides in order to facilitate stitching together of hide segments into garments, or for fitting of dress fastenings such as buttons or toggles. The almost exclusive occurrence of side scrapers, thumbnail scrapers and reamers in Trench 10 (Table 20.19) also fits well with a focus on hide-working in this part of the site.

Cutting of hides is likely to have been a major use for chert and obsidian blades of all shapes and sizes and the many points and reamers would be suitable for piercing of hides, while bone points could also serve in piercing and stitching. Study of microlithic blades from Younger Dryas sites in north-central China has suggested that their major use was as inserts in slotted bone handles serving as sharp and robust knives for cutting hides of deer, rabbit and other animals in order to provide winter clothing (Yi *et al*. 2013). Certainly the provision of ample warm clothing would be essential in the cold winter climate of the Zagros region.

In addition to cleaning and processing of hides, scraping tools could also have been used for plant-based activities such as wood-working, wickerwork and fibre processing for making, for example, baskets, cordage and nets (van Gijn 2010: 84–96). We have little direct evidence for plant-based craft activity at Bestansur and Shimshara. The charred plant remains discussed in Chapter 18 provide little idea of which plants may have been available for use in craft activity. Rare direct evidence comes in the form of charred patches of matting (Fig. 20.54), also found as articulated spreads of phytoliths, made from interwoven split reeds and grasses, and as impressions on floor surfaces in micromorphological thin-sections (Chapter 12). We have already discussed the possibility that chert blades with sickle sheen may have been used in repeated reed gathering. Chipped stone blades could also be used to cut reeds and grasses to required lengths for working into mats, coverings or baskets. Van Gijn's (2007) experiments have suggested that chipped stone tools have little significant role to play within the production of nets and basketry, while in wickerwork, flint blades and scrapers are useful in collecting and preparing willow or hazel shoots but not in the subsequent crafting activity.

Wood processing is an activity where we might expect to see significant roles for ground and chipped stone tools. The charcoal record from Neolithic Bestansur and Shimshara is minimal, suggesting modest use of wood for fuel (Chapter 12), so that we have little direct evidence for the varieties of wood exploited by the sites' inhabitants. Given the sites' location at the boundaries of ecological zones, however, a rich array of tree types would have been available for craft activity during the Neolithic. Trees could have been used for a huge range of purposes, from structural timbers to basketry, from dug-out canoes to delicate fish traps, from bast fibre twine to hafting resins, and from fuel for ovens to carved figurines. In practice, our direct evidence for wood use from Bestansur and Shimshara is slight, and the role of chert and obsidian tools in wood working may have been restricted to de-barking and shaving.

Craft specialisation, toolkits, and activity areas

Does the chipped stone evidence assist in identifying areas of the settlement at Bestansur where specific activities were conducted, which might therefore be locales of craft specialisation? Table 20.19 shows the distribution of tool types across all Bestansur trenches, while Table 20.20 shows the distribution of tool types from secure Neolithic contexts across individual rooms or spaces and spatial categories.

First, it is clear that external areas have much higher quantities of chipped stone, in particular in the form of cores and debitage, including unretouched blades, a pattern supported by the flotation heavy residue

Table 20.19. (continued overleaf) Distribution of tool types, chert and obsidian, across Bestansur trenches.

Tool type	*Tool group*	*Bestansur Trench*									
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Blade	Retouched blade	37	54	13	53	33	2	244	25	288	1158
	Notched	9	19	10	29	29	9	59	19	59	323
	Serrated/denticulated	0	1	0	0	0	0	5	1	2	58
	Backed	0	1	0	0	0	0	0	0	0	4
	Beaked	0	0	0	0	0	0	0	0	0	1
	Crested	0	0	0	0	0	0	0	0	0	1
	Scoop/ handle	0	0	0	0	0	0	3	1	0	1
Sickle	Blade	1	3	1	5	2	0	8	2	16	49
	Notched	0	1	0	0	0	0	3	3	6	0
	Serrated/denticulated	0	0	0	0	0	0	2	0	2	4
	Backed	0	0	0	2	0	0	0	0	0	0
Scraper	Scraper (other)	1	0	0	0	2	0	0	0	4	12
	Blade scraper	1	2	1	0	0	0	1	0	0	9
	Blade end scraper	1	4	2	3	1	1	14	7	12	38
	Side scraper	0	1	0	0	1	0	1	0	0	11
	Flake scraper	3	7	1	2	2	1	11	15	11	40
	Notched scraper	0	0	0	0	0	0	0	0	0	0
	Round/ thumbnail scraper	0	0	0	0	0	0	0	0	0	8
	CRF/CTE/core	0	0	1	0	0	0	1	0	2	2
Flake	Retouched	1	1	0	0	0	0	11	0	13	30
	Notched	1	1	0	0	0	0	0	2	0	3
Point	Point/awl/drill/borer	4	5	1	7	1	0	11	4	17	79
	Shouldered drill	0	6	0	5	5	0	6	4	6	17
	Flake borer/point	2	0	0	2	0	0	0	0	2	2
	Blade point	0	0	0	0	1	0	0	0	2	3
	Reamer/fabricator	0	0	0	0	0	0	1	0	3	7
Micro-tool	Burin	1	2	0	2	1	0	2	0	1	12
	Diagonal-ended blade/let	0	4	3	15	2	1	22	9	15	68
	Trapeze/ trapezoid	0	0	0	0	2	1	0	1	0	2
	Transverse arrowhead	0	0	0	0	0	0	0	0	0	1
	Crescent/ lunate	0	0	0	1	0	0	0	0	2	2
	Microlith	0	0	0	0	0	0	1	0	1	3
Other	Çayönü tool	2	7	5	1	10	0	19	4	5	18
Core	Blade	1	4	0	3	0	1	9	8	6	99
	Flake	0	0	0	0	1	0	4	0	2	18
	CRF/CTE	1	0	0	2	1	0	5	1	6	31
	Total	66	123	38	132	94	16	443	106	483	2114

analysis (Chapter 14; Iversen 2015) and also detected in lithic distributions at the Late Neolithic site of Tol-e Baši in Fars (Ghasidian *et al*. 2010: 172). The activity of chipped stone tool production was clearly one undertaken in outdoor surroundings, not surprising given that knapping would have been a potentially dangerous activity generating sharp waste materials that would not be desired within a closed architectural environment. Greater light availability may also have been a factor. Secondly, there are more tools, and greater ranges of tool types, from external than internal contexts, which also suggests that most craft activities involving use of chipped stone tools took place outside. It is likely that many of the tools found in external areas were disposed of after breakage during use. The high proportions in external areas of tools such as blades with sickle sheen and diagonal-ended bladelets may relate to processing of items such as reeds and hunted game in external areas.

Thirdly, scraping tools have a more even balance between external (56/85) and internal (29/85) areas, indicating that some forms of scraping activity took place indoors. Such activities are likely to have been the less messy and noisome ones, perhaps involving production of clothing, basketry, or finer wood-working, for example. As noted above, the concentration of chert side scrapers, thumbnail scrapers and reamers in Trench 10 may relate to a focus on hide-working in the external areas here. Beyond these observations, the chipped stone evidence for conduct of distinct craft activities in specific areas of the site is slight. Rather, the picture is one of a wide range of activities, at least those involving chipped stone tools, being carried out in multiple areas of the site, with a focus on outdoor work. This picture supports an interpretation of Neolithic society at Bestansur as composed of modular, self-contained groups of people each of whom had similar rights of access to raw materials, similar ranges of skill-sets and capabilities and similar habits of food production, food consumption and craft tradition.

Further support for this social interpretation comes from contextual analysis of find-spots of chipped stone tools and other artefacts. In Trenches 7 and 10 at Bestansur we have detailed evidence for multiple activities taking place in external areas, many of

Table 20.19. (continued from previous page) Distribution of tool types, chert and obsidian, across Bestansur trenches.

Tool type	*Tool group*	*Bestansur Trench*				*Shimshara*
		11	*12*	*13*	*Total*	*Total*
Blade	Retouched blade	153	72	91	2223	244
	Notched	3	16	15	599	29
	Serrated/denticulated	0	1	3	71	3
	Backed	0	0	0	5	0
	Beaked	0	0	0	1	2
	Crested	0	0	0	1	0
	Scoop/handle	0	0	0	5	0
Sickle	Blade	0	7	7	101	21
	Notched	0	0	0	13	1
	Serrated/denticulated	0	0	1	9	0
	Backed	0	0	0	2	0
Scraper	Scraper (other)	0	1	1	21	1
	Blade scraper	0	1	0	15	1
	Blade end scraper	4	2	5	94	12
	Side scraper	0	0	0	14	0
	Flake scraper	2	2	0	97	7
	Notched scraper	1	0	0	1	0
	Round/thumbnail scraper	0	0	0	8	0
	CRF/CTE/core	1	0	0	7	0
Flake	Retouched	18	0	3	77	0
	Notched	0	0	0	7	0
Point	Point/awl/drill/borer	6	3	10	148	12
	Shouldered drill	1	1	0	51	0
	Flake borer/point	0	0	0	8	0
	Blade point	0	0	0	6	0
	Reamer/fabricator	0	0	2	13	0
Micro-tool	Burin	3	0	0	24	0
	Diagonal-ended blade/let	3	9	6	157	7
	Trapeze/ trapezoid	0	0	0	6	1
	Transverse arrowhead	0	0	0	1	0
	Crescent/ lunate	0	0	0	5	0
	Microlith	0	3	4	12	0
Other	Çayönü tool	12	3	0	86	29
Core	Blade	9	0	3	143	1
	Flake	1	4	1	31	0
	CRF/CTE	2	0	0	49	6
	Total	219	125	152	4111	377

which involved use of chipped stone tools. Figure 20.55 shows the location on a working surface of individual artefacts, including chert and obsidian tools, fragments of animal bone, clusters of small stones (many of them burnt), flecks or lumps of red pigment and discrete piles of discarded land snail shells. The clustered nature of these objects, grouped in a loose semi-circle with a blank area to the west, strongly suggests that here was a meeting place for small gatherings of people who spent some time working at handicrafts while preparing, cooking and eating snacks of edible land snail. All the lithic tools depicted in Figure 20.55 are broken, which is why they were abandoned along with the rest of the detritus in this external area. The shouldered drill, SF156, would have been used for heavy-duty perforating, for example of hide, while the obsidian blade, SF161, may have been used to prise cooked snails from their shells. The chert sickle blade, SF157, was probably discarded during repair of a sickle. Heat from the hot stones may have been used to soften a portion of bitumen to use in retooling that sickle.

We can thus envisage a small group of people sitting or squatting here while carrying out a range of dextrous activities before moving on. We note that the lithic tools recorded here can be distinguished as both hand-held tools, discarded near the point of use (the broken shouldered drill, the unretouched obsidian blade), and hafted tools discarded here during re-tooling of hafts (the sickle blade, the serrated blade, the notched blade, the retouched obsidian blade), according to the distinctions emphasised by Keeley (1982). These episodes of communal activity are attested in multiple external layers through the depth of Trench 7 and also in the external occupation deposits of Trench 10 where similar clusters of objects were excavated (Chapter 9). This pattern of artefacts, including lithics, bone and stones, arranged in a semi-circle of clusters with a blank area in the middle, is remarkably similar to that recorded in contemporary Early Neolithic external contexts at Abdul Hosein in the high Zagros to the southeast (Pullar 1990: fig. 12), and in the lowest levels at Chogha Bonut in Khuzestan, also dated to *c.* 7200 BC (Alizadeh 2003: fig. 15).

When we examine in more detail the chipped stone

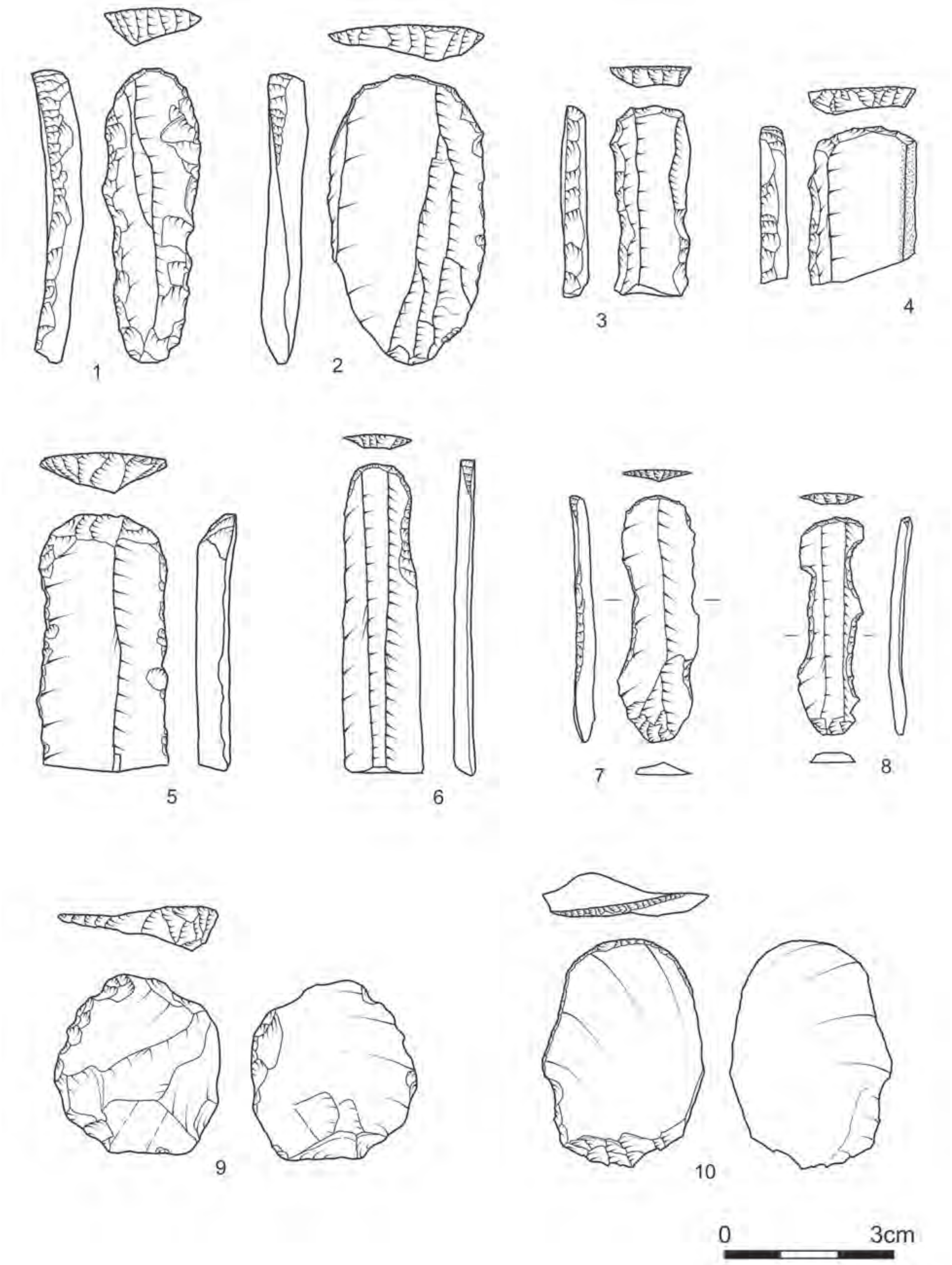


Figure 20.52. Chert and obsidian scrapers from Bestansur and Shimshara: BEST: 1) T9 C1350 Tool 3295, blade end scraper, chert (C3); 2) T12 C1525 Tool 6481, flake scraper, chert (C4); 3) T10 C1736 Tool 5753, blade end scraper, chert (C3); 6) T13 C1572 Tool 6250, blade end scraper, chert (C2); 7) T10 C1540 Tool 6929, blade end scraper or notched blade, chert (C15); 8: T10 C1736 Tool 5725, blade end scraper or notched blade, chert (C2); 9) T12 C1528 Tool 6506, flake round scraper, obsidian (O1). SHIM: 4) T1 C1653 Tool SHIM312, end scraper, chert, chocolate brown; 5) C1635 Tool SHIM564, blade end scraper, obsidian, black (greenish); 10) C1648 Tool SHIM254, flake scraper, obsidian, black (green).

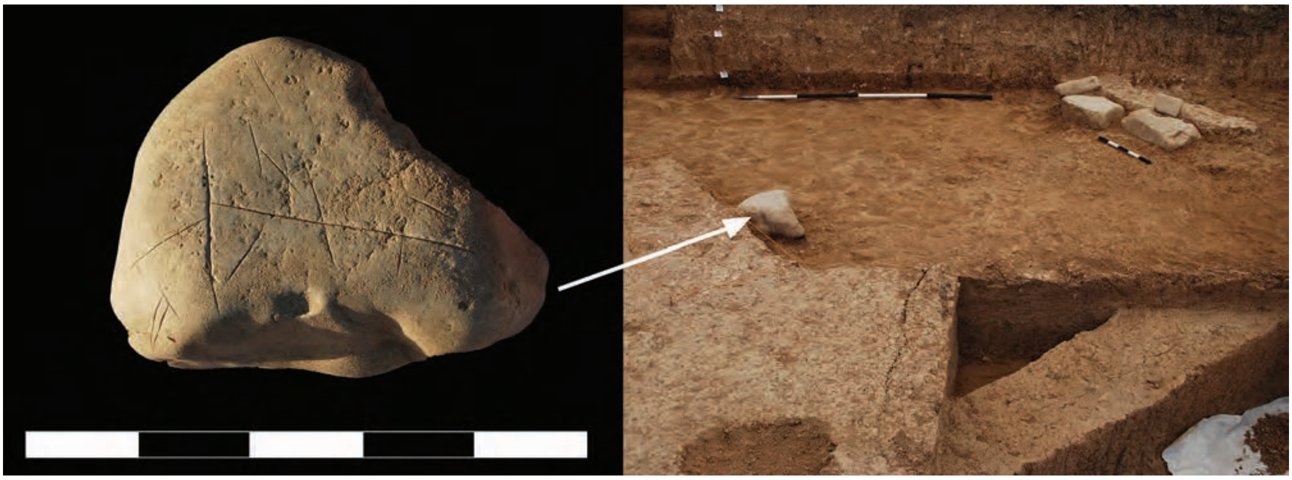


Figure 20.53. Stone SF357 at entrance to Space 40, Building 5, Trench 10, Bestansur, showing cut-marks and drill-holes. Looking north, scales = 50cm and 2m.

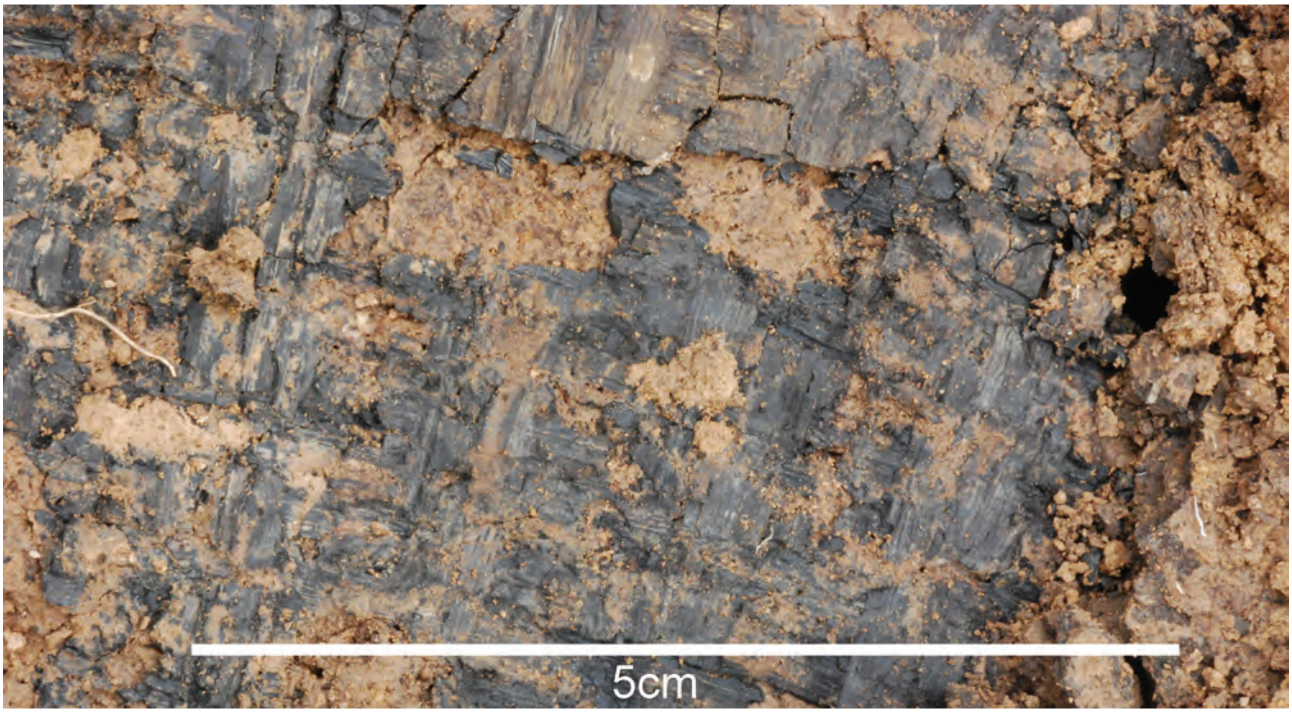


Figure 20.54. Split reed matting, Space 50, Building 5, Trench 10.

from Trench 7 we detect some intriguing patterns, particularly in contrasting external and internal areas. Table 20.21 and Fig. 20.56 graphically demonstrate the differential distribution of chipped stone debitage across the context types in Trench 7. The internal spaces of Building 3 are significantly lacking in lithic debris, and the fill deposits of the human burial and a clay-lined pit also have low quantities of chert and obsidian pieces. External surfaces and occupation deposits, by contrast, have high quantities of both chert and obsidian, particularly the former, and individual pieces are larger than those found in internal spaces. This pattern agrees with that for other forms of material evidence, supporting the interpretation that internal spaces within buildings were kept very clean while some debris was allowed to accumulate in external areas. Also notable here is the more careful curation of obsidian as against chert, as attested in the much lower average weight of recovered obsidian pieces (0.16g) against chert pieces (0.60g). This pattern is common in all deposits, both within Trench 7 and in other trenches. It suggests that obsidian was reworked into ever smaller tools through time to maximise usage of a cherished material arriving at Bestansur from afar while chert was more freely and locally available.

Table 20.20. Distribution of tool types and debitage from secure Neolithic contexts across individual spaces and spatial categories at Bestansur.

Trench	*Space*	*Spatial type*	*Blade, retouched*	*Sickle*	*Scraper*	*Point*	*Flake, retouched*	*Micro-tool*	*Çayönü tool*	*Other*	*Core*	*Unretouched blade*	*Debitage*
1	3	Building 2	6	0	0	0	1	0	0	0	1	10	31
	4	External Area	3	0	1	0	0	0	0	0	0	2	6
4	6	External Area	75	7	4	11	0	15	1	0	4	73	170
5	7	External Area	5	1	0	1	0	0	2	0	0	10	12
7	16	Building 3	18	0	0	1	1	1	3	0	0	27	54
	19	Building 3	2	0	1	0	0	1	0	1	0	1	0
	12	Building 7	1	0	0	0	0	0	0	0	0	1	0
	11	External Area	7	1	1	2	0	2	0	1	4	27	657
	17	External Area	84	7	5	8	0	10	1	1	3	135	238
	18	External Area	25	1	2	0	1	3	0	0	0	26	29
	21	External Area	1	0	0	0	0	0	0	0	0	0	0
	22	External Area	32	1	3	2	0	0	4	0	0	60	113
8	14	Building 4	1	0	0	0	0	0	0	0	0	1	3
	13	External Area	4	0	0	1	0	1	0	0	0	5	1
	57	External Area	0	0	1	0	0	0	0	0	0	0	8
9	15	External Area	1	0	1	0	0	0	0	0	0	0	9
	28	External Area	328	18	21	25	13	16	4	0	13	375	526
10	40	Building 5	20	3	1	1	0	2	0	0	1	22	97
	42	Building 5	39	9	6	3	0	2	0	0	3	36	207
	47	Building 5	11	3	3	3	0	0	0	0	1	10	99
	48	Building 5	6	0	0	1	1	1	0	0	0	12	53
	49	Building 5	3	0	0	0	0	0	0	0	0	3	53
	50	Building 5	66	4	10	4	1	10	0	0	5	63	737
	60	Building 5	26	0	3	3	0	2	0	0	0	15	80
	63	Building 5	3	0	1	0	1	1	0	0	0	5	19
	54	Building 8	0	0	0	0	0	0	0	0	0	0	216
	61	Building 9	22	0	4	2	0	0	0	0	0	7	3
	23	External Area	2	0	0	0	0	0	0	0	0	0	13
	27	External Area	105	4	5	7	1	12	0	0	13	183	3201
	29	External Area	348	12	9	27	8	8	1	0	34	655	791
	43	External Area	6	0	0	0	0	1	0	0	0	9	63
	44	External Area	53	0	6	8	0	7	0	0	2	34	163
	51	External Area	6	1	0	2	0	0	0	0	0	2	16
	52	External Area	24	0	2	2	0	1	0	0	3	16	35
	53	External Area	41	1	4	3	0	6	1	0	9	18	207
	55	External Area	2	0	0	1	0	2	0	0	0	19	104
12/13	26	Building 7	3	0	0	0	0	1	0	0	1	21	22
	45	Building 7	13	1	1	0	0	2	0	0	0	21	30
	24	External Area	12	0	0	2	0	2	0	0	1	29	32
	25	External Area	18	3	2	3	0	2	0	0	0	33	73
		Total	1442	71	85	125	23	103	14	3	119	2246	8436

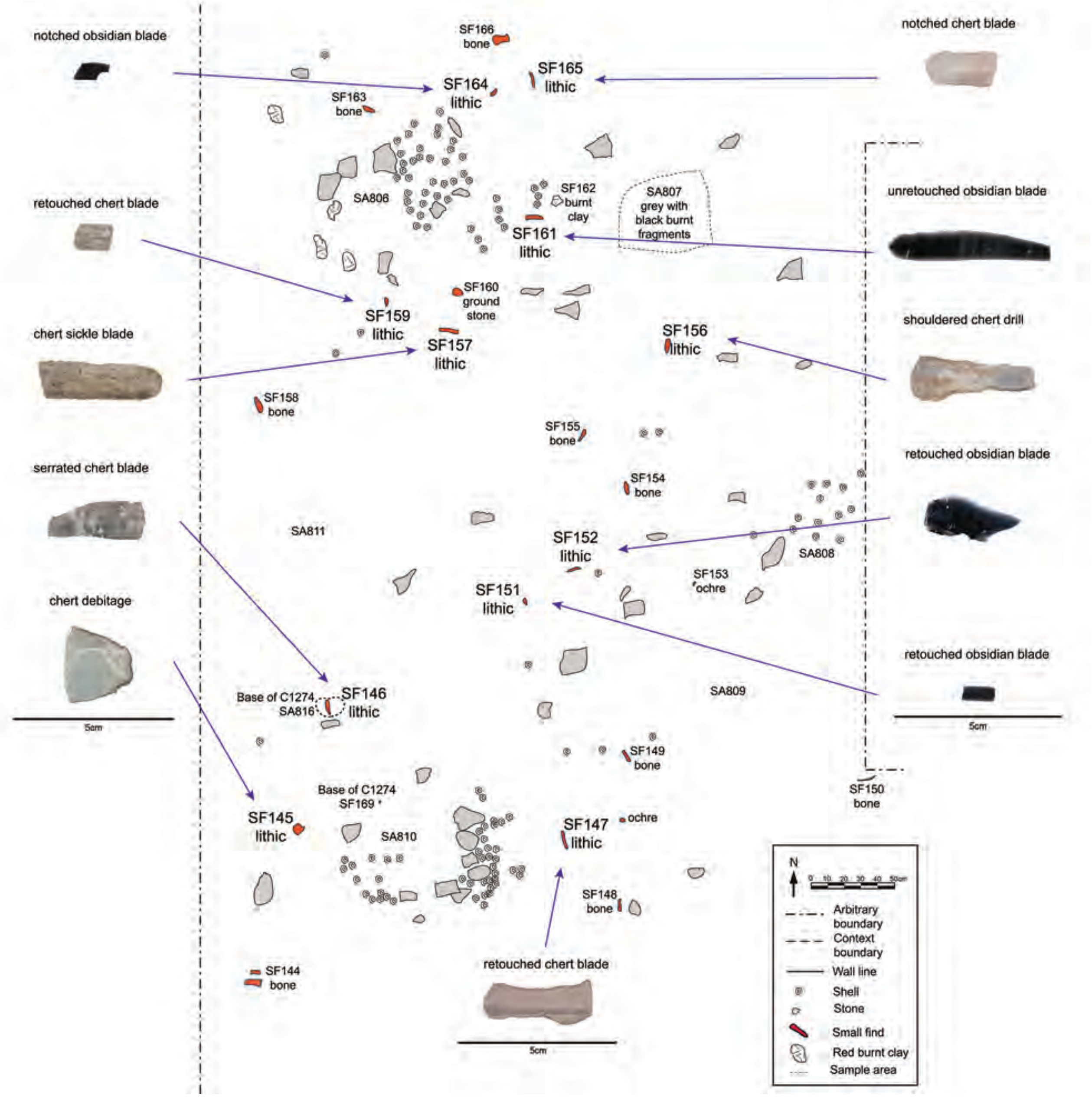


Figure 20.55. Trench 7 external area, Context 1274, Space 17, showing distribution of in situ finds.

Turning to examine tools in Trench 7, Table 20.22 and Figure 20.57 show the distribution of chipped stone tools of chert and obsidian, including unretouched blades, across the different context types. Again the relatively high representation of tools in external contexts is notable, although two internal occupation contexts, C1243 and C1255, both have significant numbers of tools, particularly of obsidian, which are likely to relate directly to activity within Space 16. The 17 obsidian tools from Contexts 1243 and 1255 in Space 16, a room with multiple ground-stone items possibly deposited as off-season storage (Chapter 22), comprise two fragments of Çayönü tools, 14 unretouched blades, two drill-borers and one diagonal-ended blade. Chert tools from the same contexts include six unretouched blades and one serrated blade.

More generally, the strong representation of obsidian tools as against chert tools (Fig. 20.57) is in sharp contrast to that attested by the debitage (Fig. 20.56). These figures indicate the major significance of obsidian tools within the range of activities carried out by the Early Neolithic occupants of Bestansur, and they underline the considerable care and skill employed by them to maximise the tool-yielding potential of their imported obsidian nodules, blocks or blanks.

If we remove unretouched blades and bladelets from the Trench 7 analysis, making the assumption that they may relate more to tool production than serve themselves as tools, we can examine the distribution of all other tools and production elements such as cores, as shown in Table 20.23.

Table 20.21. Distribution across context types of chipped stone debitage, chert and obsidian, Trench 7, Bestansur (totals by Context type in italics).

Space	*Context*	*Context type*	*Area type*	*Chert (g)*	*Chert (n)*	*Chert (av g)*	*Obsidian (g)*	*Obsidian (n)*	*Obsidian (av g)*
17	1224	Fill of human burial	Burial	3.31	18	0.18	0.36	4	0.09
				3.31	*18*	*0.18*	*0.36*	*4*	*0.09*
16	1229	Occupation	Internal	1.10	7	0.16	0.00	0	0.00
16	1243	Occupation	Internal	2.31	10	0.23	2.16	19	0.11
16	1255	Occupation	Internal	0.00	0	0.00	0.36	5	0.07
20	1268	Occupation	Internal	0.00	0	0.00	0.00	0	0.00
16	1280	Occupation	Internal	0.00	0	0.00	0.00	0	0.00
				3.41	*17*	*0.20*	*2.52*	*24*	*0.11*
19	1253	Room fill	Internal	0.00	0	0.00	0.00	0	0.00
20	1266	Room fill/floors	Internal	0.00	0	0.00	0.00	0	0.00
				0.00	0	0.00	0.00	0	0.00
17	1220	Surfaces/occupation	External	20.55	17	1.21	1.25	11	0.11
17	1248	Surfaces/occupation	External	0.66	5	0.13	0.65	4	0.16
18	1249	Surfaces/occupation	External?	11.47	10	1.15	5.43	6	0.91
17	1254	Surfaces/occupation	External	23.70	17	0.91	3.76	28	0.13
17	1259	Surfaces/occupation	External	2.05	3	0.68	0.40	5	0.08
17	1274	Surfaces/occupation	External	22.84	30	0.76	0.16	7	0.02
				81.27	*82*	*0.99*	*11.65*	*61*	*0.19*
18	1225	Occupation	External?	13.72	46	0.30	0.81	7	0.12
18	1227	Occupation	External?	8.26	14	0.59	0.43	3	0.14
22	1275	Occupation	External?	5.41	5	1.08	0.30	1	0.30
				27.39	*65*	*0.42*	*1.54*	*11*	*0.14*
17	1226	Lower pit fill	External	0.00	0	0.00	0.30	2	0.15
17	1218	Upper pit fill	External	0.00	0	0.00	0.00	0	0.00
				0.00	*0*	*0.00*	*0.30*	*2*	*0.15*
17	1261	Burnt?	External	1.14	12	0.10	0.29	2	0.15
				1.14	*12*	*0.10*	*0.29*	*2*	*0.15*

Table 20.22. Distribution across context types of chipped stone tools, chert and obsidian, Trench 7, Bestansur (totals by Context type in italics).

Space	*Context*	*Context type*	*Area type*	*Chert tools*	*Obsidian tools*	*Total tools*
17	1224	Fill of human burial	Burial	8	6	14
				8	*6*	*14*
16	1229	Occupation	Internal	0	0	0
16	1243	Occupation	Internal	4	8	12
16	1255	Occupation	Internal	3	9	12
20	1268	Occupation	Internal	0	0	0
16	1280	Occupation	Internal	0	0	0
				7	*17*	*24*
19	1253	Room fill	Internal	3	2	5
20	1266	Room fill/floors	Internal	0	0	0
				3	*2*	*5*
17	1220	Surfaces/occupation	External	21	29	50
17	1248	Surfaces/occupation	External	6	8	14
18	1249	Surfaces/occupation	External	8	14	22
17	1254	Surfaces/occupation	External	26	16	42
17	1259	Surfaces/occupation	External	6	5	11
17	1274	Surfaces/occupation	External	23	27	50
				90	*99*	*189*
18	1225	Occupation	External	14	11	25
18	1227	Occupation	External	15	15	30
22	1275	Occupation	External	0	3	3
				29	*29*	*58*
17	1226	Lower pit fill	External	0	2	2
17	1218	Upper pit fill	External	2	1	3
				2	*3*	*5*
17	1261	Burnt?	External	13	4	17
				13	*4*	*17*

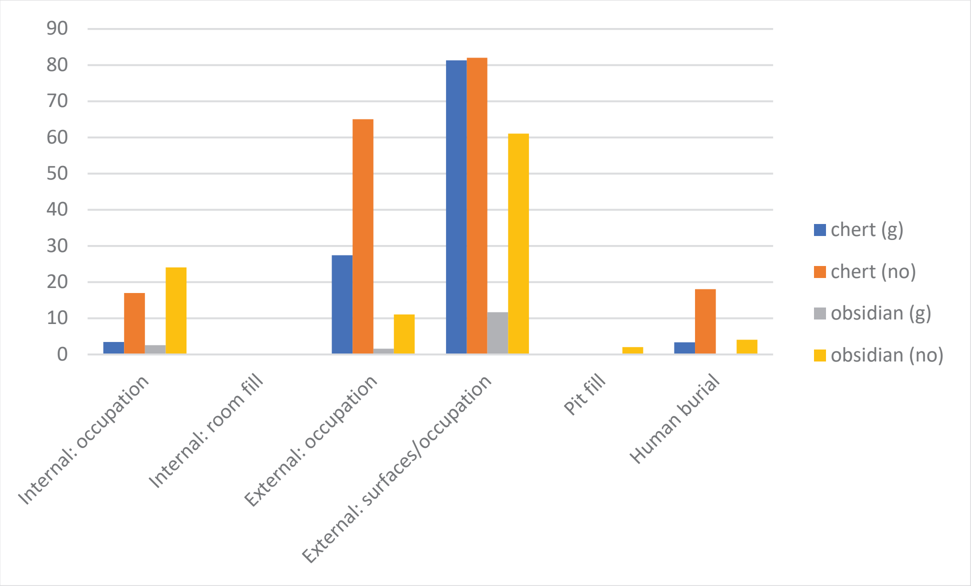


Figure 20.56. Summary distribution by context type of chipped stone debitage, chert and obsidian, Trench 7, Bestansur.

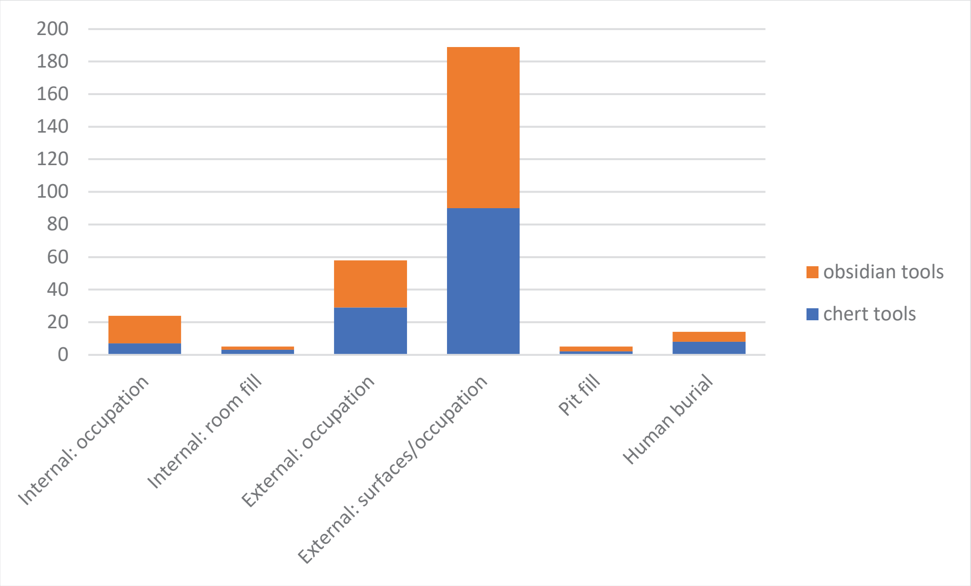


Figure 20.57. Summary distribution by context type of chipped stone tools, chert and obsidian, Trench 7, Bestansur.

The exclusive occurrence of notched blades, of both chert and obsidian, in external deposits, represented in all contexts of 'surfaces/occupation' type, is especially striking. This distribution is likely to be related to activities taking place on these surfaces. Notched blades would be useful for trimming and sharpening wooden sticks and implements, perhaps especially tapering and pointed sticks that might be convenient for extracting snails from their shells once cooked, for example, but also for a range of other possible activities such as working of leather, basketry and netting. Diagonal-ended bladelets found on these external surfaces probably got there embedded in hunted prey. Cores, all of chert, are also found only in external deposits, indicating a preference for tool manufacture in outside areas.

The patterns of tool and debitage distributions across Trench 10 are tabulated in Table 20.24, showing broad agreement with the Trench 7 pattern. The majority of tools come from external occupation, including diagonal-ended bladelets. But significant quantities of scrapers, blades, and diagonal-ended bladelets from internal contexts suggest that many activities were also undertaken indoors.

Some distinctive chipped stone finds were made in Space 47, Context 1620, excavation of a thin whitish floor and underlying packing (Fig. 20.58). Apart from small quantities of chips and flakes, a total of nine

Table 20.23. Distribution across context types of chipped stone tools excluding unretouched blades and bladelets, Trench 7, Bestansur.

Space	*Context*	*Context type*	*Area type*	*Notched blade*	*Serrated blade*	*Blade with burin facet*	*Diagonal-ended blade(let)*	*Drill/ borer*	*Shouldered drill*	*Scoop/ handle*	*Blade end scraper*	*Flake scraper*	*Point*	*Core*
17	1224	Fill of human burial	Burial	0	0	0	0	0	0	0	0	0	1	0
16	1229	Occupation	Internal	0	0	0	0	0	0	0	0	0	0	0
16	1243	Occupation	Internal	0	1	0	0	0	0	0	0	0	0	0
16	1255	Occupation	Internal	0	0	0	1	2	0	0	0	0	0	0
20	1268	Occupation	Internal	0	0	0	0	0	0	0	0	0	0	0
16	1280	Occupation	Internal	0	0	0	0	0	0	0	0	0	0	0
19	1253	Room fill	Internal	0	0	0	0	0	0	1	0	1	0	0
20	1266	Room fill/floors	Internal	0	0	0	0	0	0	0	0	0	0	0
17	1220	Surfaces/ occupation	External	1	1	0	0	1	0	0	1	0	0	0
17	1248	Surfaces/ occupation	External	3	0	0	0	0	0	0	0	0	0	1
18	1249	Surfaces/ occupation	External	1	0	0	0	0	0	0	0	0	0	0
17	1254	Surfaces/ occupation	External	2	0	0	1	0	2	0	0	2	0	1
17	1259	Surfaces/ occupation	External	1	0	1	0	0	0	2	0	0	0	0
17	1274	Surfaces/ occupation	External	7	1	0	3	0	1	0	0	1	0	0
18	1225	Occupation	External	0	0	0	2	0	0	0	0	0	0	0
18	1227	Occupation	External	1	0	0	0	0	1	0	0	0	1	1
22	1275	Occupation	External	0	0	0	0	0	0	0	0	0	0	0
17	1226	Lower pit fill	External	0	0	0	0	0	0	0	0	0	0	0
17	1218	Upper pit fill	External	0	2	0	0	0	0	0	0	0	0	0
17	1261	Burnt?	External	1	0	0	3	0	0	0	0	0	0	0

tools was found *in situ* in these deposits, as detailed in Table 20.25.

The wide range of tools from Context 1620 is quite striking, including blades (of chert and obsidian), a sickle blade with sheen and fixative staining, a thumbnail scraper, a flake scraper and an awl or point. This range of tools suggests that multiple activities were taking place within Space 47 and/or that tools for such activities were stored or deposited in Space 47. The two long obsidian blades, CS1 and CS2, are especially notable, found in close proximity in the northern corner of Space 47 (Fig. 20.58). These blades had clearly been struck from the same nodule and both had snapped, probably during use. Traces of wear damage at the tips suggest these tools were used as prongs in some manner, perhaps in order to extract snails from shells. Both these blades closely resemble the long obsidian blade with broken tip (SF161) found in the external area of Trench 7 in close association with cooked and discarded snail shells (Fig. 20.55). Their bulbar ends had also been flattened by delicate flaking, perhaps in order to fit into a handle.

A structured death: patterns of discard

The final stage in the biography of a stone tool is its deposition in what was to become the archaeological record. The ways in which such a deposition might occur were varied and often dependent on the ways in which tools were used during their working lives. Many tools would get broken during use, snapping in two during hide cutting or piercing, for example, or splintering into fragments if accidentally encountering harder materials such as ground stone. Tools would also get worn out through repeated usage, no longer capable of sustaining their scraping, piercing or cutting edges. Our interpretation is that many of the tools recovered by us, in particular from external working surfaces as in Trenches 7 and 10, were discarded there in the process of retooling of multi-component implements, as discussed above. Other tools were broken during use in craft and food processing activities and abandoned in places proximate to their last phase of use, again especially in open external areas where there was less emphasis on keeping surfaces immaculately clean.

Many tools might be lost from a single instance of usage, in particular chert or obsidian barbs on arrows fired at fast-moving prey on the plains and in the mountains a long way from the home base. Such tools are largely lost to us, although it is possible for intensive field survey to encounter solo instances of

Table 20.24. Distribution of chipped stone tools across Buildings and Spaces, Trench 10, Bestansur.

Building	Space	Material	Retouched blade	Notched blade	Serrated blade	Sickle blade	Blade/ flake scraper	Point/ awl/ drill/ borer	Shouldered drill	Diagonal-ended blade/let	Other microlith
5	40	Chert	8	10	0	3	1	1	0	1	0
		Obsidian	1	1	0	0	0	0	0	1	0
	42	Chert	22	12	0	9	6	0	2	2	0
		Obsidian	4	1	0	0	0	1	0	0	0
	47	Chert	3	2	1	3	3	2	0	0	0
		Obsidian	5	0	0	0	0	0	0	0	0
	48	Chert	2	1	0	0	0	0	0	0	1
		Obsidian	1	2	0	0	0	0	0	0	0
	49	Chert	3	0	0	0	0	0	0	0	0
		Obsidian	0	0	0	0	0	0	0	0	0
	50	Chert	28	18	3	4	10	2	1	7	3
		Obsidian	13	2	0	0	0	1	0	0	0
	60	Chert	19	6	0	0	3	0	3	2	0
		Obsidian	1	0	0	0	0	0	0	0	0
	63	Chert	3	0	0	0	1	0	0	1	0
		Obsidian	0	0	0	0	0	0	0	0	0
8	54	Chert	0	0	0	0	0	0	0	0	0
		Obsidian	0	0	0	0	0	0	0	0	0
9	61	Chert	8	1	0	0	4	1	0	0	0
		Obsidian	13	0	0	0	0	0	0	0	0
External area	23	Chert	2	0	0	0	0	0	0	0	0
		Obsidian	0	0	0	0	0	0	0	0	0
	27	Chert	59	28	2	4	5	5	1	12	0
		Obsidian	10	4	0	0	0	0	0	0	0
	29	Chert	203	56	15	12	9	23	2	4	2
		Obsidian	68	5	0	0	0	2	0	1	1
	43	Chert	4	0	0	0	0	0	0	1	0
		Obsidian	1	1	0	0	0	0	0	0	0
	44	Chert	34	15	0	0	6	7	1	5	1
		Obsidian	3	1	0	0	0	0	0	1	0
	51	Chert	4	0	0	1	0	1	0	0	0
		Obsidian	2	0	0	0	0	0	0	0	0
	52	Chert	11	5	3	0	2	0	1	1	0
		Obsidian	4	1	0	0	0	0	0	0	0
	53	Chert	21	10	0	1	1	1	1	5	1
		Obsidian	9	1	0	0	3	1	0	0	0
	55	Chert	1	1	0	0	0	1	0	2	0
		Obsidian	0	0	0	0	0	0	0	0	0
	–	Chert	324	109	25	16	38	17	5	16	4
		Obsidian	261	29	9	0	27	13	0	6	5
Total			1155	322	58	53	119	79	17	68	18

flint or obsidian tools, as was the case on our Zarzi survey season of field-walking (Chapter 4). Given that all the tools studied here were excavated from *in situ* deposits at the sites of Bestansur and Shimshara, we can assume that they all relate either to activities directly undertaken at those sites, or to activities undertaken elsewhere but with some meaningful connection with the sites. In the latter class, we could place projectile points or barbs brought back to the site within the flesh of hunted animals and discarded at the locus of their butchery or consumption, for example.

At neither Bestansur nor Shimshara have we found any evidence for caching or storing of chipped stone materials, whether as blanks, cores, or finished tools, such as are commonly found on many other Neolithic sites (Carter 2011). The impression is rather that the availability of good chert sources and steady access to obsidian supplies meant that the inhabitants of Bestansur and Shimshara did not

Table 20.25. Chipped stone tools from Trench 10, Building 5, Space 47, Context 1620.

Tool	*Context*	*Tool type*	*Material*	*Colour*	*Comments*
4809	1620	awl/point	chert	green/brown banded	Broken both ends
4810	1620	flake scraper	chert	mid-grey	Complete
4811	1620	thumbnail scraper	chert	dark grey	Complete?
4812	1620	blade	chert	mid-grey	Complete
4813	1620	sickle blade frag.	chert	pale grey with dark mottling	Fine sickle sheen both faces of one edge, traces of staining of fixative on opposite edge. Nb sickle sheen blades often made of this chert
4814	1620	blade frag.	obsidian	dark grey	Mid-section, very fine bladelet
4815	1620	blade frag.	obsidian	dark grey	Mid-section
4816 CS1	1620	blade	obsidian	grey	Complete but found in two pieces, adjacent, ancient break. Long curving blade, tapering to point at distal end, probably broken during use and left at side of room, close to CS2
4817 CS2	1620	blade	obsidian	grey	Complete but found in two pieces, adjacent, ancient break. Long curving blade, tapering to point at distal end, probably broken during use and left at side of room, close to CS1

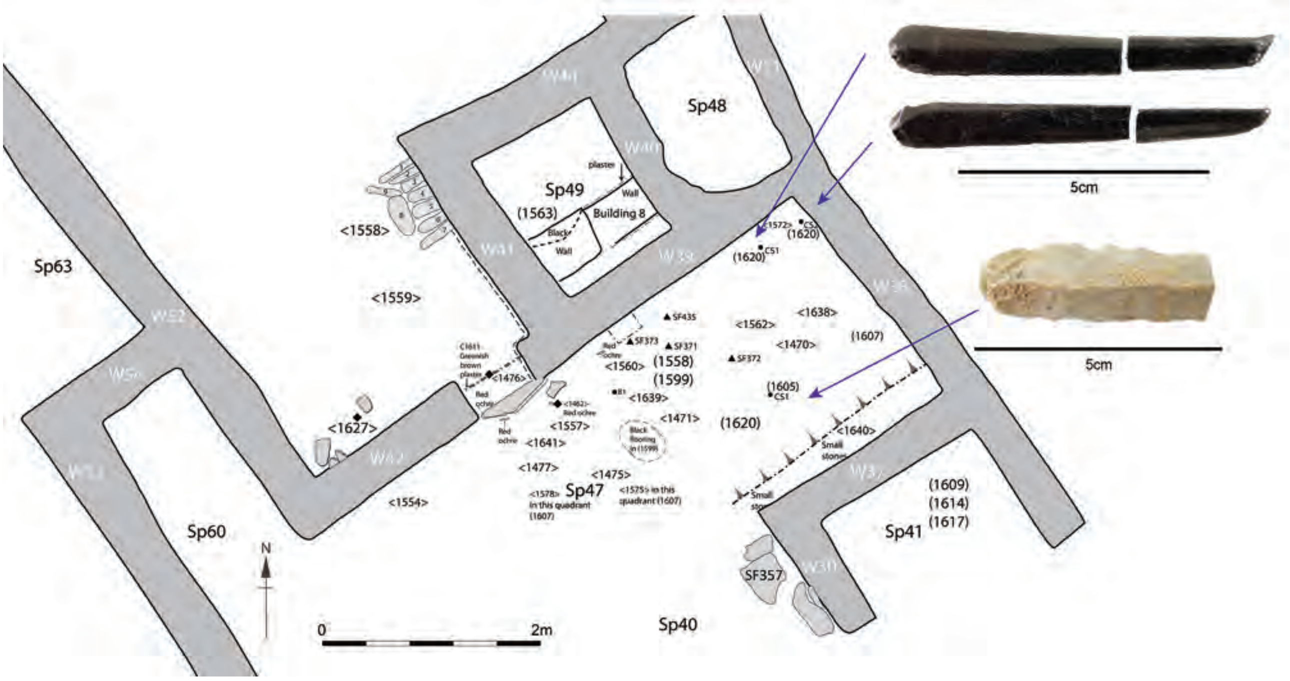


Figure 20.58. Plan of Space 47, Building 5, Trench 10 to show distribution of finds.

feel the need to deposit caches of valued material against future hard times, but it has to be conceded that only a small proportion of each site has been excavated and this picture could change with further investigation. As always, we can provide the most informative interpretations when we have contextually rich associations with which to explore the life and death of Early Neolithic material culture. The chert diagonal-ended bladelet accompanying the human bone mass in Trench 10, discussed above, is a rare candidate amongst our chipped stone finds for a deliberately broken and deposited item, perhaps an arrow with a single barb or point, placed in a funerary context as a special offering to accompany the dead.

Conclusion: living meaningful lives

Finally, in the light of the lithic analyses presented above we return to the research issues articulated at the start of this chapter. How do our lithic studies enlighten us in each of these important areas?

Table 20.26. Chronological indicators in the material culture from excavated trenches at Bestansur and Shimshara.

Material attribute	*Bestansur*	*Shimshara*	*Relative dating implication*	*Absolute dating implication cal. BC (approx.)*
Çayönü tools	Common	Common	Contemporary with and/or later than Çayönü Cell-Building phase	Post-7600
			Earlier than Pottery Neolithic	Pre-7000
			Earlier than Jarmo upper levels	Pre-7000
Geometric microliths	Rare	Very rare	Later than Zarzian Late Upper Palaeolithic	Post-11,000
			Earlier than Jarmo upper levels	Pre-7000
Diagonal-ended bladelets	Common	Present	Contemporary with Jarmo lower levels and Deh Luran Early Neolithic	Post-7600
			Earlier than Jarmo upper levels	Pre-7000
Burins	Very rare	Very rare	Later than Çayönü early levels	Post-8000
Side-blow blade-flakes	Absent	Absent	Earlier than Jarmo upper levels	Pre-7000
Obsidian/chert proportion (quantity)	25/75	80/20	Later than Late PPNA	Post-8000
			Earlier than Pottery Neolithic	Pre-7000
Neolithic pottery	Absent	Absent	Earlier than Pottery Neolithic	Pre-7000
Alabaster/marble bracelets with flanged profiles	Present	Absent	Mid-Late PPNB?	Post-8000
				Pre-7000

Chronology of change and continuity

The Bestansur and Shimshara assemblages show considerable continuity with earlier chipped stone technologies of the EFC, as discussed above. Any chronological variability must therefore be viewed against a stable backdrop of tradition and material culture continuity. Nevertheless, within the assemblages there are some useful pointers to assist in the relative and absolute dating of the two sites, as tabulated in Table 20.26. Taken together, these distinctive attributes agree in dating the excavated levels of both Bestansur and Shimshara to a time range of approximately 7700 to 7000 BC, in agreement with the radiometric absolute dating discussed in Chapter 11.

Sedentism and seasonality

How might the study of lithic assemblages inform us on the issue of sedentarisation (Andrefsky 2005: 224–244)? In a study of chert core technologies, Parry and Kelly (1987; Ashkenazy 2013) theorised a connection between what they termed 'expedient core technologies' and transitions to a sedentary way of life, arguing that settled groups of people would have ready access to known raw material sources which they could exploit in order to produce tools on demand, without the need to carry pre-prepared tools. It could be argued that the inhabitants of Early Neolithic Bestansur and Shimshara, with their ready access to nearby chert sources and their widespread employment of an expedient core technology in the form of pressure flaking of regular blades and bladelets from fine cores, fit this model rather well. But the association does not necessarily imply year-round sedentism, as it is possible that human groups were employing expedient core technologies for certain seasons of the year, while settled in one place, and yet travelling across the landscape in seasonal patterns at other, mobile, seasons while using pre-prepared tools. Intensive landscape surveys investigating multiple contemporary sites (Andrefsky 2005: 210–213) and detailed studies of raw material sources would address this issue more fully.

Regarding seasonality, Keeley (1982: 804) cites ethnographic evidence to suggest that retooling of hafted tools is an activity frequently undertaken during quieter, winter months in preparation for spring and summer food-gathering activities. In that case, the presence of multiple broken sickle-sheen blades at a site might be indicative of seasonal winter occupation rather than occupation at the time of actual use of the hafted tools during, for example, summer harvest. The low proportions of sickle blades from Neolithic sites would not then negate the idea of summer occupation. For Bestansur, in particular, the evidence that multiple tasks and activities involving chipped stone tools were taking place in open external areas, in association with seasonally available foods such as edible land snail, strongly argues at least for a significant late spring and summer presence. Cooking of snails and recurrent outdoor activities would be challenging in the cold and severe winters of the Zagros foothills. The chipped stone evidence cannot confirm that people lived at Bestansur year-round but taken in conjunction with other strands of evidence, discussed in Chapters 15 (Fig. 15.25) and 24, it helps to fill in the picture of season by season occupation and activity at the site.

More broadly, the evidence for widely dispersed lithic knapping and tool use across the entire site at Bestansur argues for a modular, heterarchical social structure whereby individual social components, whether families, clans or small tribal groups, were each self-sufficient in their power to exercise decisions and conduct activities while respecting a communal framework of beliefs and social codes that bound all the components together in a viable and dynamic community.

Food, craft, and natural resources

Studies by Bleed (1986) and Eerkens (1998) have addressed the issue of hunting strategies through the lens of chipped stone tools, discerning a division between 'reliable' and 'maintainable' hunting strategies. The 'reliable' strategy involves exploitation of resources with high predictability and short windows of opportunity, as provided by seasonally migrating herds of animals, for example. In these circumstances, the hunter needs a standardised tool-kit whereby a weapon can be quickly retooled with a chert or obsidian piece that fits smartly into a haft. In the reliable strategy, then, chipped stone tools will be of standardised shapes and portable sizes. In the 'maintainable' strategy, hunters operate in an environment of less resource predictability where opportunism is favoured. Tool-kits are more versatile and varied, with more multi-purpose tools and less emphasis on the need for standardised replacement parts. The Bestansur evidence fits the 'reliable' strategy more closely than the 'maintainable' strategy. The emphasis is on high volume production of standardised blades and bladelets to provide a restricted range of single-purpose tools. Tools such as diagonal-ended bladelets would serve well as identikit components, easily portable and ready to be slotted into hafts of arrows or spears without use of adhesive and with minimum fuss, ideal for intensive episodes of mobile hunting of seasonally migrating animals such as gazelle and onager, for example, and wild sheep more year round. We assume that hunters would make every effort to recover spent arrows in the field in order to re-use them and would therefore carry multiple spare chert tools for rapid repair of barbs or points broken by impact.

It is especially difficult for us to address issues of gender and age through the lithic materials. There is considerable danger in ascribing gender to specific craft activities (Costin 1996; Bolger 2010), but many ethnographic studies agree in seeing tasks such as the processing of fibres, textile work and basketry as primarily female and also often involving children under female supervision (van Gijn 2010: 91, 158). From our point of view, such activities need not have involved significant chipped stone tool engagement. In a rare consideration of lithics and gender, van Gijn (2010: 158) has proposed a loose binary association of women/plants/domestic versus male/hunting/public for the Dutch Neolithic, in which "male, flint and killing are intimately linked" (van Gijn 2010: 172). If this schema were applicable to the Zagros Neolithic (a large 'if'), it would imply a stronger association of males with chipped stone tool production and maintenance in open spaces as well as with hunting, as opposed to female associations with craft activities requiring less engagement with chipped stone tools. Keeley (1982: 802) cites ethnographic evidence that the "manufacture and maintenance of stone tools was in many societies predominantly a male activity" which, again if valid for the Early Neolithic of the EFC, might suggest that the deposits of lithic and other debris excavated by us in external areas of Trenches 7 and 10 relate to small groups of males gathered together in open areas to undertake a range of social and craft activities, an interpretation which also fits with van Gijn's (2010: 158) tentative association of 'male' with 'public'. Rare instances of the deposition of chert and obsidian artefacts in human burials at Çatalhöyük (Carter 2011) show a correlation of weapons and butchery tools with adult males and a single instance of obsidian 'toilet-kit' blades with an adult female.

Material engagement and networks

The lithic raw materials used at Bestansur and Shimshara, obsidian in particular, demonstrate the participation of both communities in extensive networks with their contemporaries across the Zagros region and into eastern Anatolia (Chapter 24). As we have seen, the absolute volumes of material on the move need not have been massive but they confirm both sites' participation in these networks. There is also evidence for difference in the wider roles of Shimshara and Bestansur. Imported obsidian forms a far greater proportion at Shimshara, 80% of the lithic assemblage by count, than it does at Bestansur at 26%. At 375km as the crow flies, Shimshara is located significantly closer to the east Anatolian obsidian sources than Bestansur at 490km, but it is still separated from those sources by major mountain ranges of the north Zagros and east Taurus.

Of greater significance than absolute distance is the topographic location of the two sites. Shimshara was strategically located at a node of natural route-ways at the northeast corner of the Rania plain where the Lesser Zab breaks through the Zagros onto the plain. A settlement at this location has the potential to control movement of people and commodities, in particular along the course of the Lesser Zab either southeast into the Iranian high Zagros or west onto the Erbil and Kirkuk plains of Upper Mesopotamia. Once on these plains, the western route leads readily up the Tigris into eastern Anatolia or southwards into Lower Mesopotamia. Shimshara's strong Anatolian connections are demonstrated both through its heavy consumption of obsidian but also through specific technological practices, such as the use and retouching of Çayönü tools. For Bestansur, on the northwest edge of the Shahrizor plain, the landscape is more open and there is less scope for control over movement along specific routes. The nearby Tanjero river, which flows into the Diyala river at the south end of the plain, forms one means of access southwards to the foothills and fertile plains of the western Zagros outliers adjacent to the Lower Mesopotamian flood-plain. Such a route would intersect with an east–west route connecting the lower Diyala region east of Baghdad with the highlands of Iran via Khanaqin, part of the famous Great Khorasan Road.

The little understood Early Neolithic sites of Rihan III in the Hamrin region (Tusa 1984; 1985) and Tamerkhan near Mandali (Oates 1968: 3–4), both east of Baghdad, with their obsidian tools, stone bowls and bracelets, are accessible from the Shahrizor plain via the Tanjero-Diyala route but obsidian could more easily reach these sites by following the Erbil-Kirkuk-Ba'qubah route, avoiding the Shahrizor plain altogether. Indeed, this route is taken by the modern railway and until recent times was the major road for travel between Mosul and Baghdad rather than the current Tigris route (Postgate 1984: 151). Use of this route for movement in the Neolithic could explain why sites such as Rihan III and Tamerkhan, despite being much further from obsidian sources than Bestansur, appear to have significantly higher proportions of obsidian in their lithic assemblages (Barge *et al*. 2018: 305–306, fig. 5).

Nevertheless, we are still left with the question: how did people distribute obsidian, and other transported materials such as fine-grained alabaster and semi-precious stones, over the hundreds of kilometres from source to destination in the Early Neolithic period (Barge *et al*. 2018)? First, it is worth stating that the time factor is accommodating. Even if a block of obsidian was transported only a few dozen kilometres a year, in only 20–30 years it could travel from Nemrut Dağ to Bestansur, for example, moving down the line from settlement to settlement. In a stimulating review, Kozlowski (2013) specifies the period 7500–7000 BC as a critical time for the broadening of horizons across the entire Fertile Crescent and the establishment of networks that persisted for centuries. This period is also when communities in the Iranian high Zagros started to make significant use of obsidian. In his model, Kozlowski argues for degrees of pre-processing and pre-forming of final artefacts at production sites close to raw material source prior to transport to destination settlements, following riverine routes. While it is clear that some artefacts such as Çayönü tools and stone bowls and bracelets may have received considerable pre-forming prior to delivery, and that decortification of obsidian and chert nodules was probably also taking place close to raw material source, there is evidence from many widely dispersed sites to indicate *in situ* working of materials including obsidian and alabaster. It is likely that materials were processed through a combination of pre-forming and on site working. Kozlowski hypothesises that pre-formed artefacts were then transported village to village through a network of specialist intermediaries who might distribute their goods at seasonal festivals, rituals, and other regional and trans-regional occasions. In this model, a specialist intermediary might carry a load of pre-formed alabaster bowls and bracelets along with pre-formed Çayönü tools and other obsidian blanks, for example, thus providing villagers with both the roughed-out artefacts required for their social signalling and also the tools with which to finish and maintain them.

We should also allow for the significance of direct, long-distance connections between Early Neolithic communities, whereby special expeditions may have travelled from remote locations directly to the raw material source to enable exchange of goods or products specific to those communities. Furthermore, Neolithic communities need not all have engaged in the same way within obsidian networks, with some acting as hubs of regional distribution and others more focused on local consumption (Ibáñez *et al*. 2015; Ortega *et al*. 2016).

Future directions

Analysis and material classification of cherts through hyperspectral imaging using near infrared (NIR) spectroscopy, a non-destructive and rapid technique (Sciuto *et al*. 2018), provides an exciting way forward for systematic investigation of patterns of chert exploitation and use at Bestansur through the generation of 'spectral fingerprints' for individual artefacts. Coupled with selective use of pXRF and interpreted through multivariate statistics, the use of hyperspectral mapping has great potential for the investigation of diachronic and/or spatial patterns in chert use and trends in access to sources of raw materials.

There is also considerable scope for further investigation of modes and means of movement of raw materials, obsidian in particular, through the application of analytical techniques such as 3D GIS (Barge *et al*. 2018), agent-based modelling and social network analysis (Ibáñez *et al*. 2015; Ortega *et al*. 2016). These techniques may be especially effective when integrated with pattern detecting approaches such as richness and diversity indexes to enable characterisation of large assemblages of material (Campbell and Healey 2018).

Analysis of the sickle blades has revealed the potential for a much greater in-depth study of the plant and hafting residues and has developed a methodology for identifying chipped stone tools used in the harvesting of plants, even where sickle sheen is not readily apparent. Furthermore, recent studies have demonstrated the potential for extracting phytoliths from the residues on sickle blades (Kealhofer *et al.* 1999; Hart 2011; Liu *et al.* 2017). Experimental analyses on sickle blade residues and hafting materials have been successful in illustrating the potential for deriving a wealth of information from these tools (see, for example, Evans and Donohue 2005; Goodale *et al.* 2010). Combined approaches integrating techniques such as scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) have highlighted the benefits of elemental mapping of gloss (Kamińska-Szymczak 2002). Furthermore, analysis of the bitumen residues from sickle blades using isotopic approaches and gas chromatography coupled with mass spectrometry, combined with analysis of local sources, may enable us to identify bitumen sources used for the making of these composite tools (Connan 1999; Gregg *et al.* 2007).

In this study of the chipped stone tools and debitage from Bestansur and Shimshara we hope we have succeeded in demonstrating the value of an integrated, contextual approach to the analysis and interpretation of the Early Neolithic chipped stone worlds of two very important sites in the Eastern Fertile Crescent. Much further work remains to be done but we feel that we now have in place a theoretical framework and a methodology for taking these studies to the next stage.

21. MATERIAL CULTURE AND NETWORKS OF BESTANSUR AND SHIMSHARA

Amy Richardson

Introduction: a Neolithic revolution

Across the Fertile Crescent in the eighth millennium BC, Early Neolithic communities engaged in innovation, experimentation and technological developments, as attested at many archaeological sites. Sedentary lifeways afforded opportunities unavailable in mobile life, such as greater investment of time and energy into the development of place or the production of non-transportable objects. In conjunction with early domestication practices, people enhanced their skills in material construction, clay use and pyrotechnology. Through new interactions with materials, individuals and communities found new ways to create expression and memory, encouraging conceptualisation and comprehension of the abstract (Renfrew 2004; Malafouris 2013). Societies and individuals employed clay figurines and tokens, engraved stones and applied pigments and paints as symbolic signifiers. Combining dynamic processes of problem-solving through creative solutions and an expansive use of material resources, the Early Neolithic people of the Central Zagros put material culture to use in new and enduring ways.

Research context and rationale

When Robert Braidwood and his team first drew attention to the hilly flanks of the Central Zagros, it was with a view to understanding the transitions "from cave to village, from food-collecting to food production" (Braidwood and Howe 1960: 1; Braidwood *et al.* 1983). These early excavations in the Eastern Fertile Crescent (EFC) revealed a region occupied by communities experimenting not just with plants and animals, but also with materials and materiality. Increasingly entangling themselves within a material world (Hodder 2012), Neolithic communities bound their lives to landscapes and sought to find new and revolutionary ways of using the resources available to them.

Following investigations at the tenth–eighth millennium BC sites at Sheikh-e Abad and Jani in the high Iranian Central Zagros (Matthews *et al.* 2013a), Bestansur and Shimshara offer the opportunity for new insights into the chronological and spatial developments of material culture in the Neolithic of the EFC and more widely. At Sheikh-e Abad, people intensified their uses of clay through the ninth and eighth millennia BC, in the form of tokens and figurative objects, as the inhabitants engaged with networks of ideas, utilising a material culture made solely from local resources (Cole *et al.* 2013). The communities of the Zagros participated in knowledge exchange and shared cultural practices in making tools, tokens, figurines and adornments, as well as building construction and the management of plants of animals, at sites including Sheikh-e Abad, Ganj Dareh, Asiab, East Chia Sabz, Ali Kosh and Chogha Golan (Hole *et al.* 1969; Smith 1978; Darabi *et al.* 2011; Matthews *et al.* 2013a; Riehl *et al.* 2013; Darabi *et al.* 2018). Contemporary innovations amongst the communities of the Northern Fertile Crescent (NFC) along the Taurus arc, at Qermez Dere, Nemrik 9, Çayönü and Körtik Tepe (Watkins *et al.* 1989; Özdoğan 1999; Kozlowski 2002; Özkaya 2009), shared common elements but took different trajectories, and it is only in later periods that raw materials, such as obsidian, passed between the regions. Investigations at Jarmo have demonstrated that by the seventh millennium BC, engagement with both the EFC and the NFC influenced the material culture of the inhabitants occupying the hinterland between these two core zones of innovation (Braidwood *et al.* 1983). The geographical and chronological position of Bestansur and Shimshara, poised chronologically and geographically between these two very different lifeways provides the opportunity to explore the intersection and increasing complexity of Early Neolithic networks.

Research aims and objectives

The analyses conducted in this research aim to examine and elucidate the changing relationships between Neolithic communities and their material culture, and to explore the broader geographical context of resource use and wide-ranging networks (see also Chapter 24). At the heart of this research are key questions that feed into the overarching aims of the project:

- Situated, as these sites are, along key transitional routes through the landscape, to what extent is it possible to trace the ways in which individuals and communities forged networks of materials, ideas and practices, within and between communities?
- How did communities integrate the use of locally available materials with the acquisition of materials from further afield and in what ways did they use them differently?
- Did the ways in which people used raw materials and conducted craft activities vary within the community and did these practices change over time?

In order to investigate the movement of materials through networks of exchange, the objective in field analysis was to study and identify the range of material resources utilised by the inhabitants of the Neolithic settlements, by portable X-ray fluorescence (pXRF) analysis, where appropriate, for the purpose of provenance studies and to investigate material choices. Chemical characterisation techniques have proven fruitful elsewhere, for the sourcing of obsidian, chert and clay, as well as bead materials (Carter *et al.* 2006; Goren *et al.* 2011; Nazaroff *et al.* 2014; Querré *et al.* 2014).

Methods and approaches

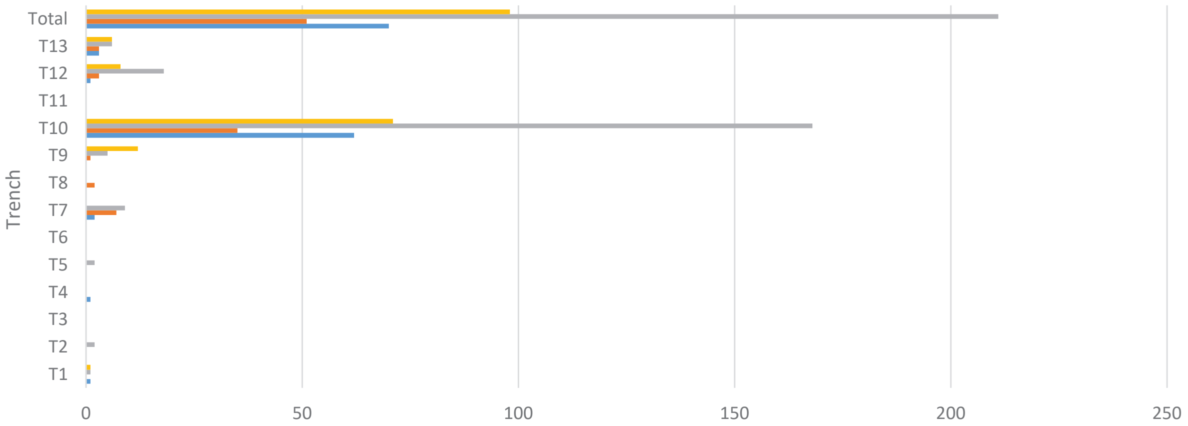
This investigation of artefacts categorised as 'Small Finds' (SFs) recorded during the 2011–2017 CZAP investigations at Bestansur and Shimshara highlights and examines key object categories from the assemblage and the results of their analysis. The SFs include objects of personal adornment, worked stone and bone objects, and non-pottery clay objects. From 1.3 tonnes of archaeological artefacts (Bulk Finds, BF) recorded from Bestansur, 577 Small Finds were selected as being of particular cultural significance in terms of their representation of technology, activity or conceptualisation, thus meriting separate treatment from the assemblages for zooarchaeology (Chapter 15), chipped stone (Chapter 20) and ground stone (Chapter 22). Post-Neolithic finds (including objects of glass, pottery and metal of Iron Age, Sasanian, Islamic and modern date) are recorded in the catalogue and the database (Chapter 2). These objects are not discussed in this volume, but further details on all SFs can be accessed in the online Archive reports: https://www.czap.org/archive-reports.

In the field, SF numbers were assigned to artefacts, or groups of artefacts, during excavation by team members, during the processing of heavy residue (Chapter 14) and in the course of post-excavation analysis (e.g. worked bone was highlighted during the zooarchaeological analysis, Chapter 15). Each find has been catalogued, described, illustrated, photographed and is archived in the Sulaimaniyah Directorate of Antiquities, along with copies of the catalogues. The Slemani Museum is in the process of accessioning the SFs into the collection and a number of objects are now on display in the Prehistory Gallery (Chapter 23).

Where appropriate, pXRF analysis has been conducted to identify and compare archaeological materials and networks. Although analysis conducted with pXRF does not have the resolution of traditional laboratory-based analytical methods, the precision and accuracy of portable analysers has improved significantly over the last decade. Trials conducted on materials from Sheikh-e Abad demonstrated significant potential for the application of pXRF analysis on Neolithic materials. Based on these results and the non-destructive benefits of pXRF, as well as the potential for conducting rapid analysis in the field, negating the need to export cultural artefacts, the technique has been tested across a range of material types at Bestansur, from the first season in 2012. Analysis was conducted using a Niton XL3t GOLDD+ analyser, calibrated in mining mode, in a tungsten-lined stand, set up in the field laboratory in the modern village of Bestansur. Each of the four filters was run for 30 seconds, for a total run time of 2 minutes, with a minimum of two readings taken across the surface to average out material variation and highlight anomalies. As with the analysis on chipped stone materials (Chapter 20), published NIST standards were analysed at the start and end of each run, for the purpose of refining the calibrations and checking for drift over the course of a set of samples. These methods have been successfully applied to examine a range of materials across sites in the region, including to examine inter- and intra-site variability of clay use in Mesopotamia (Matthews and Richardson 2018).

The data set

Over the course of seven excavation seasons at Bestansur, small find (SF) numbers were assigned



	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	Total
🟨 Worked bone	1	0	0	0	0	0	0	0	12	71	0	8	6	98
⬜ Adornment	1	2	0	0	2	0	9	0	5	168	0	18	6	211
🟧 Stone	0	0	0	0	0	0	7	2	1	35	0	3	3	51
🟦 Clay	1	0	0	1	0	0	2	0	0	62	0	1	3	70

Figure 21.1. Total number of Neolithic SFs from Bestansur recorded by object class.

to 430 Neolithic artefacts from across 14 trenches, including 142 objects of bodily decoration, 56 clay objects, 98 fragments of worked bone and 43 stone objects. Two seasons of investigations at Shimshara yielded 45 small finds, from 36kg of bulk finds. The SF assemblages from the two sites are detailed separately in this chapter and their implications considered in relation to the key questions and aims above.

The presence of traces of organic materials, such as reed matting and woven baskets (Chapter 12) provide insight into the components of the material assemblage that are less readily visible in the archaeological record. Textiles, skins, nets and leather are just a few of the perishable objects of which we find little trace in the archaeological record. Subtle indicators and traces of these materials may be preserved, such as pigments on decayed burial wrappings (Chapters 9 and 19), matting impressions and fragile matting remains in Trench 10 and red fibres in Trench 13 (Chapter 12), but a large proportion of the organic assemblage has decayed and thus the following examination only represents a partial portion of the cultural materials actually in use.

Small finds from Bestansur

The Neolithic small finds from Bestansur comprise a diverse assemblage of artefacts from across ten trenches (T3, T6 and T11 yielding no Neolithic small finds). On average, only 0.002 Neolithic SFs per litre were recovered from Neolithic deposits, or one SF for every 413 litres of soil excavated. Higher concentrations of material were recovered from Trenches 12 and 13 to the north of the mound, where a small find was recorded for every 140 litres of earth removed. Small finds were much less frequent to the southwest of the mound in Trenches 4 and 7, with one small find occurring for every 1480 litres excavated.

In total, of the 430 Neolithic artefacts recorded at Bestansur, 420 (98%) were recorded from only five trenches: 7, 9, 10, 12 and 13 (Fig. 21.1). As the most extensively excavated area, Trench 10 yielded 78% of the Neolithic SFs from the site. Although a range of materials was recovered from each trench, it is notable that no worked bone was found in the spaces excavated across Trench 7 either inside or in the area surrounding B3, in contrast with Trench 9, where the majority of artefacts recovered were of worked animal bone from open external areas with fire installations and discard deposits. Clay object distribution also appears localised, largely within Trench 10, with only two clay artefacts from Trench 7 and only a single clay object from Trench 12. Beyond Trench 10, only eight fragments of Neolithic clay were recorded at Bestansur.

The distribution of artefacts across the site is largely determined by the objects selected for the SF category. Common tools and working materials, such as chipped stone, ground stone and butchered bone, appear in larger numbers but are treated separately (Chapters 15, 20 and 22). Nonetheless, the differential distribution of objects considered here varies across sectors of the site and highlights spatial variation (Fig. 21.2). It is notable that the intensive investigations in T10, around B5 and the surrounding spaces to the east of the mound, have significant bearing on the overall results for the distribution of artefacts.

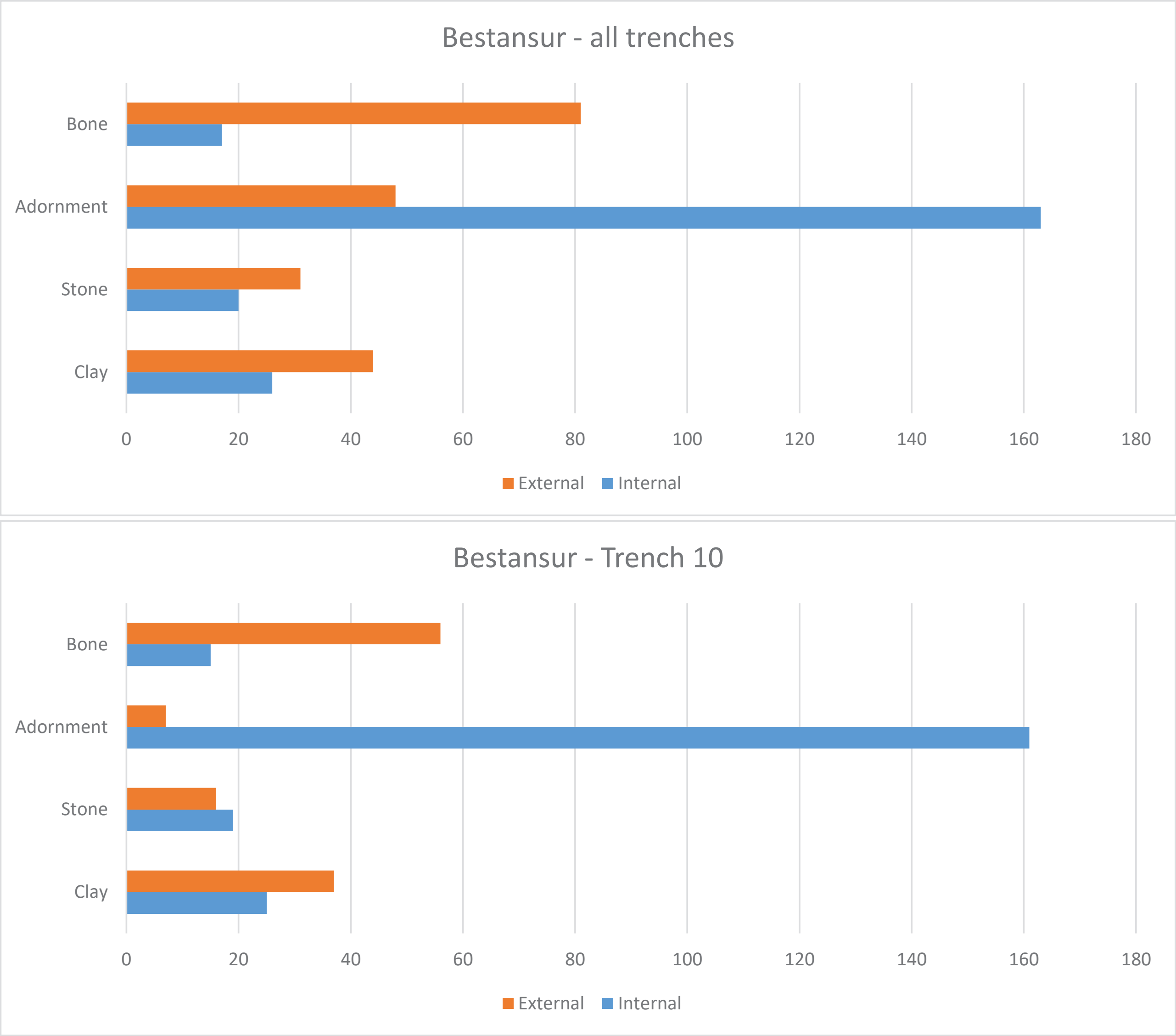


Figure 21.2. Total number of Neolithic SFs recorded according to spatial type.

This is particularly the case for the high proportion of adornments, largely in the form of beads, in Sp50 in B5 (Chapter 9) whereas, across the rest of the site, 96% of adornments have been recovered from external open areas. Overall site-wide proportions of clay and stone objects are also skewed by the activities conducted in B5 T10, as elsewhere across the settlement we have thus far only recorded one clay object in T1 and one stone object in T7 from internal spaces. On average, for all trenches excluding T10, 96% of all SFs were recovered from external open areas, compared with only 35% from external open areas in T10. Consequently, it may be that the T10 assemblage and particularly those objects from B5 are not representative of site-wide practices. Future investigation of the neighbouring buildings will provide a key frame of reference to understand varied practices of spatial use (Chapters 12 and 14).

Clay artefacts

The recovery of clay objects has been dependent on a range of factors including, but not restricted to, the production of the object and whether it was baked prior to deposition, their small size at often <2cm, taphonomic factors including humidity of the deposits, visibility as deposits dried out and recovery methods such as visibility in dry sieving and structural survival of wet sieving. In some instances, clay objects were so fragile that they had to be recorded in plan or section, as extraction from the dense, clay-rich sediment was not feasible without causing considerable damage. The conservation methods applied to preserve these artefacts during excavation are discussed in Chapter 8. Broman Morales (1983: 391–392; 1990: 27) has acknowledged the fragility of the artefacts found at Jarmo and Sarab, where clay objects were most commonly retrieved from ashy deposits, possibly due to the looser and more contrastingly coloured matrix. Almost 17 boxes, each a cubic foot, of clay objects were collected during the 1954/55 season at Jarmo (Matson 1960: 63), including clay figurines, tokens, shapes and lumps, of which two cartons were discarded as working material that had not been deliberately shaped (Broman Morales 1983: 392). The remaining clay lumps were examined together with an assemblage of 5500 clay pieces, forming one of the largest and most significant Neolithic clay assemblages recorded. Nevertheless, the range of purposes for these objects remains elusive. The frequency with which these objects are only lightly fired and found discarded with everyday household refuse has given rise to the theory that it is the act of making, rather than the object itself, that was significant (Broman Morales 1983; Daems 2008; Schmandt-Besserat 2013; Weismantel and Meskell 2014). Rapidity of making, tactility, portability and impermanence were all features of these artefacts. Meskell has conceived of the clay objects and figurines at Çatalhöyük as performative objects, rather than symbolic display objects, exploring the possibilities that they were carried around in pouches with other amuletic objects, or had interchangeable heads for use in storytelling (Meskell 2007).

Seventy shaped-clay objects were recorded across six trenches at Bestansur (Table 21.1), including from the deepest levels of Trench 10, where deliberately shaped and baked objects were deposited at around 7650 BC (Chapter 11). The most concentrated deposits of clay artefacts are from the external open areas to the south of Building 5 and its predecessor, Building 8. Of the 62 clay artefacts found in Trench 10, 36 were recovered from the spaces to the south, southeast and southwest of the buildings, encroaching no further than the entranceway to Building 5. Nineteen clay SFs were found inside Building 5, all of which were deposited in Space 50, with a further three from the floor levels in Space 53 of Building 9.

Clay 'tokens'

Clay token assemblages are well known from Early Neolithic sites in the high Iranian Zagros throughout the ninth millennium BC, with clay tokens published from sites such as early ninth millennium Asiab (Schmandt-Besserat 1979) and the start of the eighth millennium BC at Ganj Dareh (Zeder and Hesse 2000) and Sheikh-e Abad (Cole *et al.* 2013). Excavations at the early settlement at M'lefaat (217km northwest of Bestansur) have provided the best early evidence for clay use in the tenth millennium BC, with around 40 fragments recovered over the course of the University of Chicago investigations at the site (Dittemore 1983: 682). However, amongst these only one spherical token and two clay cylinders have been identifiable as objects and these from the disturbed layers (Dittemore 1983: 672; Schmandt-Besserat 1992b: 197). Jarmo in the seventh millennium BC yielded a wealth of around 2000 tokens, largely cones and tetrahedrons, and 5500 pieces of shaped clay overall (Broman Morales 1983: 369; Schmandt-Besserat 1992a: 45). The function of these objects remains disputed (Bennison-Chapman 2018) and in some cases they may have played a role in early numeracy (Schmandt-Besserat 1992a).

A notable feature of the clay artefacts from the southern external spaces of Trench 10 is the constancy of forms throughout the Neolithic sequence. Ball shapes are the most frequently occurring in the repertoire, numbering 12 in total from Trench 10 (Fig. 21.3). In the earliest levels of Trench 10, two sets of three small balls below 10mm in diameter were recovered (SF495 C1738 and SF513 C1752), with a further single example (SF486 C1751) also located in the deep sounding (Sp27), bearing traces of ochre. However, in the subsequent phases, these balls are commonly 12–20mm in diameter, with a single further example located adjacent to the Neolithic walls in neighbouring Trench 1 (SF15 C1100). Clay ball tokens are well-attested across Neolithic sites, from the earliest Neolithic, and are interpreted as an early precursor to numeracy and writing (Schmandt-Besserat 1992a).

Other token forms include a slender-spool or drum shape in Space 29 (SF258, C1409, Fig. 21.4). This rare type, local to the EFC, is known from sites such as Maghzaliyah, Jarmo and Sarab (Kozlowski and Aurenche 2005: fig. 7.6). Although tempting to speculate that this object could have travelled from elsewhere, pXRF analysis (Fig. 21.5) indicates that its clay is characteristically similar to that used for the clay balls and shapes in the lower levels of Space 27 and the clay figurine from Space 50. These results are illustrated using the potassium (K) versus titanium (Ti) ratios, which are affected by the underlying geologies and have proven effective in the provenance study of cuneiform tablets (Goren *et al.* 2011; Matthews and Richardson 2018), and the chromium (Cr)/ niobium (Nb) ratios which demonstrate trace element variability in the Bestansur assemblage. Chromium and niobium probably derive from the pegmatite gabbro present in the region, occurring as small grit inclusions in the clay (Jassim *et al.* 2006: 218; Richardson 2019).The clay used for SF258 appears to be derived from the same silty clays commonly used as packing and levelling material across the site, which is shaped and baked into this token form. Thus far it is the only example of a slender-spool token from Bestansur.

There are three clay cone 'tokens' from Bestansur (Fig. 21.4): SF264 (C1331, Sp29), SF329 (C1548, Sp40) and SF498 (C1738, Sp27). SF329 was very small and fragile in comparison to the two other examples, which are hard baked and both bear traces of markings on their surface. Clay cone token SF264 appears to be deliberately ridged on one side, with a deep gash scored diagonally downwards from left

Table 21.1. Clay objects from Bestansur.

Trench	*Space*	*Context*	*SF*	*Type*	*Length (mm)*
1	3	1100	15	Ball	12
4		1081	23	Rim sherd	27
7		1092	20	Pellet	5
7		1171	30	Object	24
10	27	1413	263	Objects	
10	27	1738	473	Rod	17
10	27	1738	495	Balls	7
10	27	1738	498	Cone	16
10	27	1751	477	Clay shapes	7–30
10	27	1751	479	Piece of clay	51
10	27	1751	486	Ball	9
10	27	1751	522	Clay object	24
10	27	1752	509	Clay Shape	10
10	27	1752	513	Balls	8
10	27	1752	517	Object	16
10	27	1768	525	Clay objects	28
10	27	1772	507	Clay Shape	24
10	27	1772	526	Clay object	16
10	29	1317	201	Ball	16
10	29	1317	202	Ball	20
10	29	1331	264	Cone	12
10	29	1402	247	Ball	17
10	29	1402	248	Object	39
10	29	1409	258	Token	15
10	29	1412	299	Rod	14
10	29	1422	285	Knob	35
10	40	1548	329	Cone	12
10	42	1550	333	Disc	40
10	42	1550	334	Clay token	15
10	42	1550	335	Clay object	17
10	43	1725	476	Objects	13
10	44	1750	511	Clay shape	21
10	44	1755	494	Objects	20
10	44	1755	512	Clay shape	26
10	44	1767	530	Clay shape	19
10	44	1769	527	Clay shape	16
10	44	1769	528	Clay object	20
10	44	1778	529	Clay object	14
10	50	1565	370	Object	27
10	50	1741	493	Object	19
10	50	1741	510	Object	12
10	50	1775	533	Clay object	25
10	50	1781	532	Figurine	40
10	50	1781	538	Clay object	43
10	50	1803	649	Lightly fired clay shape	19
10	50	1823	637	Clay object	23
10	50	1857	663	Clay shapes	23
10	50	1863	662	Clay shape	24
10	50	1864	664	Clay shape	4
10	50	1864	665	Clay shape	16
10	50	1868	707	Nullified token	16
10	50	1868	708	Ball	14
10	50	1868	714	Object	11
10	50	1870	669	Object	30
10	50	1879	711	Objects	19
10	50	1879	712	Nullified token	19
10	50	1880	713	Ball + nullified token	
10	51	1554	359	Object	45
10	53	1600	397	Clay shape	20
10	53	1756	480	Objects	40
10	55	1667	452	Ball	12
10	63	1872	672	Object	16
10	63	1875	680	Shape	
10	63	1875	681	Shape	
10		1810	602	Clay object	22
10		1828	638	Clay ball	
12		1514	342	Object	12
13		1520	358	Clay object	17
13		1576	332	Clay object	15
13		1578	352	Clay object	16

to right and opened across its surface prior to drying. The deep incision is similar to those highlighted on the 204 modified and gashed clay cones thus far only seen at Ganj Dareh, and suggested to represent an action intended to either "release" a force from the cone or "intensify" its significance (Broman Morales and Smith 1990). Portable XRF analysis of the gashed cone from Bestansur demonstrates that this is made from clays similar to those used for other clay objects and fired clay fragments at Bestansur (Fig. 21.5). Thus, this example from Bestansur demonstrates a practice shared between the high plains and foothills of the Zagros. One example of a clay cone 'token' has distinctly figurative features, SF498. Cone SF498 is more smoothly finished than SF264, although it is also ridged to create a spine, and has markings indicating a navel and division

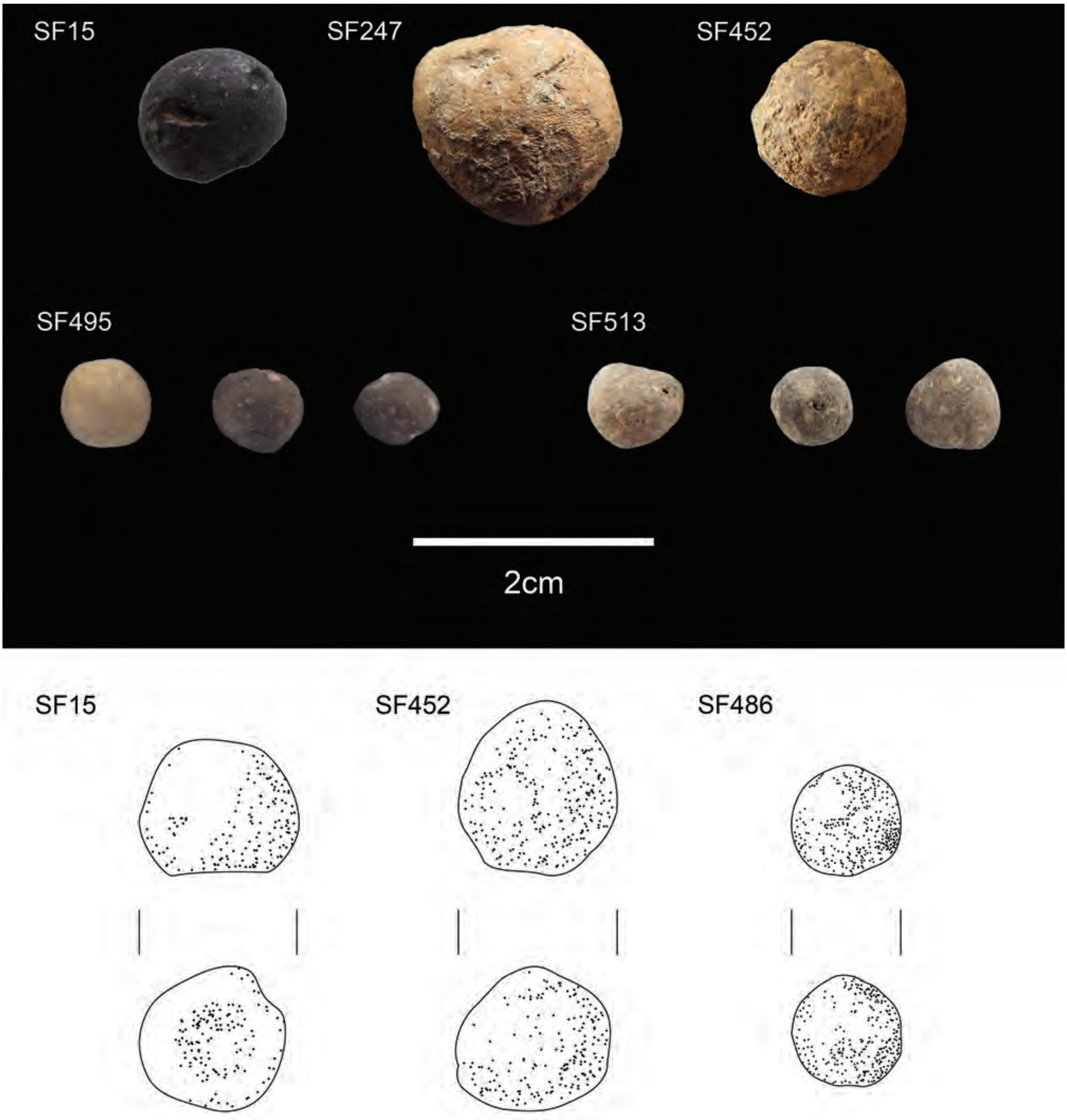


Figure 21.3. Clay ball 'tokens' from Bestansur.

of legs at the front and a short incision to the rear, thereby creating an anthropomorphised cone (Fig. 21.4). Clay cone figurines are rare at Early Neolithic sites in the region, with only two examples of conical 'bird' figurines at Karim Shahir, which have projections from the head similar to those observed on the Ganj Dareh gashed clay cones (Howe 1983; Broman Morales and Smith 1990). Figurines of this type appear to focus on an emphasis on the head, as seen in the seventh millennium stalk figurines at Jarmo and Sarab (Broman Morales 1983; 1990). Consequently, the Bestansur cone token/figurine appears to be unusual in its detail and may represent figurative experimentation by an individual at the site.

Teardrop or peaked shapes occur with frequency in Trench 10 and total 13 across the site (Fig. 21.6). These tend to be less finished forms, with lightly smoothed surfaces and made from more friable fabrics. Globular bodies lead to sometimes angular shoulders and either a pointed or rounded centred peak. This class of clay object conforms neither with the token nor with figurine repertoires, although teardrop-shaped objects make up approximately a

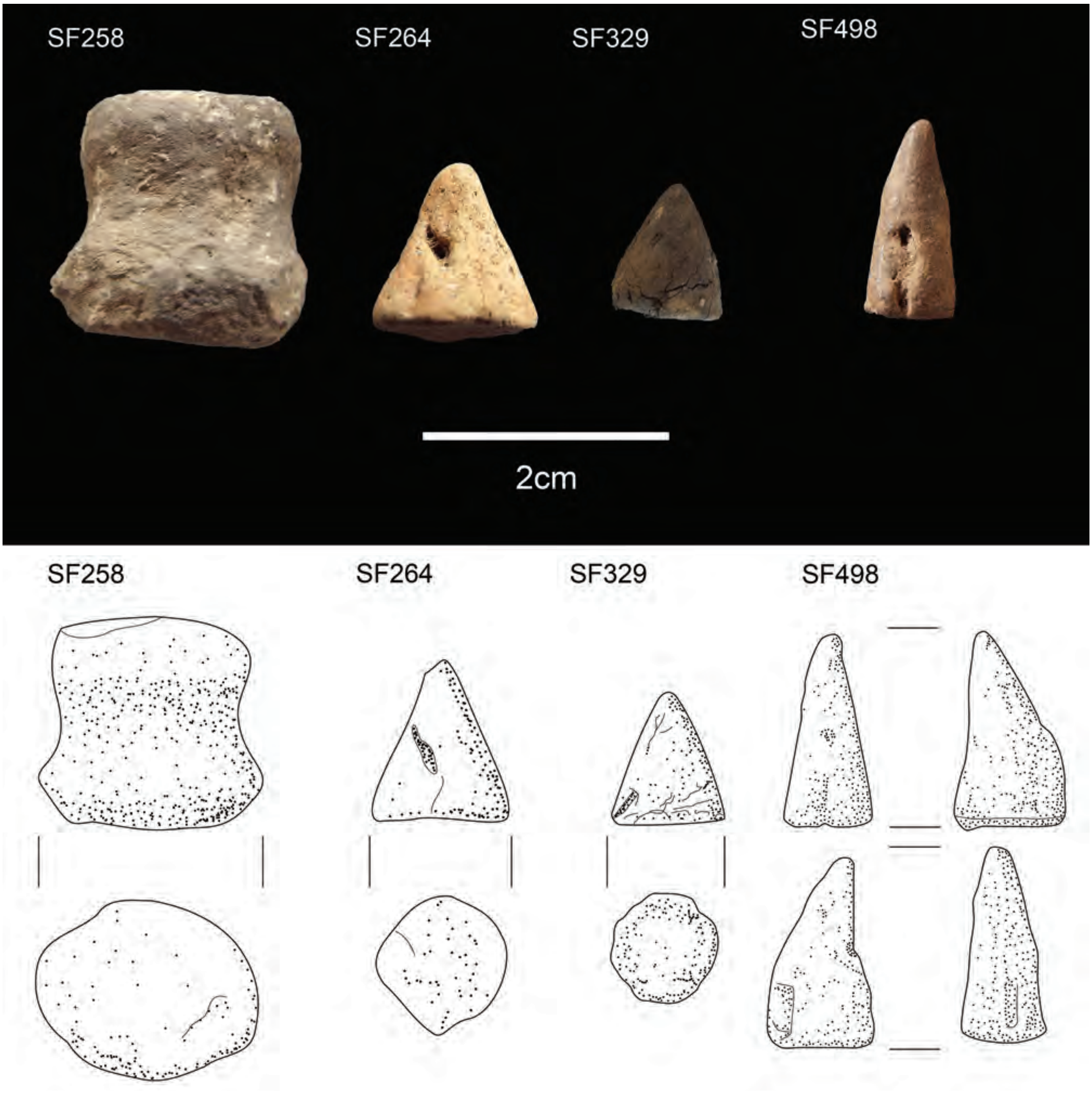


Figure 21.4. Clay spool and cone 'tokens' from Bestansur.

quarter of the total clay assemblage. These are similar in form to Schmandt-Besserat's pinched sphere or plain ovoid (1992a: 206, 2.14, or 216, 6.1). Three clay rods, or cylinder tokens, were recovered: two from Trench 10 and a third from Trench 13, each with one tapered terminal and one broken or flattened terminal. The example from Trench 13, SF352, is curved, with an impressed division around the circumference, close to the terminal, and a deeply incised line running diagonally across the length of the body (Fig. 21.6), giving it the appearance of a possible stalk object (as seen at Jarmo; Broman Morales 1983: fig. 166). Five small objects have the appearance of squashed or 'nullified' ball tokens, with uneven shape, marked with deep pressure or fingernail marks (e.g. SF334, SF510, SF517 and SF529; Fig. 21.6). The tokens have been lightly baked in their final form, indicating intentional preservation at this stage.

A small number of objects from Bestansur could be considered as 'amuletic': they are stand-alone representative objects of recognisable form, although they do not appear to articulate with the established clay 'token' and figurine assemblages. From the upper levels of the external area to the south of Building 5, Trench 10, a fragment from a larger object appears to depict a face on an inverted teardrop shape made from a very light, fired clay (SF248; Fig. 21.6). The eyes

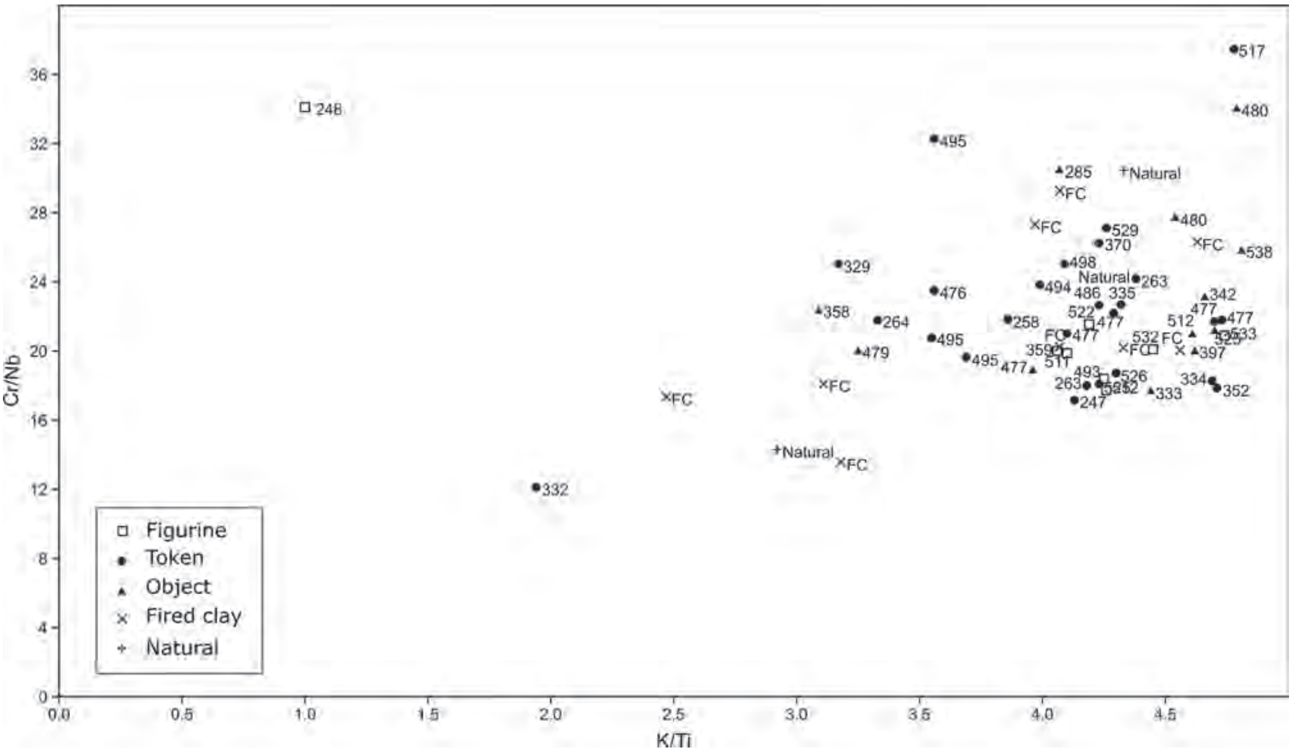


Figure 21.5. Portable XRF analysis of the potassium (K)/titanium (Ti) and chromium (Cr)/niobium (Nb) ratios for clay artefacts, fired clay (FC) and natural samples from Bestansur.

are deeply impressed, causing the clay to pucker, and the mouth is scored into the surface. The clay from which the 'mask' is made differs significantly from that commonly used at the site (Fig. 21.5 for pXRF analysis). Similar 'mask' styles are seen in the form of composite head fragments in clay from Jarmo and Sarab (Broman Morales 1983: figs 163–164; 1990: pl. 11) and stone in the Levant (Finlayson *et al.* 2009: fig. 6f). Based on the absence of comparable types and clays from Bestansur, this may have been brought to the site from elsewhere.

Furthermore, a hard-fired clay object in the shape of an almond, SF332 from C1576 in Trench 13 (Fig. 21.6), diverges from the common clay make-up employed by the inhabitants of Bestansur. The burnished surface suggests either preparation for improved tactility (a feature we see on no other clay artefacts), or burnish through repeated manipulation. Similar to the tokens in size, this shape is not a feature of the token repertoire and is perhaps better treated as an 'amuletic' object. Likewise, a perforated piece of clay, SF342 from C1514 in Trench 12 (Fig. 21.6), has clearly been deliberately shaped, perforated and has been through a firing process. With the approximate shaping of an eye and very narrow in section, the object could serve equally as a bead or an eye on a composite head. Although we have no evidence for the latter, the clay does appear to reference the shape of the cowries found in conjunction with the skulls in Space 50 (discussed below).

Clay figurative objects

In the clay assemblage from Bestansur, one artefact stands out: SF532, a simple seated figurine (Fig. 21.7), recovered from the packing levels beneath the floors of Building 5 (C1781). The figurine was excavated from a context also containing shell beads, both red and white stone beads, a green variscite bead, an alabaster bowl fragment and a fragment from a larger clay object. As arguably the only explicitly figurative representation thus far identified at Bestansur, SF532 is all the more remarkable for its deposition in the under-floor packing sequences containing human remains beneath Space 50. These packing deposits of silty clay loam sediments contain little of the low-level occupation residues that are seen across the site (Chapter 14), suggesting that these small finds represent the deliberate incorporation of selected objects, rather than the figurine's inclusion as discard.

Comparable with simple, seated types seen elsewhere in the EFC (see, for example, Jarmo; Broman Morales 1983: fig. 156.1–2), the head of figurine SF532 is absent, with a smoothed, flat surface at the neck. Whereas Meskell's whole and partial figurines at Çatalhöyük receive no differentiation in depositional treatment (Weismantel and Meskell 2014: 240), and Verhoeven (2007) has highlighted the difficulty in determining between deliberate and accidental breakage, the apparently deliberate smoothing where the head has been removed from SF532, and the incorporation of the decapitated

Figure 21.6. Clay peaked, rod and squashed 'tokens' and 'amuletic' objects from Bestansur.

figurine with disarticulated human remains, including skulls, (Chapter 19) suggest a more specific reference to the activities taking place in this space. Bailey (2007) has explored ways in which representational absence and cropping are employed in the restructuring and redefinition of the body and identity in the Balkan Neolithic. He argues that performance of processes of disarticulation, body preparation and deposition using clay figurines in place of the human body highlights the importance of the acts that took place following death. In conjunction with the disarticulation of human remains and caching of skulls (Chapters 9 and 19), the incorporation of a headless figurine in Sp50 at Bestansur raises questions about bodily representation and symbolic deposition conducted by the communities using this space.

Twenty other fragments of clay have been recorded in Sp50, none of which could be considered the head of the figurine, which may have undergone separate depositional practices. Two teardrop-shaped objects

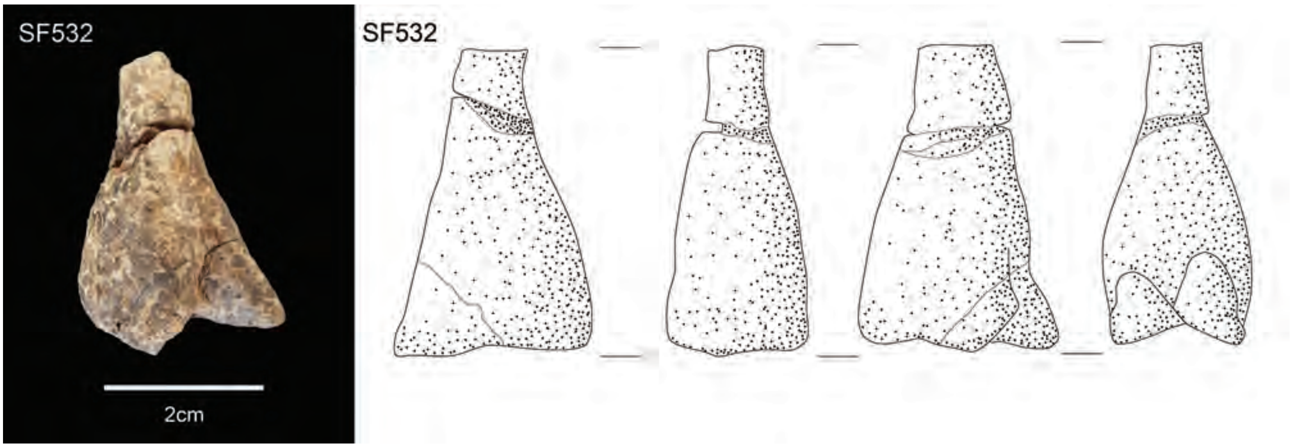


Figure 21.7. Clay seated figurine SF532 from Bestansur.

were found in the fill above the surfaces of Sp50, as was a globular shaped object (SF370). The latter, with a peaked base expanding to a globular body and a steep, narrowed neck, may reference a container. Three fragments pertaining to a shaped clay object (SF602) were recovered amongst human remains abutting the eastern wall of Sp50, which may form an object similar to the conical or triple-wing-based figurines seen at sites across the region. Below the floors, two further objects are made from the same dark, coarse clay. SF533 was deliberately shaped, with one broken surface. The clay, which uniquely includes a fragment of shell, forms two curving protrusions, set at a right-angle, with a deep score emphasizing the inner junction. SF538, in contrast, has only one partial surface intact, with the remaining surfaces broken away to reveal the construction of the body of the object around an inner core. These fragments at one time belonged to complete objects, possibly figurative, but have been deposited in the packing below the floors of Space 50 in a fragmentary state, as was the figurine, SF532.

Two further objects appear to represent human forms: SF512 from Sp44 and SF522 from Sp27 (Fig. 21.8). Another three objects may imitate this shape, though they are less distinct in their figurative description: SF511, SF525 and SF528. Both SF512 and SF522 were recovered from external open areas where numerous fragments of worked and discarded clay were deposited. Both fragments have flattened base or rear faces, for the object to be set on a surface. SF522 also has a fibrous impression, possibly from a knot. Both figurines appear to be reclining on their right elbow, with pubis and legs shaped and scored, the breasts shaped and indications of a head appendage. Although no direct parallels are known from the region for this period, reclining figurines are common amongst the Jarmo and Sarab assemblages (see, for example, Broman Morales 1983: figs 157–159; 1990: pl. 7f, and the 'snail lady' fragments, pl. 13k), with SF522 even bearing the same deep punch of the umbilicus. As with the Bestansur examples, the heads are indicated on the Jarmo figurines, but not elaborated, with focus held on the female form.

Only a single clay artefact may represent an animal figurine: SF479 (Fig. 21.8), a harder baked, buff clay fragment with one smooth and one rough side, deposited with figurine SF522 in C1751. The shape is short and stocky, with pinched legs and smoothed underbelly; the head is small, pointed and low-hanging. Although comparisons may be drawn with Jarmo Type B (Broman Morales 1983: fig.146.4–6), animal representations do not appear to occur elsewhere at Bestansur.

The human figurative depiction of the body at Bestansur and the virtual absence of animal imagery corresponds with trends identified at other sites across the Fertile Crescent, which are suggested to be a marker of changing concepts of personhood (Kuijt and Chesson 2007). Experimentation with concepts, materials and technological innovation in clay use in the Early Neolithic highlight an increasingly intense and complex relationship between people and material landscapes, as studies of pyrotechnology have highlighted (W. Matthews 2016). At sites such as Çatalhöyük, the affordances of clay brought unanticipated consequences (Meskell 2007; Hodder 2012: 65–68; 2013). At Bestansur, the debris and discarded artefacts are most concentrated immediately outside Building 5, to the south and west of the entrance, in the same spaces where high concentrations of butchering debris, worked bone and lithic debitage occurs. Only a select few clay objects have been recovered beyond these spaces, finding use or significance in internal spaces, as with those objects beneath the floors in Space 50. This may, to some extent, be a preservation issue, as clays that came in contact with fire installations bake harder and survive better in the archaeological record.

Other clay objects

Three unusually large clay objects were recovered

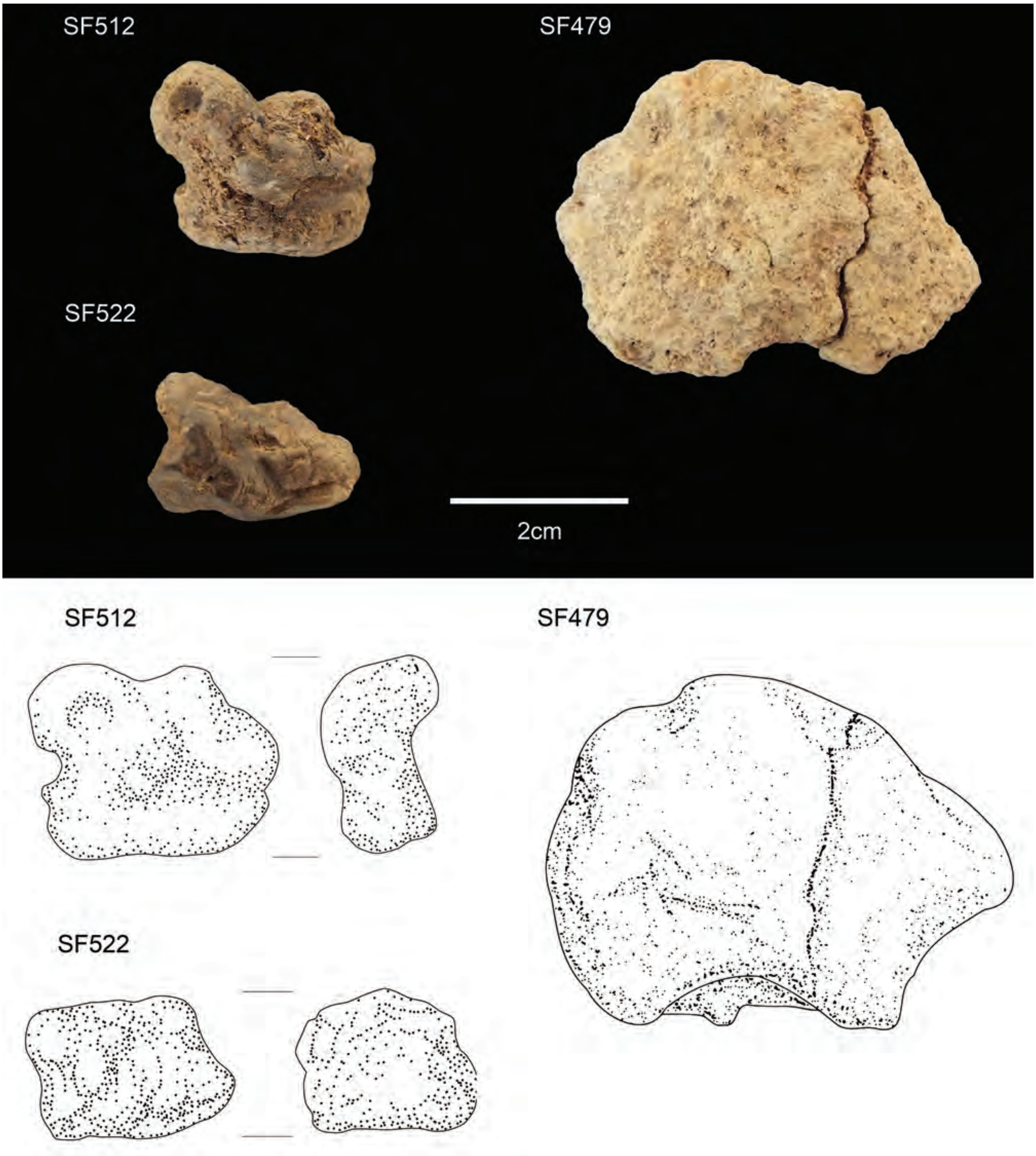


Figure 21.8. Clay figurative objects SF512a, SF522 and SF479 from Bestansur.

from the floor of the entrance to Building 9, Sp53 (Fig. 21.9). Bearing a similar composition to the clay used for the objects in Space 50, SF480 includes two non-adjoining fragments of a much larger object, similar in style to SF538. One complete object, SF359, was recovered in five separate pieces; shaped with a series of facets and ridges, its original form is indistinct and does not appear to bear any relation to the human or animal figurative forms. A single, unfired, complete clay disc (SF333) was recovered from Space 42 at the southern tip of Building 5. The rear of the disc is unevenly shaped and the surface smooth and concave.

Possible ochre staining has been noted on a couple of the clay artefacts. Whereas the clays used for the making of objects at Bestansur are rarely significantly altered, a single fragment, SF512b C1755 in Sp44 west of B5, has red ochre deep in the rough crevices of an unfinished surface and, more unusually, crushed flakes of obsidian incorporated into the clay matrix. This fragment represents experimentation at the

Figure 21.9. Large clay objects, SF359 and SF480, from Sp53 B9 at Bestansur.

site in creatively exploring new ways of using and adapting the materials available. The clay object SF512b was recovered from the ashy debris close to a fire installation F16, which also contained river clam and bird wing bones, and may represent an unusual set of activities conducted around this hearth. No other fragments or objects combining either ochre or obsidian into the clay matrix have been recovered.

Stone artefacts

Fifty-one Neolithic stone objects and object groups were assigned SF numbers (Table 21.2), including a range of artefact types. Amongst these, a dozen may be considered tokens, comparable with the size and range of small clay artefacts identified.

Stone 'tokens'

Five plain stone balls were recovered (Fig. 21.10), four of which pertain to Trench 10 and the fifth to Trench 8. These small spheres are *c.* 15–20mm in diameter, similar in size to the clay ball tokens identified around the site and they could have served a similar purpose, or even been interchangeable. Specific, preferred materials appear to have been selected for making these particular objects: a cream-white alabaster (SF33, SF268 and SF500) and a ferruginous stone, likely goethite (SF485 and SF499). The durability of these materials would have also been suitable for use as ballistics, in the hunting of birds or small mammals, or larger animals in the case of three limestone spheroids: SF35, SF366 and SF474 (Korfmann 1973).

The materials used for stone ball tokens are echoed in two variants: SF337 in ferrous stone and SF351 in a pale hard limestone. Both of these three-quarter spheres, from Trenches 10 and 13 respectively, have a deeply scored line running the vertical circumference of the object, suitable for tying a cord. SF351 has a second, short incision, running perpendicular to the base (Fig. 21.10). Three other objects of ferruginous stone were identified in Trench 10: SF329, SF371 and SF478 (identified as goethite on the basis of the iron content; Fig. 21.10). All three unfinished ferrous objects have distinctive natural shapes, making them attractive 'found' objects; SF478 is similar in both size and shape to the *Helix salomonica* shells that are ubiquitous across the site. Attractive or unusual stones may have been collected for their transformative powers, as unusually coloured or shaped rocks and river pebbles have been suggested to be considered sacred by some communities (Saunders 2004) and, for example, Mesopotamian texts indicate amulets of semi-precious stones were considered to have healing properties (Postgate 1997).

Two pebbles were accorded SF numbers, having been recovered from the clean spaces inside Building 5. From Sp63, SF475 shows signs of polish, and SF373 was located in Sp47, close to the threshold to Sp50. This small, flat pebble has short incisions on both sides perpendicular to the base, suggestive of the separation of legs, and may be an anthropomorphising alteration. Another 'found' rather than 'made' object, SF242, is a smooth trilobed stone from Trench 9 (Fig. 21.11). In a grey–brown limestone, darker than that commonly seen at Bestansur, the curvature of the lobes of the stone recall those of the clay figurine, SF532, in Trench 10, and the overall shape is that of Kozlowski and Aurenche's (2005: 28, fig. 6.4.4) "sitting ladies in the form of a tetrahedron", although this would be the only known example south of Jarmo. Emphasis, in the form of scored lines between two of the lobes, does appear to allude to the partition

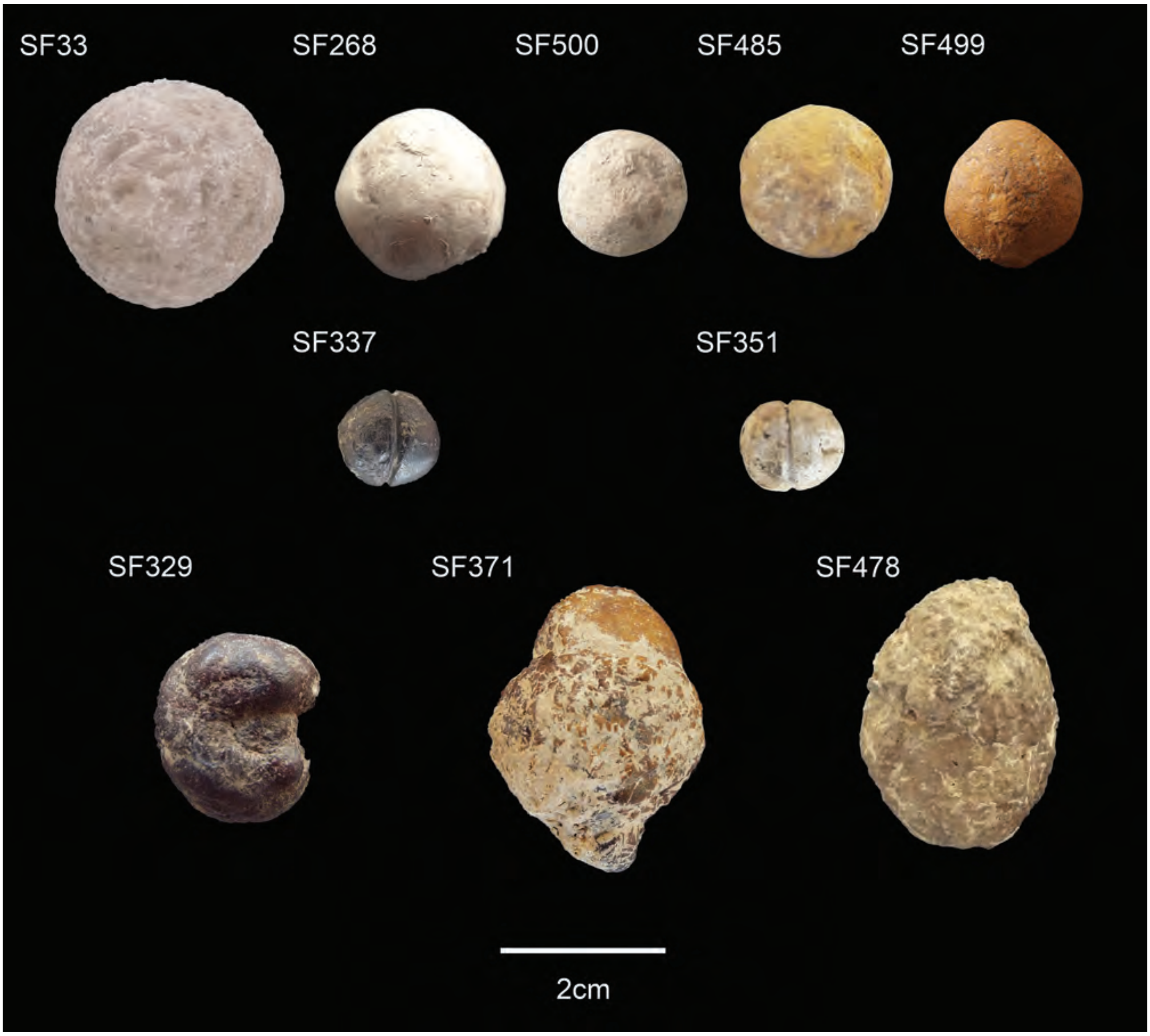


Figure 21.10. Stone 'tokens' from Bestansur.

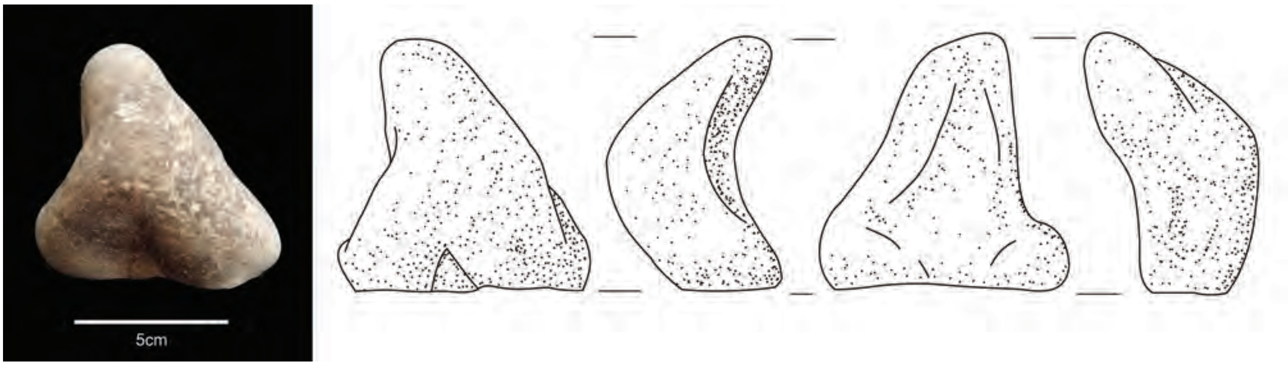


Figure 21.11. Limestone trilobed object SF242 from Bestansur.

of legs commonly seen on human figurines of this period and has parallels in the markings on SF373. Notably, Trench 9 has not yielded any other stone or clay SFs, only a small number of beads and some fragments of worked bone, and thus the discard of SF242 in the context of this open working space suggests that it did not hold any great significance in the context of the site.

Table 21.2. Stone objects from Bestansur.

Trench	*Space*	*Context*	*SF*	*Type*	*Material*	*Length (mm)*
7	16	1222	75	Net sinker	Limestone	69
7	17	1220	78	Disc	Limestone	61
7	17	1254	102	Disc	Limestone	66
7		1092	16	Tool	Alabaster	37
7		1175	21	Macehead	Alabaster	66
7		1217	57	Net sinker	Limestone	52
7		1219	73	Disc	Limestone	63
8		1134	33	Ball	Alabaster	27
8		1134	35	Ball	Limestone	53
9		1336	242	Object	Stone	70
10	27	1160	36	Tool	Limestone	190
10	27	1164	25	Tool	Alabaster	32
10	27	1772	562	Stone polisher	Marble	20
10	29	1310	499	Token	Hematite	18
10	29	1312	500	Ball	Alabaster	13
10	29	1330	239	Token	Hematite	20
10	29	1412	268	Ball	Alabaster	17
10	40	1539	357	Incised stone	Limestone	400
10	42	1540	326	Tool	Alabaster	52
10	44	1739	474	Ball	Stone	37
10	44	1755	485	Ball	Hematite	18
10	47	1599	369	Muller	Limestone	110
10	47	1599	371	Token	Hematite	37
10	47	1599	372	Disc	Limestone	62
10	47	1605	373	Token	Stone	18
10	48	1668	449	Mortar	Limestone	19
10	48	1668	450	Macehead	Stone	85
10	50	1781	537	Bowl	Marble	47
10	50	1784	568	Polished pebble	Limestone	25
10	50	1816	588	Perforated disc	Limestone	64
10	50	1870	716	Mortar	Limestone	18
10	50	1884	746	Object	Limestone	75
10	50	1884	764	Incised stone	Stone	380
10	50	1887	710	Debitage	Stone	6
10	51	1553	337	Token	Hematite	10
10	51	1554	366	Ball	Limestone	46
10	53	1756	481	Fragment	Sandstone	60
10	53	1756	482	Fragments	Fire-cracked stone	<36
10	60	1742	475	Token	Limestone	20
10	60	1878	700	Bowl	Stone	11
10	63	1748	478	Token	Hematite	33
10	63	1873	768	Token	Stone	19
10	63	1873	769	Debitage	Obsidian	12
10	63	1875	676	Pigment	Stone	3
10		1830	639	Stone tool	Marble	52
12		1320	188	Tool	Marble	35
12		1514	317	Net sinkers	Limestone	<60
12		1523	321	Net sinkers	Limestone	<55
13		1521	444	Bowl	Limestone	120
13		1574	351	Token	Limestone	10
13		1582	368	Mortar	Limestone	230

Perforated stone objects

Objects which may have held more prominent position in the cultural activities of the site include two objects commonly termed 'maceheads', although their function has not been conclusively established (Chapter 22; Fig. 21.12), from Trench 7, SF21, and Trench 10, SF450. The example from T7 was made from alabaster and that from T10 from brown marble with a yellow seam. The latter was placed in the fill of F18, the oven in Building 5; an inverted mortar (SF449) was later placed centrally within this space, between episodes of burning. These objects, which had not reached the end of their use-life, were deliberately selected and placed, as was the case with the bell-shaped pestle SF369, at the threshold between Spaces 47 and 50, and the deliberately

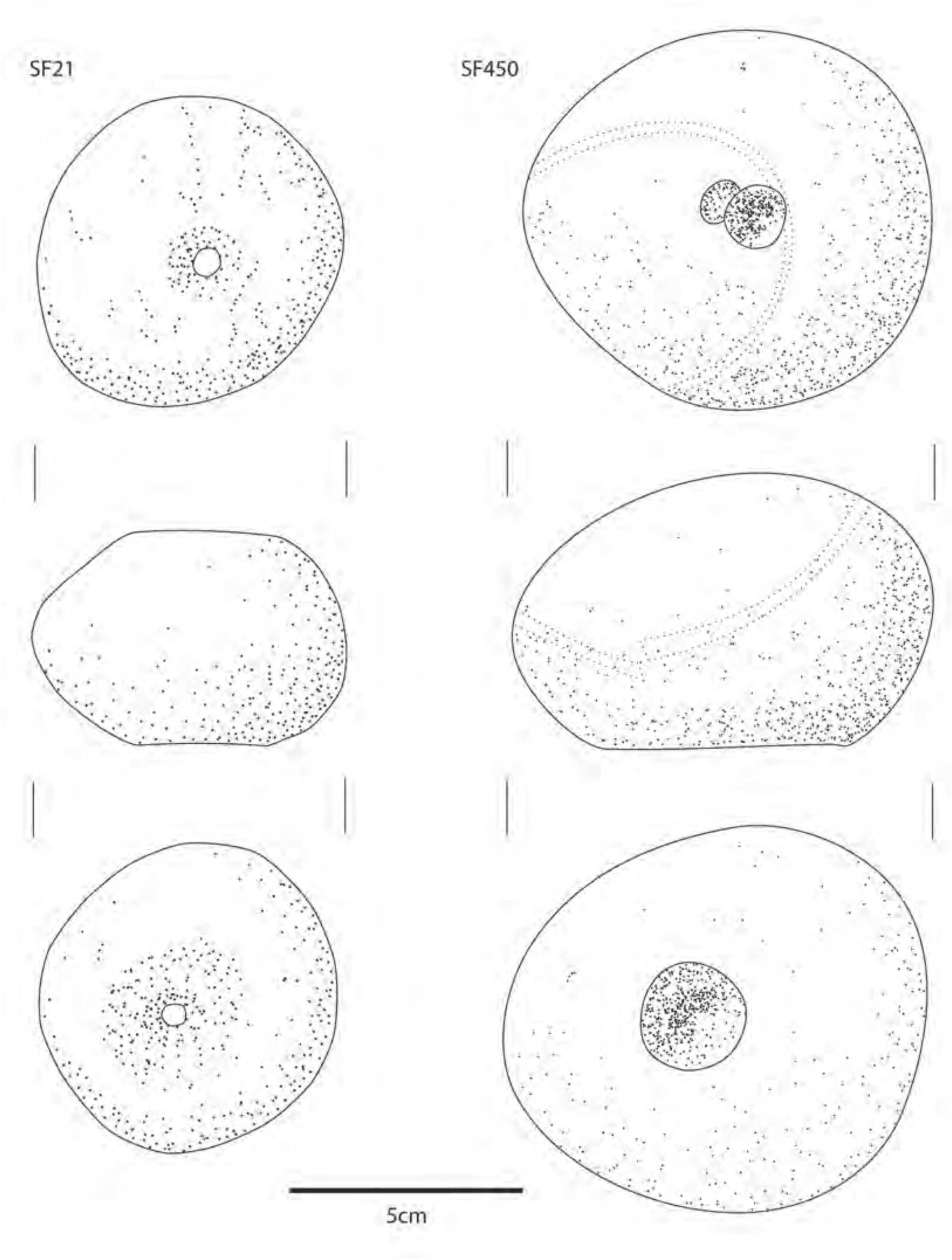


Figure 21.12. Stone 'maceheads' SF21 and SF450 (Fig. 22.19) from Bestansur.

broken and inverted mortars in Trench 9 and Trench 13 (Chapter 22).

The 'maceheads' have a particular relationship with the loci of architecture, as do perforated discs, which were also recovered exclusively from Trench 7 (SF73, SF78 and SF102) and Trench 10 (SF372). In contrast, the trapezoid perforated stones interpreted as net-sinkers, which were first recovered from Trench 7 (SF57, SF75; Fig. 21.13), do not feature in Trench 10, but there are two substantial, deposits of deliberately broken net-sinkers with impact scars in Trench 12 (SF317 and SF321, Chapter 22). Possible Late Neolithic clay impressions of a fishing-net have been observed during survey of the site (Nieuwenhuyse *et al.* 2012), and the consumption of fish is well-attested in the zooarchaeological record (Chapter 15).

Stone bowls

Fragments of stone bowls also suggest deliberate destruction and deposition in domestic spaces. Two fragments of a shallow marble bowl (SF537, Fig. 21.14) were retrieved from the packing underneath the floors

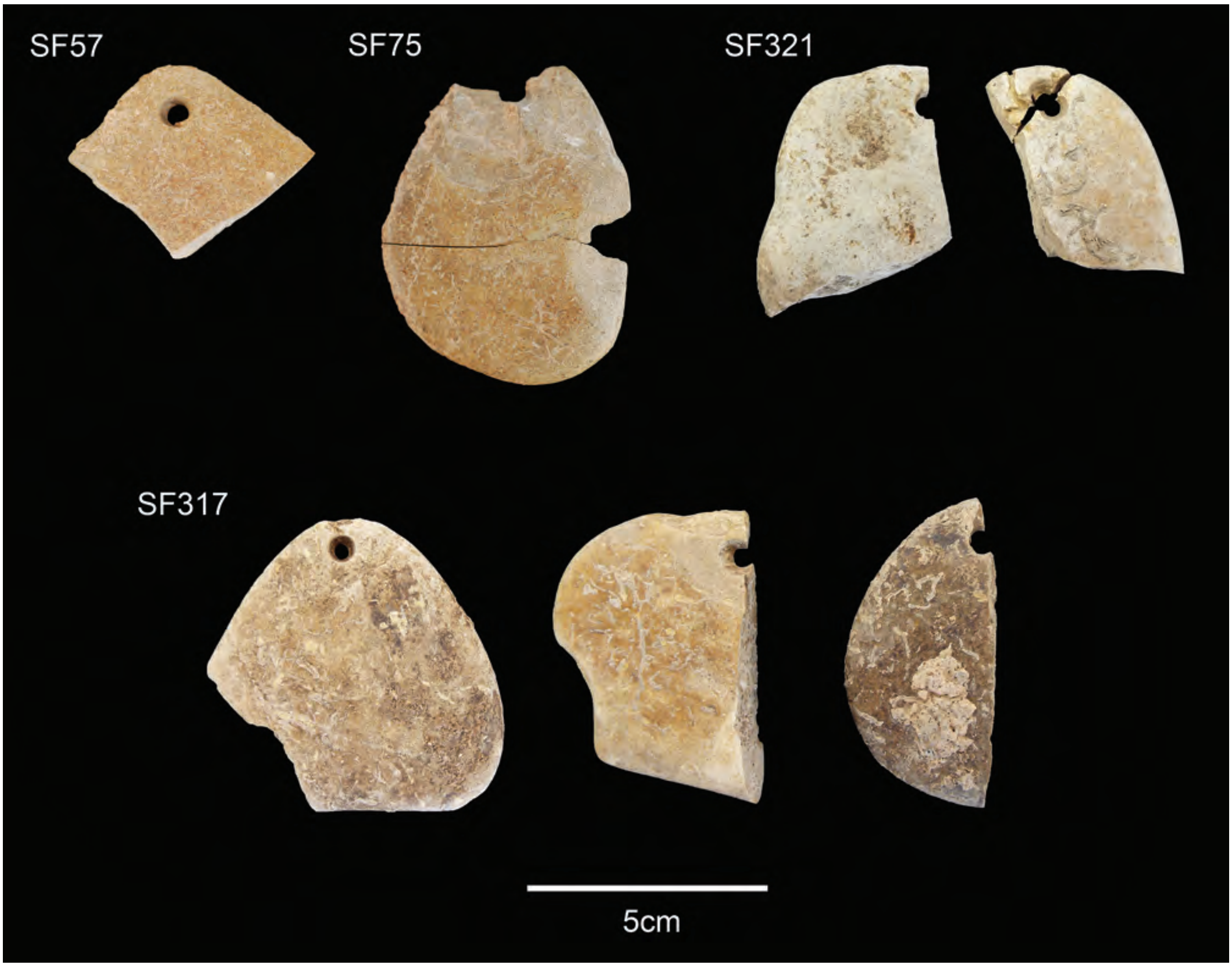


Figure 21.13. Stone net sinkers from Bestansur.

Figure 21.14. Stone bowls from Bestansur.

Figure 21.15. Incised boulder SF357 from Bestansur (see also Figs 20.53 and 22.14–22.16).

in Sp50, in C1781 alongside human remains and the clay figurine SF532. Unlike those at Shimshara, this straight-sided vessel would have extended down to a flat base, comparable with Kozlowski and Aurenche's (2005) Type 3.2.2, with 1cm thick walls. These vessels occur at a small number of sites throughout the Early Neolithic and are seen in the early levels at Jarmo (Adams 1983: 210, Type A). Fragments of limestone bowls were also found either within or directly outside buildings at Bestansur, including stone bowl SF444 from T13, immediately to the east of B7, stone bowl SF167 in B3 T7 and a further large limestone bowl fragment within the collections of ground stone in B3 Sp16, possibly indicating an intention to repurpose the material.

Stone tools

The placement of a deeply scored stone SF357 at the entrance to Building 5, Sp40, is testament to the importance of the juxtaposition of everyday objects to create meaning (Fig. 21.15). Framing the entrance to the building in conjunction with unworked stones, the boulder may have been used as a leather worktable (Chapters 9 and 22). The 27kg boulder would have been heavy to move and it may have been used for craft practices in the wide entrance to this building, perhaps relating to the preparation of materials for use within B5.

Tools manufactured from carefully selected stones, such as three alabaster, one grey marble, and one black marble with white seams (SF188), were not deposited with such care at Bestansur. The five small pecking tools (Fig. 20.14), possibly used for the retouch of chipped stone (Chapter 20), were found in Trench 7 (SF16), Trench 10 (SF25, SF326, SF639) and Trench 12 (SF188). Discarded in external spaces outside buildings, three of the tools have perforations for mounting on a handle: SF25 is perforated along the shaft, whereas both SF188 and SF639 have perforations running both along and perpendicular to the shaft. SF16 has a flattened edge, perhaps for binding to a mount and SF326 nestles comfortably in the hand.

Adornments

Two hundred and eleven clay, shell and stone SFs classified as Neolithic 'adornments' were catalogued over the course of five seasons at Bestansur (Table 21.3), including two bracelets and four cowrie shells. These objects are selected for evidence of decorative function. Bodily adornment would not have been restricted to these items, and the community at Bestansur may have decorated their bodies in myriad ways, including clothing, hair, tattoos and forms of body modification, that are not evident in the archaeological record. Furthermore, tools and functional items may have been worn on the body, and adornments may have been used to decorate textiles and objects. For the purposes of this chapter, decorative items included under the adornment categorisation are decorative shells and shell beads, stone beads and bracelets. SF numbers have been assigned to beads and groups of beads depending on whether they were found individually or clustered together; the 202 SF numbers assigned to Neolithic beads represent 553 individual beads.

Shell adornments

The four cowries were all recovered from Grid Square E in Sp50, in close proximity to two sets of juvenile skeletal remains in the packing below the floors (Fig. 21.16; Chapters 9 and 19). SF468 and fragmentary SF470 were recovered close to the skull of C1731 SK1, SF600 was close to the skull of C1812 SK8, and fragmentary SF590 was recovered from packing

Table 21.3. (continued overleaf) Adornments from Bestansur.

T	*Sp*	*C*	*SF*	*Item*	*Material*	*L (mm)*
1	58	1011	19	Bead	Calcite	5
2	5	1024	56	Bead	Shell	7
2		1036	53	Bead	Shell	5
5		1074	8	Bead	Limestone	6
5		1074	12	Bead	Limestone	6
7	16	1222	74	Bead	Crab claw	13
7	16	1243	84	Bead	Limestone	8
7	18	1221	99	Bead	Shell	5
7	22	1223	63	Bead	Limestone	7
7	22	1223	65	Bead blank	Serpentine	9
7	22	1223	100	Bead blank	Clay	23
7		1211	48	Bead	Limestone	7
7		1217	54	Bead	Limestone	8
7		1217	72	Bead	Shell	6
9	28	1152	18	Bead	Clay	5
9	28	1305	182	Bead	Limestone	8
9	28	1307	236	Bead	Shell	5
9	28	1333	207	Bead	Shell	6
9	28	1350	255	Bead	Stone	6
10	27	1772	563	Bead	Marble	4
10	27	1772	567	Bead	Stone	5
10	27	1772	652	Bead	Alabaster	15
10	50	1621	436	Bead	Dentalium	26
10	50	1621	437	Bead	Limestone	8
10	50	1623	385	Beads	Shell	4–6
10	50	1623	451	Bead	Chalcedony	20
10	50	1625	377	Beads	Shell, stone	2–20
10	50	1625	384	Beads	Shell, stone	3–6
10	50	1625	443	Bead	Dentalium	20
10	50	1625	447	Bead	Stone	4
10	50	1625	448	Bead	Dentalium	21
10	50	1625	454	Beads	Shell, stone	3–7
10	50	1625	489	Bead	Shell	6
10	50	1714	463	Beads	Shell	6
10	50	1729	469	Bead	Clay	17
10	50	1731	467	Beads	Shell	6
10	50	1731	468	Cowrie	Shell	24
10	50	1731	470	Cowrie	Shell	24
10	50	1731	471	Bead	Stone	6
10	50	1746	541	Bead	Stone	4
10	50	1775	536	Bead	Shell	6
10	50	1775	540	Bead	Stone	3
10	50	1775	546	Beads	Shell, stone	3–8
10	50	1775	549	Beads	Shell	6
10	50	1775	552	Bead	Crab claw	9
10	50	1780	531	Bead	Shell	6
10	50	1780	551	Bead	Shell	6
10	50	1781	539	Bead	Variscite	10
10	50	1781	542	Beads	Stone	1
10	50	1781	543	Bead	Stone	1
10	50	1781	545	Beads	Stone	1
10	50	1781	550	Beads	Shell, stone	3–9
10	50	1784	569	Beads	Stone	3
10	50	1803	561	Beads	Shell, stone	1–6
10	50	1803	564	Beads	Shell, stone	5
10	50	1803	570	Beads	Shell	5
10	50	1803	590	Cowrie	Cowrie	31
10	50	1803	591	Bead	Stone	3
10	50	1803	592	Bead	Shell	5
10	50	1803	593	Bead	Shell	5
10	50	1803	595	Bead	Shell	5
10	50	1803	596	Bead	Shell	5
10	50	1803	597	Bead	Shell	5
10	50	1803	598	Bead	Shell	5
10	50	1803	599	Bead	Shell	5
10	50	1803	601	Bead	Shell	5
10	50	1803	603	Bead	Shell	5
10	50	1803	605	Bead	Shell	5
10	50	1803	606	Bead	Shell	5
10	50	1803	607	Bead	Shell	5
10	50	1803	610	Bead	Shell	5
10	50	1803	611	Bead	Shell	5
10	50	1803	612	Bead	Shell	5
10	50	1803	613	Bead	Shell	5
10	50	1803	614	Bead	Shell	5
10	50	1803	615	Bead	Shell	5
10	50	1803	616	Bead	Shell	5
10	50	1803	617	Bead	Shell	5
10	50	1803	618	Bead	Shell	5
10	50	1803	619	Bead	Shell	5
10	50	1803	620	Bead	Shell	5
10	50	1803	621	Bead	Shell	5
10	50	1803	622	Bead	Shell	5
10	50	1803	623	Bead	Dentalium	20
10	50	1803	624	Bead	Stone	5
10	50	1803	625	Bead	Shell	5
10	50	1803	626	Bead	Shell	5
10	50	1803	627	Bead	Shell	5
10	50	1803	628	Bead	Shell	5
10	50	1803	629	Bead	Shell	5
10	50	1803	641	Bead	Shell	5
10	50	1803	642	Bead	Shell	5
10	50	1803	643	Bead	Shell	5
10	50	1803	644	Bead	Stone	5
10	50	1803	645	Bead	Shell	5
10	50	1811	560	Beads	Shell	5
10	50	1811	565	Beads	Shell, stone	5
10	50	1811	589	Bead	Shell	5
10	50	1811	594	Bead	Shell	5
10	50	1811	600	Cowrie	Cowrie	18
10	50	1811	609	Bead	Shell	5
10	50	1811	630	Bead	Stone	11
10	50	1811	632	Bead	Shell	5
10	50	1821	571	Beads	Stone	3
10	50	1853	660	Bead	Carnelian	7
10	50	1853	661	Bead	Shell	8
10	50	1853	667	Bead	Stone	6
10	50	1853	670	Bead	Shell	7
10	50	1853	689	Bead	Shell	5
10	50	1853	695	Bead	Shell	6
10	50	1853	696	Bead	Stone	4
10	50	1857	668	Bead	Crab claw	5
10	50	1857	687	Bead	Shell	10
10	50	1857	688	Bead	Shell	12
10	50	1863	671	Bead	Stone	1
10	50	1863	692	Bead	Shell	6

Table 21.3. (continued from previous page) Adornments from Bestansur.

T	*Sp*	*C*	*SF*	*Item*	*Material*	*L (mm)*
10	50	1863	693	Beads	Stone	3
10	50	1863	701	Bead	Stone	1
10	50	1863	703	Bead	Shell	5
10	50	1863	704	Bead	Shell	4
10	50	1863	741	Bead	Stone	3
10	50	1863	763	Bead	Stone	2
10	50	1866	690	Beads	Shell	5
10	50	1866	691	Beads	Stone	2
10	50	1866	697	Beads	Shell, stone	5
10	50	1866	698	Bead	Shell	6
10	50	1868	699	Bead	Stone	3
10	50	1868	705	Beads	Stone	1
10	50	1868	706	Beads	Shell, stone	2
10	50	1868	715	Bead	Shell	7
10	50	1868	718	Bead	Shell	6
10	50	1868	719	Bead	Stone	3
10	50	1868	721	Bead	Shell	5
10	50	1868	722	Bead	Chalcedony	30
10	50	1868	723	Bead	Stone	5
10	50	1868	724	Bead	Shell	6
10	50	1868	725	Bead	Shell	5
10	50	1868	726	Bead	Stone	6
10	50	1868	727	Bead	Shell	7
10	50	1868	729	Bead	Shell	7
10	50	1868	732	Bead	Stone	3
10	50	1868	736	Bead	Shell	7
10	50	1868	737	Bead	Shell	7
10	50	1868	738	Bead	Shell	7
10	50	1868	739	Bead	Shell	7
10	50	1868	740	Bead	Shell	6
10	50	1868	742	Bead	Stone	4
10	50	1868	744	Bead	Shell	7
10	50	1868	745	Bead	Stone	3
10	50	1868	748	Bead	Stone	6
10	50	1868	749	Bead	Stone	7
10	50	1868	750	Bead	Shell	6
10	50	1868	751	Bead	Shell	7
10	50	1868	752	Bead	Shell	7
10	50	1868	753	Bead	Shell	6
10	50	1868	754	Bead	Shell	8
10	50	1868	756	Bead	Shell	7
10	50	1868	757	Bead	Stone	7
10	50	1868	758	Bead	Stone	5
10	50	1868	759	Bead	Stone	7
10	50	1868	760	Bead	Shell	6
10	50	1868	761	Bead	Shell	7
10	50	1868	766	Bead	Stone	6
10	50	1876	673	Bead	Shell	6
10	50	1876	674	Bead	Shell	7
10	50	1876	675	Bead	Shell	6
10	50	1876	677	Bead	Shell	6
10	50	1876	678	Bead	Stone	1
10	50	1876	679	Bead	Shell	7
10	50	1876	682	Bead	Shell	6
10	50	1876	683	Bead	Shell	6
10	50	1876	684	Bead	Shell	6
10	50	1876	743	Bead	Stone	4
10	50	1880	767	Bead	Stone	4
10	50	1882	709	Beads	Shell, stone	6
10	50	1882	728	Bead	Shell	7
10	50	1882	730	Bead	Stone	3
10	50	1882	731	Bead	Shell	6
10	50	1882	733	Bead	Shell	6
10	50	1882	734	Bead	Shell	6
10	50	1882	735	Bead	Shell	7
10	50	1882	755	Bead	Shell	6
10	50	1884	765	Bead	Stone	
10		1161	71	Bead	Limestone	7
10		1312	187	Bracelet	Alabaster	30
10		1315	205	Bead	Limestone	5
10		1700	460	Bead	Stone	8
12		1372	250	Beads	Stone	4-7
12		1470	286	Bead	Clay	4
12		1482	211	Bead	Shell	6
12		1514	340	Bead	Stone	3
12		1514	341	Bead	Stone	3
12		1523	330	Bead	Stone	3
12		1523	346	Bead	Stone	4
12		1524	347	Bead	Stone	3
12		1526	348	Bead	Stone	3
12		1526	349	Beads	Stone	3-4
12		1526	350	Bead	Shell	3
12		1526	362	Bead	Stone	4
12		1528	336	Bracelet	Alabaster	19
12		1528	355	Bead	Stone	3
12		1528	360	Beads	Stone	3
12		1528	375	Bead	Stone	4
12		1528	376	Beads	Stone	3-4
12		1529	374	Bead	Stone	4
13	24	1521	492	Bead blank	Crab claw	5
13		1378	300	Beads	Stone	3
13		1384	251	Beads	Stone	3-4
13		1515	315	Bead	Variscite	7
13		1575	328	Bead	Carnelian	17
13		1577	356	Bead	Stone	4

between the two deposits. Each cowrie had been cut, with the dorsum deliberately removed and with bitumen sediments in the rear or teeth of the shell. The cowries are type *Cypraea monetaria moneta* or *monetaria annulus* (likely the former), both of which are common to the Red Sea and Persian Gulf rather than the Mediterranean (Moorey 1999: 131). Cowries are included here in the adornment category based on

Figure 21.16. Cowries found associated with burials in Sp50 B5 at Bestansur.

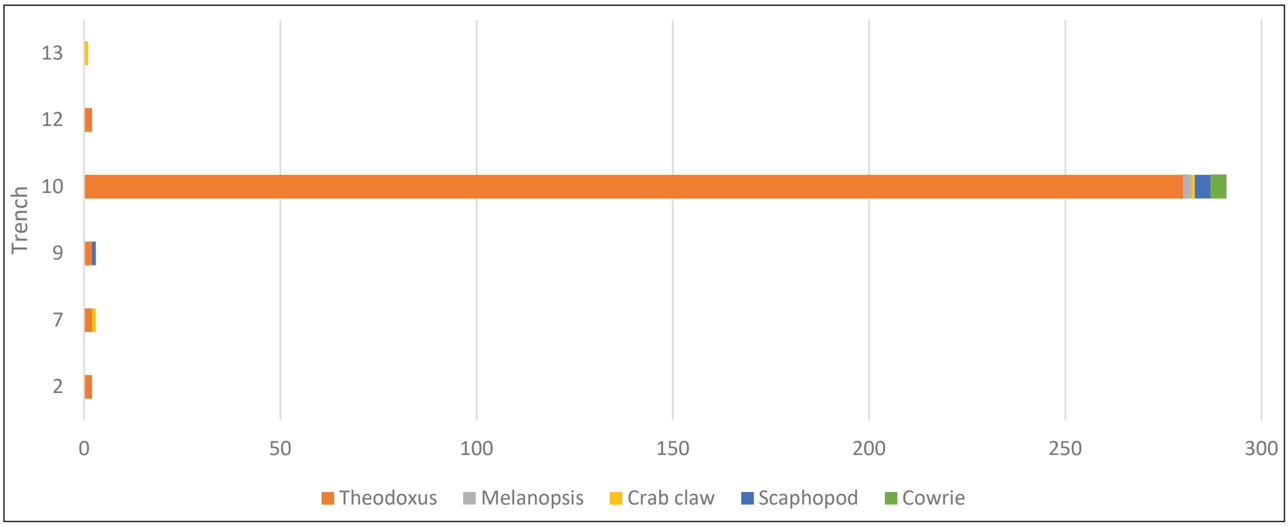


Figure 21.17. Shell bead assemblage by trench at Bestansur.

evidence for deliberate perforation at the terminals of at least two examples, which was subsequently covered by bitumen residues.

The presence of bitumen on the cowries indicates their adhesion to another material, rather than being strung, although they were found in contexts with abundant stone and shell beads. They may have been attached to a perishable material related to the final inhumation of the remains, although they could have served as bodily adornments or beads earlier in their object biographies. The cowrie fragment SF590 bears the labial teeth, whereas SF470 represents the columellar teeth, and these two halves may belong to the same shell. Further supporting this likelihood, SF590 shares the fracture at the anterior canal and retains the spire, which is absent from SF470, making the former a little longer than its counterpart. Two halves of the same cowrie could have been used and displayed separately, although the uneven break surface does not suggest any smoothing or modification to serve this purpose.

The fixative on SF468 and SF470 is comparable with that found on the bone sickle haft and sickle blades (Chapter 20, Fig. 20.33), characterised by elevated readings in the balance of light elements detected using the pXRF spectrometer, reflective of the bitumen C_6H_6 compound. Depleted aluminium values distinguish the residues from the common soil compositions, and sulphuric values are elevated to between 30,000 and 100,000 parts per million (3–10%). This attribute is in keeping with the Mesopotamian bitumens, which vary between 3% and 8% sulphur. Numerous surface deposits and outcrops lie between Tigris and the Zagros mountains (Forbes 1936: 20), and a bituminous stone was identified in Trench 10 (Chapter 22).

Cowrie shells have not been found in any other Neolithic contexts at Bestansur but adornment with shell beads is common; 280 beads made from perforated *nerita* shells, *Theodoxus jordani,* were recorded at the site (51% of the total bead assemblage; Fig. 21.17). The beads are each perforated either once or twice by the apex, allowing a cord to pass through the apex and the aperture or to be suspended from the apex. On all the shell beads, the ovoid perforations are worn smooth.

In the shell bead assemblage, five scaphopod shells and four crab claw beads have been recorded (Fig. 21.18). Freshwater crab and small nerites would have been readily available from the local water course fed by the spring, but the scaphopod shells (also known as tusk shells or 'dentalium') belong to marine creatures and potentially travelled long distances prior to their deposition on site. Marine shells were transported by mobile groups and exchanged over vast distances from the Epipalaeolithic (Bar-Yosef Mayer 2005), contributing to the intricate network of social relations that connected Neolithic communities (Richter *et al.* 2011). Scaphopods are distributed throughout the Mediterranean, the Red Sea and the Persian Gulf (Moorey 1999: 131). These beads are particularly difficult to identify to species, as only five well-worn, white tusk shells were recovered. Furthermore, scaphopods bear little morphological change over time, and fossilised scaphopods are known to have been used at Neolithic sites such as Belo Brdo in Serbia, where they were collected from a Middle Miocene outcrop (Dimitrijević 2014). Based on the thickness of the walls, the degradation of the morphology and the opacity of the scaphopods at Bestansur, it is possible that these marine shells were gathered from a fossiliferous deposit. The 'dentalium' beads from Epipalaeolithic levels at Karim Shahir were suggested to have come from rock formations in this area of the Zagros rather than from marine sources (Howe 1983: 48, 100).

The crab claws were prepared by trimming the ends to form a shape similar to the natural scaphopod tusk-shaped shells. Evidence for the local working of the crab claws, which are comparable with the crab species inhabiting the river in modern times (Chapter 15), can be seen in the fragments: SF74, SF492 and SF552. However, the four tusk beads from clustered human remains in Sp50, C1621 and C1625, appear to be marine scaphopod, rather than the local crab claw variant, with working cuts to the surface of SF436 and SF448.

One further species of freshwater mollusc has been identified in the shell bead assemblage, in two examples of *Melanopsis* SF687 and SF688, from the room fill above the floor of Sp50, C1857, found with crab claw bead SF668. Each shell had been perforated once. An increase in the frequency of *Melanopsis nodosa* at Abu Hureyra has been attributed to the collection of river mud for the construction of mud-brick architecture, although only three of the 80 examples had been perforated (Ridout-Sharpe 2015).

Stone beads

The finds in Space 50 are exceptional in comparison to the concentrations seen elsewhere across the site. The clean floor deposits are starkly contrasted with the relatively rich artefactual materials buried beneath the floors with the human remains. Of the 553 beads recorded at Bestansur, 470 (85%) were found in Space 50, including 274 shell beads, 185 tiny stone disc and cylinder beads, crab, clay and limestone, as well as less common minerals such as variscite, chalcedony and carnelian. Although the beads were recovered in groups, they were scattered throughout the under-floor interments, indicating repeated episodes of activity associating strings of beads with the dead. The stone disc and cylinder beads (Fig. 21.19) are not found in any other spaces of Trench 10, in contrast with their prevalence in Trenches 12 and 13, where the 53 beads are scattered throughout the external deposits adjacent to, and to the south of, Building 7. These beads make up a further 10% of the total bead assemblage, highlighting how concentrated the distributions of adornments are at Bestansur.

A feature common to both the trenches to the north (Trenches 12 and 13) and east (Trench 10) of the mound is the presence of adornments of exceptional materials, not locally available and therefore transported to site from considerable distances. Obsidian has provided an insight into the movement of quantities of raw materials between groups spread out across the Fertile Crescent (Chapter 20), but these sparse examples of unusual materials record a broader network of movement and exchange, their social significance asserted by their rarity, their deposition in contexts of cultural activities and inclusion specifically with other extraordinary objects. Three different examples of carnelian occur in Trench 13 and Trench 10. Lozenge-shaped bead SF328 (Fig. 21.20) is a light, translucent pale orange colour, with a perforation drilled from both ends of the length, visible through the material. Highly polished flat bead SF651 is made from a semi-opaque vibrant orange-red carnelian. Smaller

Figure 21.18. Shell beads from Bestansur: Theodoxus jordani (SF560), scaphopod (SF436, SF448), crab claw (SF74, SF552, SF668) and Melanopsis (SF687, SF688).

flat bead SF660, is made from a translucent orange-brown carnelian with lenticular section, associated with infant remains cut into the packing below the floors of Sp50 in B5.

Two further examples from Sp50 are made from chalcedony: SF451 and SF722 (Fig. 21.20) are perhaps better characterised as red jasper, a dark red, opaque variety of chalcedony. Both examples are shaped as large 'flat' or 'tabular' type beads, commonly seen across the Fertile Crescent in the eighth millennium BC, comparable to examples from Jarmo and Nevalı Çori (Kozlowski and Aurenche 2005: fig. 5.1.1). Unlike the carnelian examples, the chalcedony beads both show signs of conchoidal fracture around the worked terminals and SF722, found in a large mixed burial group C1868, has a crude and rough finish with striations marring the surface. The larger bead size and cruder finish suggest the chalcedony beads were

Figure 21.19. Stone disc and cylinder beads from Bestansur.

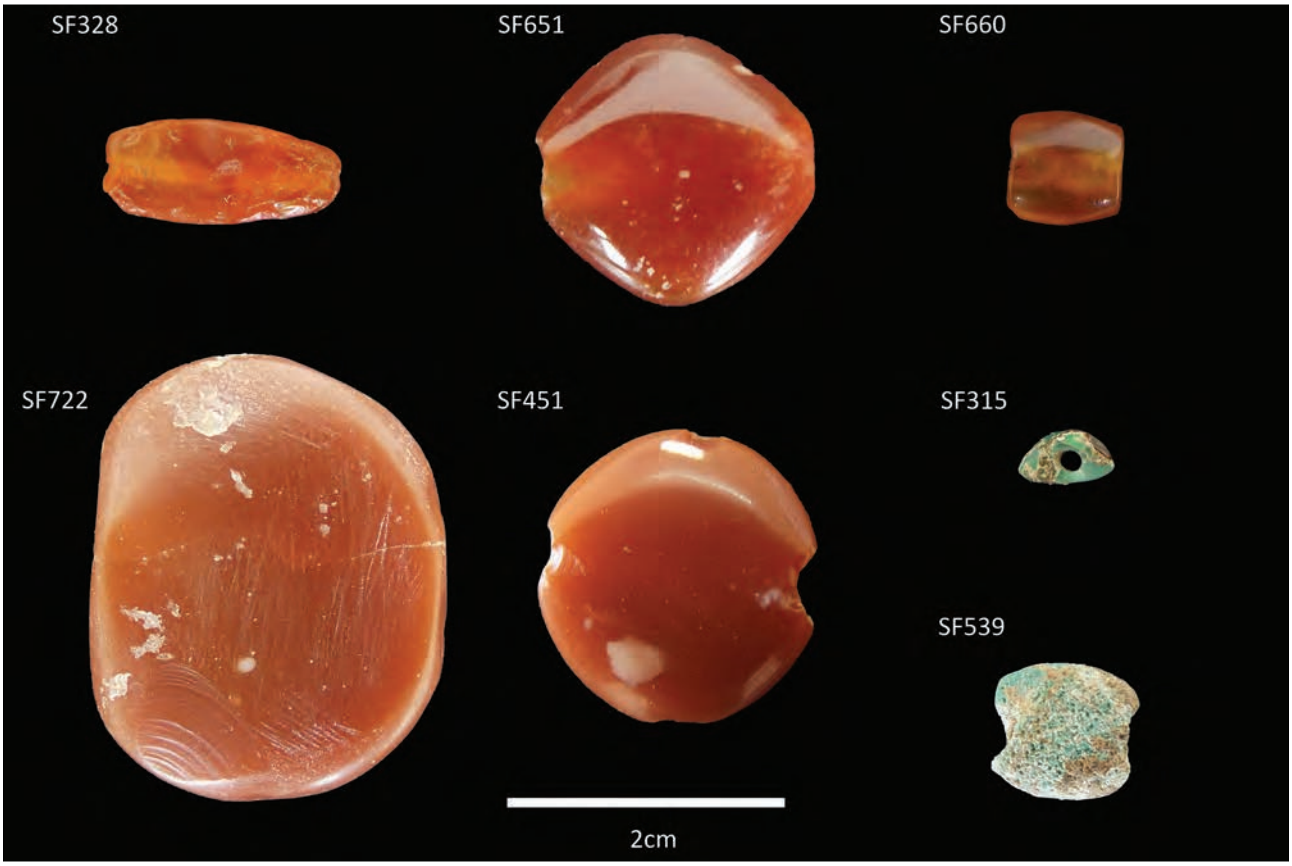


Figure 21.20. Beads made from carnelian (SF328, SF651, SF660), chalcedony (SF451, SF722) and variscite (SF315, SF539) from Bestansur.

not produced to the high standard and curated in the same way as the small carnelian variants, although their deposition was ultimately the same.

A similar source to the carnelian may be posited for the variscite bead SF539 from Sp50 B5 (Fig. 21.20), and for SF315 in T13. The material used to make the green, flat bead SF539 is distinguished by its high levels of phosphorous and aluminium. The common

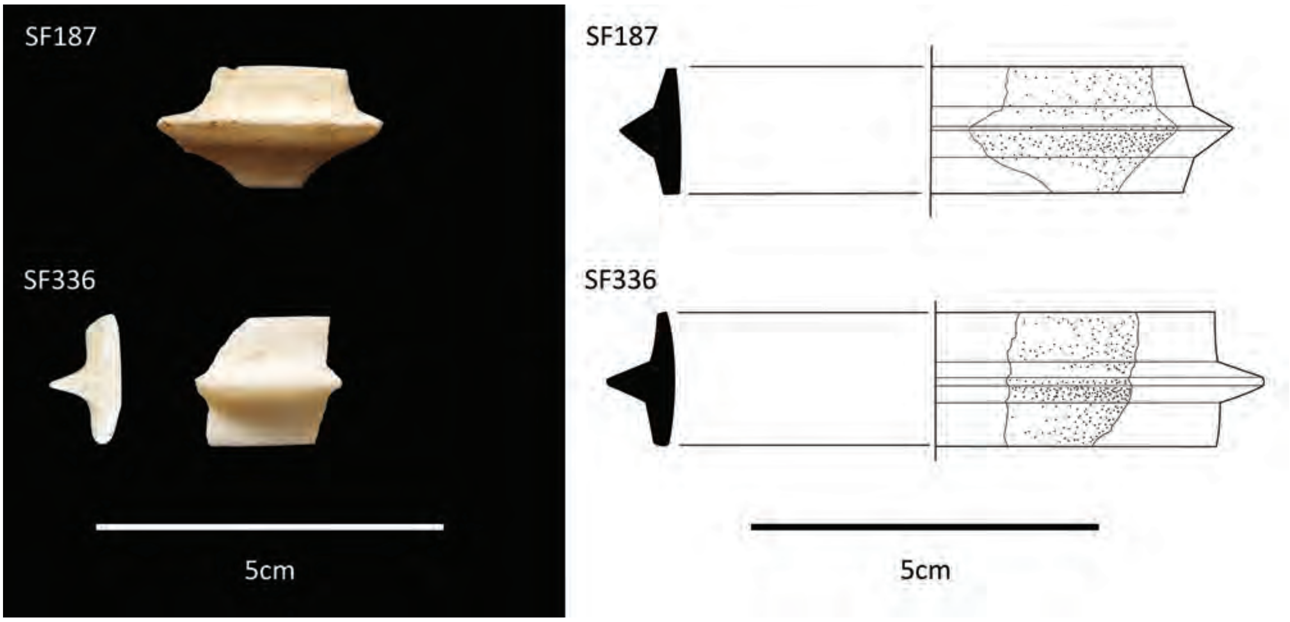


Figure 21.21. Alabaster flanged bracelets, SF187 and SF336, from Bestansur.

seams of crandallite are most pronounced in SF315, a short variant of the flat bead.

In contrast with the exotic materials in Trench 10 and Trenches 12 and 13, the assemblage from Trench 7 to the west of the mound represents a very different set of materials. Red beads are substantially larger and made from a coarse pink-red limestone (SF48, SF54, SF63, SF83), white beads are made from crab claw rather than marine shell (SF74) and even the 'exotic' materials are locally sourced, in the form of SF65, a serpentine green-brown bead blank, likely from the Penjwin complex less than 50km from the site. The only bead type in common with the northern and eastern trenches are the nerite shell beads, which may be directly from the spring adjacent to the settlement. Trench 9, the open working area to the south of the tell, contained a combination of limestone cylinder beads and white nerite beads, as well as a single tiny red bead and an orange clay bead (SF18), possibly intended to imitate the stone disc beads. A similar clay bead mirroring the proportions of the red stone beads was found in Trench 13 (SF286). A single clay bead, biconical in shape, came from Trench 10 (SF469).

Bracelets

Only two examples of bracelets have been found thus far at Bestansur, both calcite alabaster with a lenticular section and protruding flange: SF187 from the upper levels of Trench 10 and SF336 from Trench 12 (Fig. 21.21). Early, simple marble bracelet forms are known from the Central Zagros at Karim Shahir and Palegawra (Braidwood and Howe 1960), with later, complex forms from Jarmo (Moholy-Nagy 1983). Bracelets with a complex profile are known from Central Anatolia to Deh Luran (Kozlowski and Aurenche 2005). Examples of bracelets with a protruding flange from Cafer Höyük (Maréchal 1985) and Aşıklı Höyük were produced in a range of materials, including marble, basalt and obsidian. The closest parallels for the shape of the Bestansur examples are an obsidian example from the contemporary site of Aşıklı Höyük in Cappadocia (Astruc *et al.* 2011), and a white marble example from early seventh millennium BC Tell Maghzaliyah (Bader 1993: fig. 2.25.23), on the flanks of the Sinjar Mountains. Tribological analysis of the production methods required to achieve this form has demonstrated the complexity of the morphologies, attributing the capability of producing these forms to eastern Anatolia (Astruc *et al.* 2011). It is possible that these adornments were carried from this region to the site at Bestansur through established obsidian routes. But the argument that so-called Çayönü tools of obsidian may have been used in the manufacture and polishing of flanged alabaster bracelets (Chapter 20) suggests that high-quality stone bracelets were manufactured, or at least finished, at the destination sites, including Bestansur.

Worked bone tools

A total of 98 Neolithic worked bone tools and fragments were identified and recorded at Bestansur (Table 21.4). Only a small quantity of worked bone was assigned SF numbers in the field, with the majority identified by the zooarchaeology specialist. All worked bone has been incorporated into the zooarchaeology database and assigned Bone ID numbers accordingly (Chapter 15). The distribution of these artefacts was limited to Trenches 9, 10, 12 and 13, with the exception of a single bone peg from Trench 1. High levels of worked bone in Trench 10

Table 21.4. Worked bone objects from Bestansur.

T	*Sp*	*C*	*SF*	*Item*	*L (mm)*
1	2	1007	6	Peg	16
9	28	1309	189	Peg	32
9	28	1339	254	Discard	30
9	28	1339	265	Discard	20
9	28	1344	270	Fragment	27
9	28	1347	345	Fragment	56
9	28	1350	271	Fragment	24
9	28	1350	401	Fragment	16
9	28	1356	344	Needle	15
9	28	1357	262	Needle	51
9	28	1357	353	Fragment	29
9	28	1357	354	Fragment	24
9	28	1364	295	Fragment	23
10	27	1413	266	Fragment	14
10	27	1413	267	Spatula	16
10	27	1752	506	Needle	6
10	29	1330	237	Point	47
10	29	1330	238	Point	91
10	29	1330	240	Fragment	31
10	29	1331	243	Fragment	40
10	29	1331	244	Needle	20
10	29	1331	245	Needle	83
10	29	1331	280	Needle	16
10	29	1402	282	Fragment	25
10	29	1402	283	Needle	18
10	29	1405	249	Point	40
10	29	1405	324	Spatula	19
10	29	1405	325	Spatula	12
10	29	1409	256	Discard	30
10	29	1409	259	Discard	60
10	29	1409	260	Discard	45
10	29	1409	343	Discard	33
10	29	1409	364	Shaft	40
10	29	1409	365	Discard	36
10	29	1412	269	Point	97
10	29	1412	338	Point	34
10	29	1412	339	Shaft	34
10	29	1412	394	Fragment	20
10	29	1412	395	Fragment	22
10	29	1412	396	Discard	42
10	29	1414	287	Discard	26
10	29	1414	288	Point	52
10	29	1414	289	Fragment	35
10	29	1414	290	Fragment	21
10	29	1414	291	Discard	43
10	29	1414	294	Peg	27
10	40	1539	383	Discard	54
10	40	1539	404	Point	27
10	40	1539	406	Shaft	40
10	40	1539	407	Shaft	30
10	40	1539	409	Piercer	27
10	40	1539	417	Shaft	30
10	43	1730	514	Haft	41
10	44	1739	505	Spatula	8
10	44	1743	502	Needle	8
10	44	1743	508	Needle	84
10	44	1743	515	Discard	26
10	44	1755	547	Discard	23
10	47	1620	435	Spatula	23
10	50	1731	504	Fragment	11
10	50	1733	472	Spatula	36
10	50	1831	647	Shaft	15
10	52	1720	503	Fragment	55
10	52	1721	496	Fragment	53
10	52	1721	497	Fragment	50
10	53	1756	483	Needle	37
10	53	1756	484	Needle	18
10	53	1758	548	Shaft	55
10	53	1763	544	Point	47
10	60	1742	501	Piercer	24
10		1165	173	Point	24
10		1317	197	Peg	33
10		1317	198	Shaft	46
10		1317	199	Spatula	37
10		1317	203	Peg	22
10		1538	363	Shaft	63
10		1538	398	Shaft	31
10		1538	399	Shaft	50
10		1538	400	Point	32
10		1538	402	Needle	10
10		1546	418	Needle	20
10		1554	420	Fragment	6
10		1606	419	Needle	8
10		1719	465	Shaft	41
12		1388	279	Needle	17
12		1523	331	Needle	7
12		1523	403	Needle	34
12		1525	379	Needle	7
12		1526	361	Needle	15
12		1528	367	Point	70
12		1528	415	Shaft	64
12		1528	421	Needle	19
13	24	1521	488	Polisher	40
13	24	1521	490	Polisher	21
13	24	1521	491	Polisher	28
13	45	1580	416	Shaft	26
13		1386	292	Point	105
13		1520	318	Needle	86

were noted during excavation, particularly in the external spaces to the southwest of Building 5. Trench 10 accounts for more than 72% of the worked bone assemblage from the site.

All bone with evidence of deliberate modification was flagged for small finds analysis and, thus, the worked bone includes finished tools, fragments of tools and manufacture discard, although those simply bearing butchery scars have been excluded. The incorporation of manufacture discard and working debris demonstrates that concentrations of bone-working activity took place in the vicinity of both Trenches 9 and 10 (Fig. 21.22). Fifty percent of the worked bone from across the site was located in the later levels of the areas immediately adjacent to the entrance of Building 5. The manufacture of bone tools was restricted to external working areas, however, as the absence of any working materials from Trenches 12 and 13 and from the buildings in Trench 10 highlights. Butchery debris is relatively common in the external spaces of Trench 10 and in Trench 9, suggesting that the selection of bones for tools took

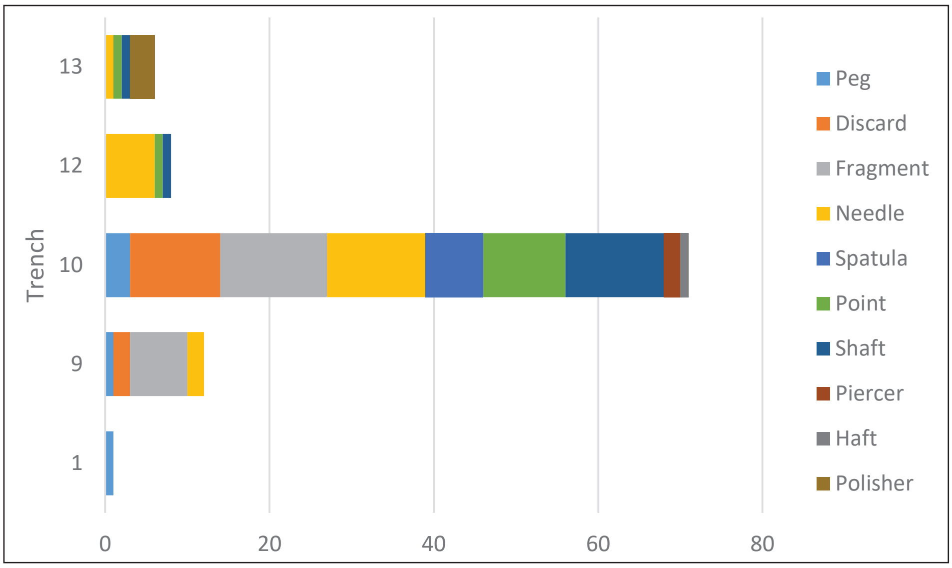


Figure 21.22. Bone tool types by trench at Bestansur.

place as a response to availability and did not appear to involve the movement of the required materials to a specialist working area. The tools produced by these activities demonstrate a range of work undertaken across the different areas of the site: an abundance of specifically needles, points and polishers appear in the domestic contexts of Trench 12/13 whereas a wide range of tools occur in Trench 10.

Tool categorisation has developed on the basis of the protocols applied to the study of materials from Sheikh-e Abad and Jani (Russell 1995; 2005; Cole *et al.* 2013), to ensure comparability between CZAP sites. Fragments too small to identify to a tool type have been incorporated, as have broken shafts that may represent any of a number of tool types. Manufacture discard has been identified as the unpolished, unfinished, unusable segments that have been removed in the course of tool manufacture, most often bearing saw-and-snap scars.

Two worked bone artefact types are notably absent from the assemblage: shaft straighteners and beads. The former is equally highlighted in the ground stone assemblage (Chapter 22). The saw-and-snap scars are most frequently on the distal metapodials of goat/sheep and gazelle (Chapter 15), and could relate to bone bead making although no examples of bone beads have thus far been recovered at Bestansur.

The average length of worked bone artefacts recorded from Bestansur is 33mm, indicating a highly fragmented assemblage. Very few of the artefacts remain fully intact or complete. This contrasts starkly with the preservation of finds from Sheikh-e Abad (average length: 59mm). However, the recording methodology applied at the site has deliberately targeted the inclusion of off-cuts, fragments and working debris, as has been applied at Shimshara, a site with notably good preservation, where the average length of worked bone fragments is 36mm. Evidence for bone tool working appears to intensify in the later levels at the site, although the nature of activities in these external areas remains consistent and may reflect changing practices in the cleaning of external spaces rather than the extent to which these activities took place.

Discounting the unidentifiable fragments and shaft fragments, the most common bone tool types occurring at Bestansur are needles (n=21) and points (n=12). Thirteen fragments of bone working debris were also identified, indicating a high proportion of on-site working activity. Only small numbers of spatulas, pegs and polishers were recovered, and a single fragment of a bone haft (SF514; Fig. 20.33). The sickle haft was recovered from the south section of Trench 10. The area to the south of Building 5 yielded 22 of the 105 sickle blades recorded at Bestansur, including sets of up to four blades made from the same chert and likely hafted together (C1422). Many of these blades bore traces of sickle sheen along one edge and dark residues along the other (Chapter 20). The testing of these residues identified the presence of bitumen, used as a hafting fixative. Embedded into a straight-sided groove, cut into the cattle-sized long bone fragment, a black residue also proved to be bitumen, chemically comparable with that adhering to the sickle blades themselves. The presence of more than 100 sickle blades and evidence for only one haft may represent the rarity of bone hafts used at Bestansur, where perishable materials, such as wood, were more frequently selected (for a detailed review of sickle technology in Neolithic Southwest Asia, see Healey 1988).

Small Finds from Shimshara

During two short seasons of investigations at

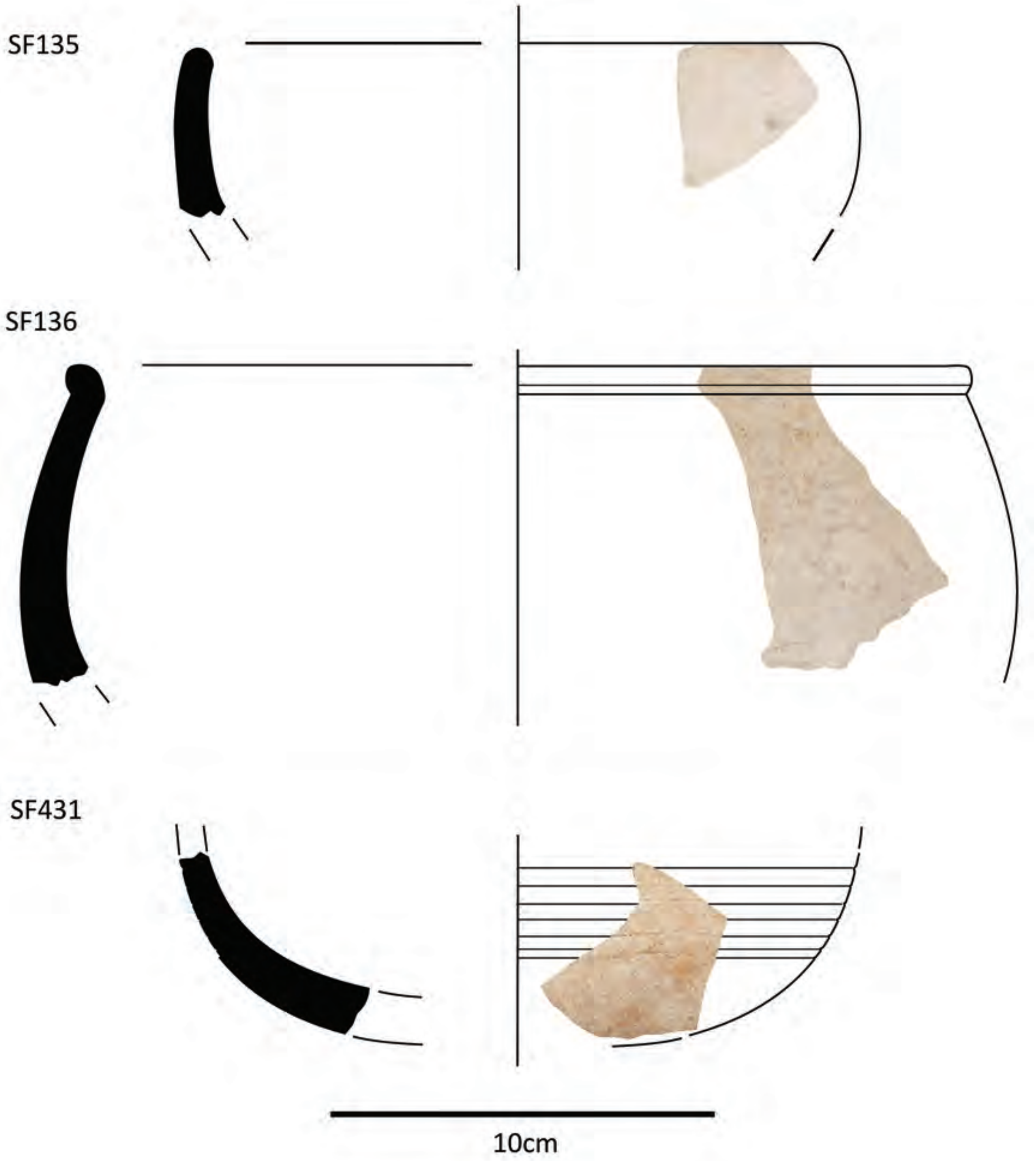


Figure 21.23. Stone bowls from Shimshara.

Shimshara, 46 artefacts were assigned SF numbers, including one post-Neolithic clay artefact, 23 objects made from stone (Table 21.5) and 22 worked bone fragments (Table 21.6). Amongst these is a remarkable collection of 12 fragments of marble bracelets, found widely spread across the Neolithic occupation phase of the site, during section cleaning and in both the excavated trenches.

Stone tools, vessels and adornments

There have been no Neolithic clay artefacts recovered in the two seasons of interventions at Shimshara and, although no clay tokens have been identified, two small stone pebbles of equal size (SF439) were recorded in Trench 1. One further limestone ball from Trench 2 (SF440) is heavily pitted and may have served as a hammer-stone. A small, grey stone, pointed polisher or piercer (SF430; comparable with Mortensen 1970: 52–53, fig. 42p) indicates some stone-working activity taking place onsite, although no other material found thus far indicates that the marble bowls and bracelets were produced at Shimshara, with the possible exception of the Çayönü tools which may have been used in their polishing (Chapter 20) .

Five fragments of stone bowls were recovered from Shimshara (Fig. 21.23), one of which is a thick-walled, crudely shaped limestone (SF378) example, with the remaining four made from marble (SF135, SF136, SF137, SF431). Each of the marble bowls is wide (18–24cm in diameter) and globular, with walls tapering to a simple rim (see, for example SF135), or a shouldered, facetted rim (SF136). Two of the body sherds are incised with at least five hand-scored irregular lines around the circumference of the shoulder (SF137 and SF431). No food or fire residues were visible on any of the marble bowls. Ingholt's excavations in the 1950s produced a very similar series, including the simple rim, the facetted rim and the incised line decoration (Mortensen 1970: fig. 38h–k). These features do not occur in the earlier Bestansur stone bowl assemblage, which is made predominantly from limestone and is produced in simple forms without the rim shaping or linear decoration. Similar bowl repertoires are, however, well-documented at Jarmo, where comparable wide, round marble bowls occur most frequently in the earlier J-I levels (Adams 1983). The incised parallel line decoration is rare, occurring at Shimshara and Thalathat in the seventh millennium BC (Kozlowski and Aurenche 2005: 25, 170). In contrast to the 1950s investigations, no pottery was recovered from our investigations at Shimshara, indicating that these levels represent the Early Neolithic, prior to the supplanting of stone vessels by innovations in clay manipulation, as supported by the radiocarbon chronology (Chapter 11).

Twelve stone bracelets also represent the same range from Shimshara as recovered during the 1950s investigations (Fig. 21.24), made from white marble, with circular, ovoid or irregular angular section. These bracelet fragments represent approximately 5–25% of the bracelet surviving. However, to call them all 'bracelets' may be a misnomer; they range in size from 6.5cm to 11cm in diameter and could have been worn on the wrist, the upper arm, or suspended as pendants. One facetted example, SF140, of which only 5% remains, may have had a diameter of up to 20cm. Comparable, large stone rings have been found at Jarmo (Moholy-Nagy 1983) and the function of these objects needs to be reconsidered. Notably, three fragments with lenticular section come from Trench 1, and those from Trench 2 all have sub-circular or sub-rectangular section, indicating either chronological or preferential differentiation between the types. Only a single type of stone bead was found at Shimshara, made from a white marble similar to that used for the bracelets (SF138, SF445 and SF446; Fig. 21.25).

Worked bone artefacts

In contrast with Ingholt's findings (Mortensen 1970: 58–61), the recent work at Shimshara has brought to light a rich range of worked bone artefacts, though lacking the lancet-shaped hafts previously recovered. A small, polished bone pendant (SF117; Fig. 21.25), with a "flat, pierced extension above a conical bulb" is identical to that already identified at Shimshara and of a type also known from Jarmo in both bone and stone (Mortensen 1970: fig. 51; Moholy-Nagy 1983: fig. 136.22; Watson 1983: fig. 144.39). One example of a bird-bone cylinder bead (SF442; Fig. 21.25) exemplifies the wide use of the local fauna at the site. A flat, rectangular pendant (SF425; Fig. 21.25) has working abrasions across the surface, possibly caused by its usage rather than its manufacture. The suspension of tools is a practice known at the site, seen also in the use of pierced whetstone pendants (Mortensen 1970: 52, fig. 42) and pierced obsidian tools (SHIM Tool 221, see Chapter 20). A thin, polished bone plaque, SF432, also has perpendicular scratches in the surface, though these appear to be more deliberate and possibly decorative.

The majority of the worked bone assemblage from Shimshara is made up of points, numbering ten in total. These are largely broken, with either a mid-shaft portion or tip remaining. Bone tool SF429 is unusual in its shaping, uneven and bearing the scars of its use; this point may originally have been hafted into a handle. SF381 and SF382 could have served as handles for tools and the grooved SF172 could have hafted a blade. Four needle fragments were located in the course of section cleaning and in the excavation of Trench 1, indicating domestic activities taking place in the latter (Fig 21.25). Two of these fragments (SF433 and SF441), with ancient break, were reconstructed to form a complete, slightly curved bone needle, 63mm in length.

The worked bone illustrates a significant difference

Table 21.5. Stone objects from Shimshara.

T	C	SF	Type	Material	Diam. (mm)
1	1632	438	Bracelet	Marble	32
1	1634	423	Bracelet	Marble	10
1	1634	439	Pebbles	Limestone	18
1	1653	428	Bracelet	Marble	14
1	1664	445	Bead	Marble	4
1	1664	446	Bead	Marble	3
2	1633	430	Tool	Stone	48
2	1636	422	Bracelet	Marble	30
2	1640	440	Ball	Limestone	48
2	1650	378	Bowl	Limestone	82
2	1652	426	Bracelet	Marble	57
2	1659	431	Bowl	Marble	62
2	1662	434	Bracelet	Marble	42
Unstrat	1276	116	Bracelet	Marble	90
Unstrat	1276	135	Bowl	Marble	180
Unstrat	1276	136	Bowl	Marble	240
Unstrat	1276	137	Bowl	Marble	200
Unstrat	1276	138	Bead	Marble	9
Unstrat	1276	139	Bracelet	Marble	60
Unstrat	1276	140	Bracelet	Marble	20
Unstrat	1276	141	Bracelet	Marble	90
Unstrat	1276	142	Bracelet	Marble	95
Unstrat	1276	143	Bracelet	Marble	90

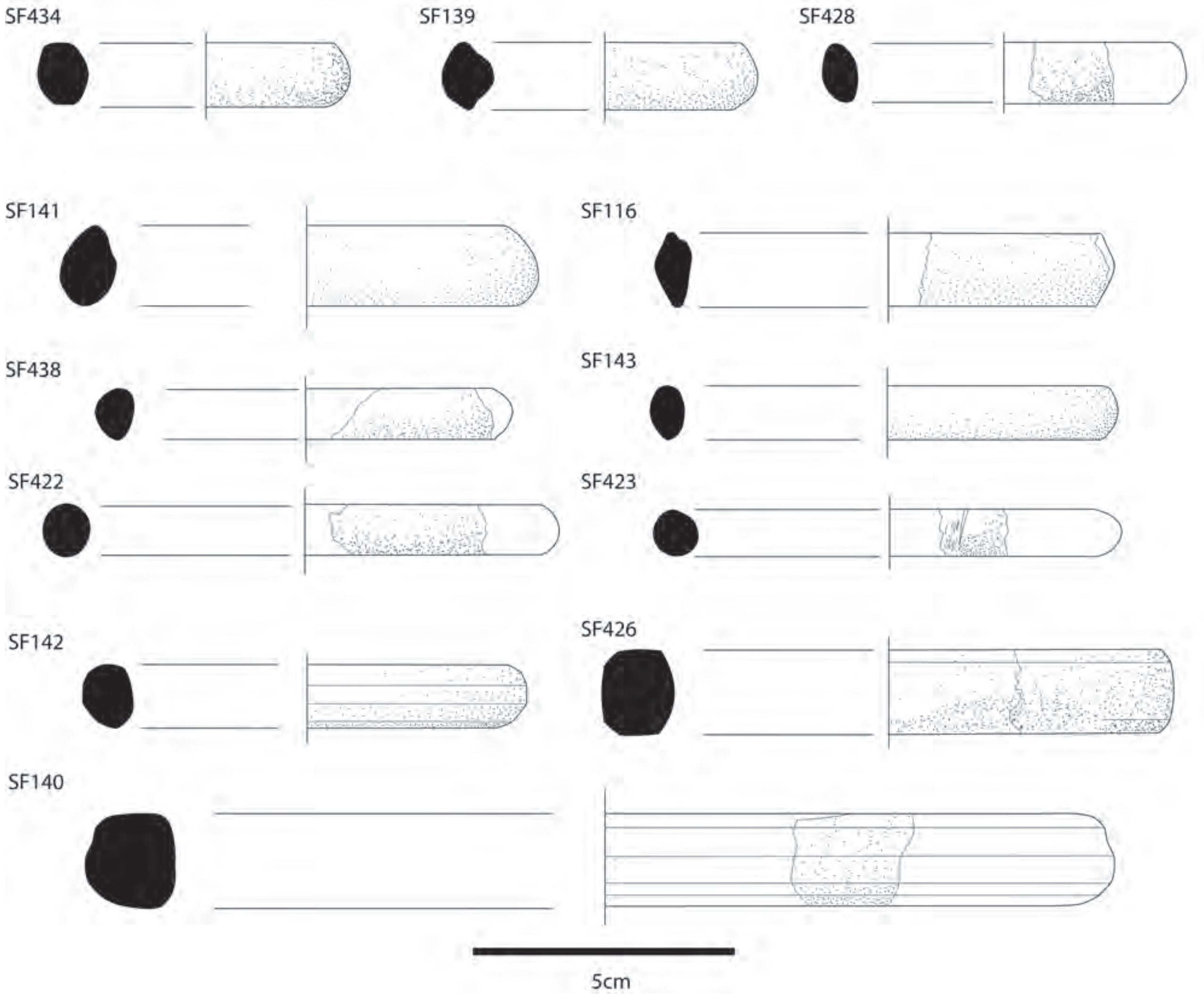


Figure 21.24. Marble bracelets from Shimshara.

in working practices between the communities at Bestansur and Shimshara. At the former, worked bone was largely reserved for tool-making, rather than personal adornment. The Shimshara assemblage demonstrates a narrower range of materials, principally stone and bone, used in creative ways to serve a multitude of purposes. Some of these objects, such as the stone bowls and bracelets, were made using deliberately selected materials and crafted with a high degree of skill. The chipped stone assemblage from Shimshara (Chapter 20) highlights a large proportion of obsidian used by the inhabitants and indicates a degree of connection with networks to the north. However, the range of materials used for producing objects indicates that the participation in material networks may have been intensive but not extensive.

Conclusions

Local materials dominate the Bestansur assemblage, in the form of bone, limestone, chert, shell and clay. The residents drew on material resources in the immediate fertile plain, the local spring, from the hilly flanks and the rich mineral seams of the uplands. These materials are ubiquitous across the site. Regardless of the abundantly available local resources, materials from farther afield were brought to the site, drawing on wide-ranging networks (Chapter 24). These exotic or rare materials were confined to spaces either inside or immediately outside buildings. In Trench 10, non-local materials are almost completely restricted to Space 50 and the under-floor burials, where exceptional objects and the departed were interred. These associations underline the special significance of Building 5. Beyond the walls, outside the wide entrance, clay, bone, alabaster and chert were all worked into tools, animals were butchered and their hides removed. This was an area of activity and industry, of making and discarding. Clay tokens and objects, broken blades and sickles and offcuts of bone: all working debris was abandoned on the surfaces, each to their own established area, whilst the internal floors were kept meticulously clean (Chapters 12 and 14). The people of Bestansur organised their usage of materials, their making of objects and their arrangement of space, seeking out resources and participating in networks that facilitated the development of distinctive lifeways at the site.

Table 21.6. Worked bone objects from Shimshara.

T	*C*	*SF*	*Item*	*Material*	*L (mm)*
1	1649	410	Point	Bone	43
1	1649	412	Fragment	Bone	50
1	1649	414	Fragment	Bone	37
1	1653	408	Fragment	Bone	49
1	1660	442	Bead	Bone	16
1	1661	380	Fragment	Bone	19
1	1661	433	Needle	Bone	35
1	1661	441	Needle	Bone	28
2	1633	425	Pendant	Bone	25
2	1633	429	Tool	Bone	45
2	1636	424	Shaft	Bone	50
2	1650	381	Fragment	Bone	40
2	1652	382	Fragment	Bone	20
2	1652	411	Fragment	Bone	37
2	1658	413	Fragment	Bone	28
2	1658	432	Incised frag.	Bone	24
Unstrat	1276	117	Pendant	Bone	29
Unstrat	1276	127	Needle	Bone	160
Unstrat	1276	134	Point	Bone	96
Unstrat	1276	170	Point	Bone	53
Unstrat	1276	171	Point	Bone	40
Unstrat	1276	172	Chisel/gouge	Bone	29

Variations in craft practice

In the Early Neolithic, experimental activities in shaping clay, stone and bone intensified and diversified throughout the eighth millennium BC, as sedentarising groups found new ways to utilise and manipulate materials to their advantage. Tools were used to make objects of increasing complexity, demonstrating ever-growing skills; adornments of stone and shell were transmitted great distances before ultimately adorning the dead in their underfloor burials; clays were manipulated to greater effect, in the making of objects and dwellings.

The earliest pottery from the Central Zagros dates to the mid–late eighth millennium BC, at Ganj Dareh in the high Zagros of Iran (Crépeau and Smith 1983). Possibly Late Neolithic pottery has been provisionally identified in the course of field survey at Bestansur (Nieuwenhuyse *et al.* 2012), although excavations have not located any levels containing comparable material. Whereas convincing Early Neolithic pottery has yet to be been found at Bestansur and Shimshara, at the former a significant repertoire of shapes and objects in clay demonstrate the inhabitants' familiarity with the material and technological skills in its manipulation from the mid-eighth millennium BC onwards. The inhabitants of the Neolithic settlement at Bestansur were situated on clay-rich sediments (*Bestan-Sur* translating as 'red earth' or 'red garden'), with abundant deposits available across the alluvium of the Shahrizor Plain. Clay was used throughout

Figure 21.25. Stone bead and worked bone artefacts from Shimshara.

the Early Neolithic abundantly and experimentally, though not uniformly across the site, for making small objects. At Bestansur, activity was intensely focused around Building 5, to the east of the mound. In and around B5 in T10, 88% of the clay assemblage was recovered, including 29% of the total clay assemblage from Sp50. The small clay fragments deposited in this room dedicated to the burial of the dead were mixed into the fill and destruction levels (48% of the clay objects in Sp50), in the silty clay packing and foundations of the building (14%) and included in the fill of the burials (29%). In contrast, only four clay objects were found in other spaces in B5. Thus far, T10 provides a view of varied practices in the disposal of clay objects in this sector of the site, including possibly deliberate deposition with the dead, deposition in ashy deposits around fire installations (21% of the total clay assemblage), and abandonment on internal and external surfaces (21%).

Worked bone, however, was deposited in different sectors of Bestansur – only 3% of the total assemblage was recovered from Sp50, whereas 7% was lying on surfaces in the entrance to B5. For the most part, bone working, use and discard of bone tools appears to have been conducted in external spaces, with 83% from external open areas, particularly to the east of the mound (T10), north (T12/13) and south (T9). West of the mound, no worked bone has thus far been documented, although buildings, external activity areas (Chapter 9) and stone tools (Chapters 20 and 22) have been identified in this sector of the site. Although we have no Early Neolithic clay objects from Shimshara, the worked bone assemblage demonstrates a high degree of skill in the use of this material, with bone needle fragments, a pendant, a bead and an incised plaque, all of which were deposited in external areas at the site.

Material resources

The community at Bestansur made abundant use of the availability of the plastic silty clays and butchery debris available to them, but also sought specific materials for making functional and decorative items. The rocky outcrops of the surrounding hills provided ample limestone for making simple stone tools, but marble and alabaster for stone bowls, bracelets, knapping tools, bolas balls and 'maceheads' would have been sourced further afield, possibly from the exposed Mesozoic sediments of the Zagros suture zone less than 50km to the east (Jassim *et al.* 1982; Jassim *et al.* 2006; Al-Barzinjy 2008; Azizi *et al.* 2013). The raw materials may have been brought to the site through the same routes as the chert nodules used for making chipped stone tools (Chapter 20), whether collected by the Bestansur community themselves or through mechanisms of exchange with as yet unidentified settlements closer to these rich resources. Although locally available materials may have sufficed to serve the functions of these objects, stone from elsewhere was specifically used for objects that may have been intended to be seen, given the skill levels required to produce the objects and the highly polished surfaces, particularly of the carnelian beads. The highly developed craftsmanship is most evident in the case of the two flanged alabaster bracelet fragments, SF187 and SF336, from Bestansur, which drew on regional styles and may have been made locally but worked using obsidian tools from hundreds of kilometres to the north.

In some instances, for example in the creation of 'token' objects, materials may have been interchangeable and secondary to the intention of the maker. Small abstract geometric shapes were made from clay, ferrous stone or alabaster, and each of these materials could be anthropomorphised by the scoring lines to emphasise legs or punctuated with a navel. At Bestansur, people appear to have been creatively engaging with ideas, materials and meanings, experimenting with and learning from the resources at their disposal.

The range of materials represented in the small Shimshara assemblage is very narrow compared with the array in external activity areas investigated at Bestansur. The marble bowls and bracelets demonstrate considerable skill in their making, but no direct evidence for their working on-site is apparent. Shimshara may represent a phase of craft specialisation and spatial organisation that separated domestic and working activities, or these objects may have been brought to the site from elsewhere. Based on the presence of rough and unfinished examples at Jarmo and the nearby sources of marble (Adams 1983), there is a strong case for local manufacture. Little working debris for non-local stone and marble has yet been located at Shimshara, or Bestansur (Chapter 22). However, the common occurrence of Çayönü tools at both sites may indicate the production, or at least the finishing, of stone bowls and bracelets (Chapter 20).

Early Neolithic networks

The Small Finds from Bestansur support the proposition that this community participated in extensive Early Neolithic networks of communication and exchange of ideas, technology and raw materials. These objects support the evidence from the architectural materials (Chapter 12), the chipped stone (Chapter 20) and the ground stone (Chapter 22), as well as the practices of human burial (Chapter 19) and plant and animal management (Chapters 15 and 18).

The settlement of Bestansur occupied a key point in the landscape, situated between the Neolithic communities of the NFC and the settlements on the high plateaux of the EFC. Consequently, the inhabitants appear to have drawn from the activities and material practices spanning the Fertile Crescent from the Mediterranean in the west to the Zagros and beyond in the east, perhaps facilitating the transmission of objects and knowledge through networks of exchange.

The Bestansur assemblage of 70 clay objects contributes to the filling of the chronological and temporal gaps in our knowledge of the spread of the phenomenon of clay object production in the EFC, establishing new evidence for regional practices shared between communities, such as the incision of clay cones (Broman Morales and Smith 1990), the presence of a simple seated figurine and possible precursors of the 'snail-lady' figurines in the eighth millennium BC, preceding examples from Jarmo (Broman Morales 1983).

The bracelet fragments SF187 from the upper levels of T10 and SF336 from T12 at Bestansur support the development of an inter-regional network with communities to the north and west in the later phase of the Early Neolithic settlement, where this distinctive form appears in obsidian at Aşıklı Höyük (Astruc *et al.* 2011), but may be locally produced. Furthermore, cut cowries occur across many sites in the WFC and have been identified as adornments at Tell Aswad and Tell Halula (Alarashi 2010; Alarashi *et al.* 2018). The evidence from burials at Tell Halula indicates that Early Neolithic cowrie adornments included pelvic girdles and diadems (Alarashi *et al.* 2018). The use of cowries in mortuary contexts is well-documented at sites such as Jericho, as eyes on plastered skulls (Kenyon 1957: 60-72). Cowries are also known from Çatalhöyük, both as beads and in the vicinity of skull remains, although not set into the eye sockets (Düring 2003).

The source of carnelian beads is uncertain and they have been found at Early Neolithic sites across the Fertile Crescent, from 'Ain Ghazal in the west, possibly drawing on sources in Jordan or Palestine (Rollefson 1984: 11; Wright and Garrard 2003: 281), Aşıklı Höyük and Çatalhöyük to the northwest (Bains 2012: 217), which could have obtained materials from volcanic sources in Cappadocia, and Jarmo in the Zagros foothills (Moholy-Nagy 1983: 322). In the later Neolithic, carnelian beads are known from sites such as Sialk (Marshall 2012: 372) and Tall-e Bakun (Alizadeh 2006: 78), both on the Iranian plateau, although they are less common at the early Central Zagros sites. As well as possible sources in the Levant and Turkey, carnelian sources may have travelled from deposits in Iran, either from the Mashhad region in the east or the Elborz Mountains in the north (Voigt 1985: 24; Potts 1997: 265; Marshall 2012: 431; Moutsiou and Kassianidou 2019). The sources for carnelian beads SF328 and SF660 require further investigation, but for variscite beads SF315 and SF539, only a limited number of variscite sources are known in Southwest Asia. These include the Kushk Mine in Bafq, Yazd Province, Central Iran (Yaghubpur and Mehrabi 1997), Nishapur and Damghan turquoise mines (Khorassani and Abedini 1976). PIXE analysis has successfully distinguished between European variscite sources and demonstrated their long-distance transport between European Neolithic sites (Querré *et al.* 2007). With the collation of further data, these methods could substantially develop the current understanding of the movement of materials between Early Neolithic sites in the Fertile Crescent.

The assemblages from Bestansur and Shimshara provide striking insights into the changes that occurred in the Neolithic Central Zagros. Bestansur highlights how the wide-reaching Early Neolithic networks of exchange brought materials and ideas from across the Fertile Crescent. In contrast, Shimshara in the late eighth and early seventh millennia BC demonstrates a remarkable homogeneity and consistency in its repertoires and material choices. The marble bracelets and bowls, as well as the worked bone pendants from the Neolithic tell at Shimshara, are consistent with the early Jarmo repertoires and regional typologies. The much higher proportions of obsidian used at Shimshara (Chapter 20) testify to the continued use of regional networks of exchange. As at Bestansur, Jarmo yielded a wide array of materials that merits further investigation and identification, with possible turquoise, hematite and carnelian in the assemblage, as well as marine shell (Moholy-Nagy 1983; Richardson 2017). It is therefore surprising that, in the restricted extent of our investigations thus far, Shimshara is yet to demonstrate interaction with the movement of these materials and objects around the Neolithic landscape, although the people there appear to have shared materials and practices with other settlements in the locality.

There is evidence for a high level of object manufacture at Bestansur, including bead-making and bone working, with working debris recovered from internal spaces and their adjacent open areas, utilising local resources. The archaeological record preserves only a fraction of the materials employed in daily activities, with organic materials leaving only a few traces of the hide-working, basket-weaving and other routine tasks. An even wider range of materials than those worked on-site adorned the inhabitants, displaying a broad material connectedness and participation in both production and reception of adornments. People interacted with circulating concepts of abstraction and individualisation, making tokens and figurines. Such objects have not yet been found at Shimshara. Pollock and Bernbeck (2010) hypothesised that the uniformity of objects at Tol-e Baši in south-central Iran was a deliberate choice, as a path to social harmony, and Bendrey (Chapter 15) has highlighted how early domestication practices could have caused tensions and thus necessitated mediation. However, Hodder's analysis of entanglement and entrapment surmises that it is far more complex to disentangle oneself from the material world, rather than to be increasingly dependent; the untying of these bonds tends to take place most readily in the "marginal peripheral areas" (Hodder 2012: 166; 2013). At Bestansur, we see the traces of a people increasingly investing in their material world, experimenting with new ways to use all the resources at their disposal, and actively engaging with complex networks of ideas and things. The evidence from Jarmo demonstrates that in the subsequent millennia these entanglements continued to change, and be changed by, the people of the Central Zagros foothills. At present, the starkly contrasting view from Shimshara is either partial or it represents a community interacting with the material and social worlds in a restricted and selective way, which may have been partially disentangled from and discordant with the world around it.

22. GROUND STONE TOOLS AND TECHNOLOGIES

David Mudd

Research context and rationale

Assemblages of ground stone (hereafter GS) artefacts are an important feature of Early Neolithic sites in Southwest Asia and have received significant study for decades. First, as indicators of changes in the nature and volumes of food production, processing and consumption, they can give a perspective on the development of sedentism and of plant and animal management and domestication which are key features of Neolithisation. Second, as well as showing these changes in stone tool function, GS artefacts are able to illustrate geographical and chronological patterns of stone procurement and changes in manufacturing techniques. Both these features can be used to study how people exploited resources in their environments in the Early Neolithic and provide insights into technology, knowledge transfer and, perhaps, identity. Third, through their use in a wide range of everyday activities, the evidence of manufacture, use and deposition of GS artefacts can contribute to our understanding of how people used living space in their settlements. Until quite recently, GS artefacts from the Zagros zone have received less research attention than those from sites in the Levant and northern Fertile Crescent, and so the study of the large GS assemblage from Bestansur offers a valuable opportunity for comparison with those from other regions. The topics outlined above are of particular relevance to CZAP's research objectives and questions, and are the focus of this chapter.

Approaches to the study of GS artefacts in the Early Neolithic

Researchers have employed differing theoretical and methodological approaches in order to investigate the role of GS artefacts in the lives of Neolithic people, most commonly a techno-typological perspective based on their morphology (Davis 1982: 129–132; Dorrell 1983; Moholy-Nagy 1983; Voigt 1983; Wright 1992a; Mazurowski 1997). Morphology alone is not necessarily a good indicator of function, however, as a grinding-stone may have been used to process a wide range of foodstuffs and other materials during a use-life of perhaps many decades. A broader range of analytical perspectives has been developed in order to approach the function and significance of GS tools (Dubreuil 2001a; Adams 2002; Odell 2004). The study of *what* these tools were used to process involves techniques such as microwear and residue analysis, experimental tool manufacture and ethnoarchaeological analogy (Hayden 1979; 1987a; Adams 1988; Piperno 2006; Buonasera 2007; Langejans 2010; Bofill *et al.* 2013; Portillo *et al.* 2013; Dubreuil *et al.* 2015; Squitieri and Eitam 2016). Variations in the typology, numbers and spatial location within and between settlements have been investigated to study social and spatial conventions such as private or communal property (Wright 2014). Diachronic changes in the size and frequency of artefacts have been used to assess changes in diet and agriculture through the Neolithic of Jericho (Dorrell 1983: 527) and to argue for increased sedentism because they are cumbrous (Hodder 2018b). This diachronic approach is imprecise, however, as GS tools are difficult to date, and may have had use-lives of decades or even centuries. The biographical approach recognises that GS has a life-history before and after its uses as a tool, and can thereby inform on a wide range of spheres of activity: raw material procurement, reduction and manufacturing techniques, use and recycling, deposition and abandonment, and cultural and non-cultural post-abandonment processes (Chappell and Strathern 1966; Taçon 1991; Hamon 2008b; Nadel 2011; Rosenberg 2013; Mudd 2016; 2019). GS artefacts may also have had overlays of symbolic and ritual meaning when used in activities such as feasting, mortuary practice, and the foundation and closure of buildings, and have been used to investigate these aspects in the Neolithic, particularly of the Levant and Anatolia (Samuel 1996; Chapman and Gaydarska 2006; Goring-Morris and Horwitz 2007; Adams 2010; Rosenberg and Gopher 2010; Nadel 2011; Rosenberg and Nadel 2014; Santana *et al.* 2015).

Research aims and objectives

The benefits of these newer approaches to studying ground stone have not yet been fully realised in the eastern wing of the Fertile Crescent, partly because there have been fewer excavations in this region in the last three decades, and many of these have been salvage archaeology. The GS assemblage from Bestansur gives the opportunity to investigate an integrated set of research issues examined in turn below.

What do the volume, typology and distribution of GS tools tell us about social organisation and practice at Bestansur?

The number of GS tools recovered by excavation at Early Neolithic sites is generally low – usually in the tens or hundreds – and only a proportion of these relate to food production, processing and consumption. Demographic evidence in the Early Neolithic is sparse. Broadly, sites were occupied for several centuries or more by populations numbering from the high tens or low hundreds upwards, with exceptions at mega-sites such as Çatalhöyük (Cessford 2005). Over time, settlement size and/or density increased although the rate of change is unclear (Wilkinson 1999: 50; Kuijt 2000; Düring 2006). Neolithic people gathered, grew, stored and consumed vegetable foods which required, or were improved by, processing techniques such as grinding and pounding to enhance their longevity, nutritional value and taste (Wollstonecroft 2011; Hastorf 2016: 83–140). These processing methods were facilitated by the use of an extended range of GS tools (Wright 1992b; 2000; Baysal and Wright 2006). Large-scale competitive feasting is argued by some researchers to have been a significant feature of the Early Neolithic, possibly encouraging domestication of plants and animals in order to produce the larger quantities of food required for feasting (Hayden 1990; 2011; Munro and Grosman 2010; Dietrich *et al.* 2012). This change in social practice might be expected to have required more GS tools. Increasing population size is also likely to have required more processing of animal hide for clothing and shelter, and GS tools are used in their production processes. The growing importance of GS tools in these activities, compounded by increasing population size and density, should have led to increasing use of GS tools, reflected in greater numbers, or more intensive use, reflected in wear and breakage. The actual numbers recovered, however, remained fairly low even at sites such as Çatalhöyük (Wright *et al.* 2013: 391). A possible explanation is that increased population size did result in more GS tools, but that this increase is disguised by settlement nucleation and the development of communities and neighbourhoods within settlements: in effect, the tools are spread over a greater area. Wright (2014) interprets the uneven distribution of food storage and preparation areas, unbroken querns and quern roughouts at Çatalhöyük as an indication of emerging social stratification. Can this interpretation be applied to the numbers, types and locations of GS tools at Bestansur? What can we infer from this evidence about social organisation and practice in the Early Neolithic of the Zagros?

What can the life-histories of GS tools tell us about the activities involved in their creation, use and deposition?

The life-history, or biographical, approach to the analysis of GS tools is critical in informing on a wide range of 'fields of action' (Robb 2010). Stone is the most durable material used in prehistory, and in the archaeological record. However, Neolithic GS artefacts are not easy to date, taphonomic issues are not well understood and stratigraphic and spatial analysis of GS artefacts from an archaeological site has tended to treat them as homogeneous assemblages rather than as palimpsests of manufacturing, use and deposition events spread over long periods. Some GS tools probably took days to manufacture, may have been used and curated over years, decades, or even centuries, and were then deposited formally. Other stones seem to have been picked up, used briefly to process something, and then discarded – a life-history of perhaps just minutes. A third category includes stone with a 'background' function, such as unused raw material, debitage, and stones in floor surfaces and firepits. These categories may not be mutually exclusive, and over time items may have been transformed or reused for different, or multiple, functions. Can we identify specific stages and life-histories in the Bestansur assemblage, and how they could be used to inform on the role of GS for the people who made and used the artefacts?

How did the functional roles of GS tools relate to their social and symbolic roles?

In the early days of investigating the Neolithic of the EFC, the focus of GS artefact analysis based on techno-typology tended to compartmentalise the objects into two categories, functional and symbolic (Hole *et al.* 1969: 106–204; Solecki and Solecki 1970; Solecki 1981: 26–46; Adams 1983; Moholy-Nagy 1983; Voigt 1983). Those which had a recognisable economic or utilitarian function were considered in the context of subsistence strategies: they were tools, with less consideration of their possible roles and meaning in activities of social importance such as feasting or funerary practice. The possible non-utilitarian reasons for the selection of different textures and colours of stone were not considered. The 'symbolic' category includes decorated (incised) stones, which are a common artefact in the Neolithic Levant, though not in the EFC (e.g. Gebel *et al.* 2002; Edwards 2007; Goring-Morris and Belfer-Cohen 2011; Mudd 2011). Many GS artefacts, however, and a considerable proportion of the Bestansur GS assemblage, do not display visibly practical or symbolic features. Can we interpret the functions and related meanings of all these categories of objects, by considering how, where and for what they were created, used and deposited, and their contextual association with other types of material culture?

Can the analysis of GS artefacts help to understand individuals or roles in Neolithic Bestansur?

Our view of the people who lived in these settlements is broad-brush. We assign labels such as 'villagers', 'first farmers' and 'early herders', but we do not have a good understanding of the component units of these societies – such as individuals, households, kinship units and groups coming together for particular tasks – and of the relationships between them. Echoing Levi-Strauss's recognition of 'House Societies' in his ethnographic studies (1979), Kuijt (2018) has argued, based on the material culture of Çatalhöyük, that Neolithic communities were organised around multiple competing and cooperating multi-family households, not limited to nor defined by single buildings. Members of these households may not have been linked biologically: recent research on skeletons at Çatalhöyük has shown that the selection of individuals for co-located burials was not based on biological kinship (Pilloud and Larsen 2011; Chylenski *et al.* 2019). Particular roles in social groups are likely to vary according to task, season, identity/status, gender and life-course; and the interdependent roles of men, women and children are more clearly highlighted if all actions and stages are considered (Abdi 2003; Bolger 2010). Similarly, there is increasing focus on agency, 'fields of action' (Robb 2010), roles (Bloch 2010) and networks (Watkins 2008; 2010) in understanding continuity and change in Neolithic ecological and social strategies (W. Matthews 2018). Regarding the transition from hunting and gathering to sedentary agriculture, it is important to consider how these changes were both shaped by and impacted on the nature, timing and organisation of particular activities, roles and relations. GS artefacts such as food processing items, figurines, beads and pendants were widely used in these fields of action, and thus have the potential to provide valuable evidence for approaching these processes and spheres of life.

What can GS tell us about continuity and change in Neolithic settlements?

A common perspective on the Neolithic in Southwest Asia is that of the *longue durée*, distinguishing loosely between long-term processes and short-term events. Few reports (Hodder 2005 is an exception) have used GS artefacts as indicators of possible economic and social change over the occupation period of a settlement, which often may have extended over centuries. Can we analyse the physical characteristics and spatial positioning of GS at Bestansur to achieve a finer level of definition of the lives of settlements, and of the broad sub-divisions of the Early Neolithic, in order better to study continuity and change in the roles and activities and socio-economic strategies of their inhabitants?

What can GS artefacts contribute to multi-proxy approaches?

New investigative techniques have significantly enhanced our understanding of palaeoclimate and palaeoenvironment, and of the plant and animal species which were present. We can see the results both at the large scale – regions and settlements – and at the microstratigraphic scale of floor and wall surfaces within built environments (Chapters 12, 14–18). How can we improve our understanding of the spatial patterning and function of GS artefacts to complement these approaches?

Summary

GS tools are a significant implement and a focal point of activities on Early Neolithic sites. They provide an exciting avenue for unlocking evidence of the range of actions at these sites, including the working of otherwise largely perishable organic materials as well as stone craft. This chapter will examine initially the volume, typology and distribution of GS artefacts at Bestansur in order to inform on social organisation and practice. The evidence of provenance, manufacture, use, curation and deposition of GS artefacts enables us to see events and stages in the life-history of the artefact. I will examine what actions, sequences of actions and inter-related fields of actions and roles the GS items show. In turn, these events and spheres of activity will be studied in order to identify and understand social identity and differentiation based on gender, age, rank or roles such as craft specialisation. Some social practice will have been domestic, functional and practical, some will have been symbolic and ritual, and much is likely to have been a fusion of the two dimensions. GS played a part in many activities, and the relationship between its functional and symbolic roles will be examined. The GS items will be studied to inform on continuity and change in Neolithic ecological and social strategies. Finally, I will assess the contribution of the GS evidence to the multi-proxy approaches of CZAP.

The questions summarised above link particularly to the major CZAP themes of the role of local environments in Neolithic transitions from hunter-gatherer to sedentary farmer, the nature of Early Neolithic settlement and architecture, and material engagement in the socio-cultural and ecological transformations in the Zagros.

Scope and nature of the data set

This section analyses the GS assemblage from Bestansur and Shimshara, excavated 2012–2014. It includes items from post-Neolithic contexts. Of the GS assemblage, 98% is from Bestansur. For the sake of simplicity, therefore, the chapter refers to the Bestansur material. The artefacts and small amount of debitage from Shimshara are described separately below. The seven GS tools from Sheikh-e Abad and Jani have been described previously (Cole *et al.* 2013: 139–140) and are included below in comparisons with other Early Neolithic sites.

Ground stone is categorised by most researchers as any artefact in which abrasion, as opposed to percussion, played a significant role in its lithic reduction (Wright 1992a: 53; Adams 2002: 1; Odell 2004: 74–75). As the same authors point out, however, and as this chapter will demonstrate, not all artefacts classified as ground stone have been reduced by abrasion, as percussive flaking and pecking are common techniques and also leave characteristic debris. This chapter uses Wright's definition of GS as "any tools made by combinations of flaking, pecking, pounding, grinding, drilling and incising" (Wright 1992a: 53). Additionally, I include some expedient tools which have not been truncated nor shaped before use (Moholy-Nagy 1983: 291; Adams 2002: 21). Their function can be inferred from use-wear, similarities to other manufactured artefacts, or from their context. Debitage and unworked stone are also considered. Stone beads, bracelets, tokens and figurines are discussed in Chapter 21.

Research approaches and methods

This section sets out how the GS assemblage has been analysed. A range of analytical perspectives has been used in order to answer the research questions set out above, and to allow comparisons with other Early Neolithic sites in Southwest Asia. Items were classified by function in order to illustrate their likely use, by petrography in order to investigate the provenance and selection of raw material, by manufacturing method in order to identify stages in the life-history of the GS items, and last, by location using the CZAP context classifications (Chapter 2). This section explains the research methods and their rationale; the results are set out in a subsequent section.

Definition and classification

The typology and definitions for GS artefacts (Table 22.1) in this report are closely based on those developed by Wright *et. al*. at Çatalhöyük (2013: table 20.12). The Çatalhöyük typology has been selected for several reasons. First, it provides a comprehensive hierarchical classification (Class – Type – Subtype) based on the assumed mode of action and morphology of the artefact. Secondly, it is appropriate for the CZAP assemblages because it describes stone from a similar time period and region, and also includes fragments, debris and debitage to inform on more expedient tools and the life-histories of materials and objects. It is important for comparative study at the regional level that researchers use a common typology, and the development of single-site based systems does not further this objective. Wright's analytical methodology and system of classification have been modified in minor ways, namely:

- a small number of sub-types have been added to categorise specific kinds of quernstones, abraders, polishers, and perforated tools found at Bestansur;
- a new class of tool categorisation has been added for items used as 'weights', Class W. This includes types of artefact with a wide range of functions, whose common characteristic is that they are used for their weight: slingstones, net sinkers, bolas balls, digging stick weights and maceheads. Some of these are perforated, others are not. Following the principle of grouping artefacts by function rather than by morphology, it is appropriate therefore to group together the various kinds of weights;
- on the same basis, a grooved abrader has been assigned to Class C (Fine abrading tools), rather than Class E (Grooved Tools).

Blanks and preforms are included under the relevant Type where this is identifiable.

Whilst the Çatalhöyük typology distinguishes between debitage and unworked stone on the basis of the stone's features, it was not always easy to decide whether a piece of stone from Bestansur should be counted as unworked stone, raw material, or manufacturing by-product. The definitions used here are:

- *unworked stone* (Class Z): pebbles, cobbles or boulders without evidence of working, but which may have been truncated/shaped by natural processes such as abrasion, erosion, or fracture in a fast-flowing river. Truncation in one plane has been considered naturally caused; truncation in two or more planes has been considered anthropogenic.
- *raw material:* there are generally two main sources of material for GS artefacts: blocks of angular or tabular stone quarried from, or found loose near to, *in situ* rock beds, and nodules of unworked stone, rounded by water or wind, from secondary sources such as riverbeds or boulder fields. Both kinds were selected for GS at Bestansur, and also a third source of stone – stone flaked or broken as an offcut from the manufacture of another artefact. Any piece of debitage can be used to make an artefact if it is the right size, shape and hardness, so a tighter definition is thus needed to classify stone which has been prepared or set aside for working but cannot be identified as a blank for a specific tool. This third category of raw material includes pieces of worked stone that have a broadly symmetrical shape (usually tabular and rectilinear or triangular), with regular fractures (usually vertical straight sides), and are big enough to be made into a tool (one dimension >*c.* 40mm).
- *debitage (manufacturing by-product):*
  i: flakes which have any evidence of a striking platform, a bulb of percussion, a bulbar scar, percussion ripples, hinge or step terminations, or radial lines on the ventral surface emanating from a point of percussion;
  ii: groups of stones numbering >*c.* 100, found within a radius of *c.* 1m, falling into a continuum of shapes and sizes:
- large: 50–120mm, sub-rectangular or triangular, thickness 10–30mm, weight *c.* 50–250g, often with one or more arrises on the dorsal surface, and usually *c.* 50% with percussion bulbs,
- medium: 25–50mm angular, flattish, thickness 3–10mm, weight *c.* 25–50g, sometimes with a percussion bulb and/or dorsal arris,
- gravel: 10–25mm, angular, weight 10–25g, not individually recognisable as worked, and more likely to be recognised in flotation heavy residue than in excavation (Chapter 14),
- grit: <10mm, <10g, not recognisable as worked, very unlikely to be recognised in excavation and almost certainly only recovered from flotation heavy residue.

Debitage can be distinguished from river-rolled gravel by its angularity, sharper edges and homogeneity of dimensions.

Where possible, fragmentary tools have been assigned to a recognisable Sub-type. Where this was not possible, they have been categorised as fragments.

One further point of definition is needed here. Types marked with an asterisk in Table 22.1 are classified, for the purposes of this analysis, as 'Tools', selected and manufactured for a particular task or mode of working. Other types may also have had specific functions (e.g. firestones, pot-boilers, floor surfaces) but their function is not clear from their morphology, and they show little evidence of manufacture other than perhaps rough shaping. 'Cores and debitage' are the by-products of tool manufacture. 'Unworked' items generally show no sign of human action, although they may have been quarried, and people will have brought them to the site.

Excavation and handling

All pieces of stone with any dimension >10mm were collected during excavation. The majority were handpicked, and the remainder were recovered by dry sieving. Noteworthy items were recorded as small finds (SF), with their spatial co-ordinates recorded in the field. Others were recorded as bulk finds (BF). Some BFs included groups of stones from the same context. Where a BF contained several stones, each was given an individual identifying number in descending size order in this GS study (e.g. BF3324.01, .02, .03 etc).

Further GS items, particularly gravel and grit debitage, were recovered from heavy residue from flotation of soil samples. Residue was put through a nest of sieves and grouped by size fraction (>1cm, >4mm, 2–4mm, 1–2mm), and then by material. Any items >1cm were recorded and given an individual BF number. It was not practical to count individual pieces of gravel and grit, so the groups of residue were weighed and given BF numbers. It is possible that some GS debitage was discarded as non-anthropogenic stone (<1cm during dry-sieving, or during sorting of flotation heavy residue).

Analytical methods

All the stone items were examined individually in the laboratory by the author, following commonly accepted practice (Wright 1992a; Dubreuil 2001a; Adams 2002; Odell 2004: 80–85; Wright *et al.* 2013). Stones were not routinely washed before examination, unless this was necessary to examine their surface or to identify the stone raw material. Items selected for surface residue analysis were only washed after spot-samples had been taken. Dimensions, weight and physical characteristics (colour, surface topography and texture, evidence of manufacturing and use-wear) were recorded. Leached carbonate concretions that obscured working surfaces were dissolved with vinegar and gentle brushing with a soft toothbrush. All items except natural unmodified stones were photographed for identification. Jeroen de Reu

Table 22.1 (continued over the next three pages) Classification and definitions of ground stone items.

Class	*Type*	*Sub-type*	*Type*	*Subtype*	*Definition*
A			POUNDING TOOLS		***Any stone artefact with traces suggesting pounding as main use (battering, flake scars from use). Often made of either hard, dense materials or materials easily expendable in local context***
A	1	0	Worktable/anvil*	General	A lower, stationary stone in a pair of tools used mainly for pounding. Other functions may also be indicated such as grinding, cutting, drilling
A	2	0	Hammer-stone*	General	Hand sized stone with battering marks or other indications of heavy pounding
A	2	1	Hammer-stone*	Hammer with edge	Irregular stone, suitable for use with 1 hand, with 1 rounded end and 1 end with sharp edges with thick edge angles; normally battering marks on the edges
A	2	2	Hammer-stone*	Irregular	Irregular shape but lacking edges
A	2	3	Hammer-stone*	Subspherical	Subspherical shape
A	2	4	Hammer-stone*	Cuboid	Battering marks and grinding wear on several sides, forming a roughly cuboid shape
A	3	0	Mortar*	General	A lower, stationary, stone in a pair of tools used mainly for pounding and vertical grinding/mixing. The use surface is relatively deep and concave, with traces of pounding on the bottom and circular vertical grinding along the upper interior walls.
A	3	3	Mortar*	Bowl mortar	Shallow mortar resembling a vessel, hemispherical with round base, but with relatively rough finishing
A	3	5	Mortar*	Boulder mortar	Mortar with medium to large depression set into a large boulder which can be moved
A	3	98	Mortar*	Fragment	Mortar fragment, type not determined
A	4	0	Pestle*	General	An elongated, upper, mobile stone in a pair of tools used mainly for pounding and vertical grinding. The ends are slightly convex or flat and the sides have traces of grinding circling the short axis of the tool
A	4	0	Pestle*	Roughout	Unfinished pestle
A	4	1	Pestle*	Conical	Pestle with a wide use surface at one end and a narrower surface at the other, conical in plan and circular in section
A	4	2	Pestle*	Cylindrical	Pestle with cylindrical shape
A	4	3	Pestle*	Bell muller	Pestle with bell shape and knob for grasping
A	4	4	Pestle*	Pestle-hammer	Elongated tool with flake scars (use wear from heavy hammering) on one end and traces of lighter pounding on the other end, and a groove or knob suggesting hafting
A	4	98	Pestle*	Fragment	A pestle fragment
A	4	99	Pestle*	Other pestle	Other
A	99		Other pounding tool*	Other pounding tool	Other pounding tool
B			COARSE GRINDING TOOLS		***Any stone artefact with traces suggesting coarse grinding or gouging, made of coarse textured materials***
B	1	0	Grinding slab*	General	A lower, stationary stone in a pair of tools used mainly for rough grinding across one or more use surfaces and made of relatively coarse-grained material. Use surfaces are flat or concave
B	1	1	Grinding slab*	Roughout	A grinding slab with traces of flaking or pecking or abrasion, but unfinished
B	1	2.1	Grinding slab*	Saddle quern	Grinding slab with concave long axis and flat/concave short axis. Complete
B	1	4.1	Grinding slab*	Tabular	Thin tabular grinding slab with flat use surface and flat base (may be unifacial or bifacial), edges may be irregular or convex. Stable on a flat resting surface

Table 22.1 (continued from the previous page and over the next two pages) Classification and definitions of ground stone items.

Class	*Type*	*Sub-type*	*Type*	*Subtype*	*Definition*
B	1	5.1	Grinding slab*	Pecked planoconvex	Unifacial planoconvex grinding slab with flat use surface and rounded base. Pecking dominates the shaping of sides and base. Can be stable on a flat resting surface depending on weight. Complete
B	1	6.1	Grinding slab*	Pecked rectilinear block	Rectilinear grinding slab with flat base and abraded edges perpendicular to the use surface. *Some examples have a pecked saucer-like depression in the use surface*. Complete
B	1	6.4	Grinding slab*	Pecked rectilinear block rimmed	As B 1.6.1 but with a defined rim in relief around the use surface. *Slabs with rim on three edges, with the fourth (lowest) left open to allow the ground material to fall are often called 'trough querns' by commentators.* Complete
B	1	98.2	Grinding slab*	Fragment: edge	An edge fragment of a grinding slab
B	1	98.3	Grinding slab*	Fragment: body	A body fragment of a grinding slab
B	2	0	Hand-stone*	General	Upper, mobile stone, deliberately shaped, in a pair of tools used mainly for rough grinding across a shallow surface, made of relatively coarse-grained, rough material. Has a flat or convex use surface and a thickness suggesting that it was part of a tool that could be picked up easily
B	2	1	Hand-stone*	Discoidal mano	Circular hand-stone suitable for use with 1 hand, with 1 or more use surfaces. Section shapes range from rectangular to lens-shaped or plano-convex
B	2	2	Hand-stone*	Oval mano	Elongated oval hand-stone suitable for use with 1 hand. Section shapes range from rectangular to lens shaped or plano-convex
B	2	3	Hand-stone*	Sub-rectangular mano	Sub-rectangular hand-stone suitable for use with 1 hand. Section shapes range from rectangular to lens-shaped or plano-convex
B	2	4	Hand-stone*	Irregular mano	A hand-stone, suitable for use with 1 hand, of irregular shape, with 1 or more use surfaces
B	2	98.4	Hand-stone*	Fragment – general	Fragment of a hand-stone
B	2	99	Hand-stone*	Other hand-stone	Other hand-stone
C	FINE ABRADING TOOLS				***Tools used for fine abrasion, made of fine textured materials***
C	1	0	Abrading slab*	General	A stable slab made of fine-grained stone, used with a hand-held abrading tool for fine abrasion. The passive tool in a pair of abrading tools
C	1	4	Abrading slab*	Palette	A very small grinding slab that can be held in 1 hand, with 1 or more shallow, concave grinding surfaces and made of a finely abrasive material
C	2	0	Abrader*	General	Made of a medium-grained abrasive stone. Variable in form, usually irregular
C	2	3	Abrader*	Discoidal	Abrader with discoidal shape
C	2	5	Abrader*	Sub-rectangular	Abrader with subrectangular shape in plan
C	2	6	Abrader*	Cuboid	Cuboid shaped abrader
C	2	8	Grooved abrader*	U shaped groove	A grooved stone where the groove is U-shaped in section. Often known as 'shaft-straightener'
C	*2*	*10*	*Abrader**	*Quadrant*	*Fragment of flat slab snapped into (usually) four pieces. Use surfaces are the lateral edges, not the flat surfaces.*
C	99		Other abrading tool*	Other abrading tool	Other abrading tool
D	POLISHING TOOLS				***Tools used for polishing, made of extremely fine-grained materials***
D	1	0	Polishing slab*	General	An abrading slab with 1 or more extremely flat use surfaces, made of very fine-grained abrasive stone (often tabular), with evidence of polishing on 1 or more surfaces
D	1	2	Polishing slab*	Sub-rectangular	Sub-rectangular in plan
		0	Polisher*	General	A small stone (hand sized or smaller) with traces of polish from use. Normally made of finest grained materials, eg marble, chert. Use surfaces vary in number. Often very small striations in diverse directions are seen on the polished surfaces

Table 22.1 (continued from the previous two pages and over the next page) Classification and definitions of ground stone items.

Class	*Type*	*Sub-type*	*Type*	*Subtype*	*Definition*
D	2	1	Polisher*	Discoidal	Discoidal in plan
D	2	2	Polisher*	Subspherical	Subspherical in plan
D	*2*	*5*	*Polisher**	*Elongated*	*Long, finger-shaped, round or rectangular in cross-section, made of very fine-grained stone. Becoming narrower, ending in rounded point. Very fine striations seen at pointed end, suggesting use to burnish plastered/pigmented surfaces*
D	2	98	Polisher*	Fragment	A fragment of a polisher
F	CUTTING TOOLS				*Any upper (edged) or lower cutting tool, in which abrasion played a key role in manufacture*
F	1	5	Axe/celt*	Oval	Axe/celt, biconvex in longitudinal section, oval in plan
F	2	0	Chopper*	Chopper	An irregular cutting tool with a rough, sinuous edge that has been both flaked and ground to form a tool suitable for rough chopping.
F	*4*	*0*	*Cutmarked slab**	*Cutmarked slab*	*A stable lower stone with narrow cutmarks or slicing marks, suggesting use as a cutting board*
F	99		Other cutting tool*	Other cutting tool	Other cutting tool
H	VESSELS				*An artefact with a well-defined rim and base and relatively delicate walls suggesting that its main use was as a container*
H	98	1	Fragment: rim*	Fragment: rim	A vessel rim fragment
H	98	2	Fragment: base*	Fragment: base	A vessel base fragment
H	98	3	Fragment: body*	Fragment: body	A vessel body fragment
J	FIGURINES				See separate analysis
K	BEADS				See separate analysis
W	*WEIGHTS*				*An artefact whose shape/features suggest that its weight was a significant factor in its function. Includes some types from 'Perforated tools' class used by many commentators*
W	1		Macehead*		A perforated stone with a cylindrical perforation that is relatively large compared to the diameter of the whole object; there are often stress fractures at the ends of the perforation. *Classified as digging stick weights by some commentators*
W	2		Spindle whorl*		*Disc shaped with central perforation, weight <c. 100g*
W	*3*		*Net sinker perforated**		*Small sub-triangular fragment of thin flat stone, drilled (single-side or biconically) at one corner for stringing. May show evidence of lengthy submersion in water eg worm-casts*
W	*4*		*Net sinker: notched**		*Small piece of biconical flat or rounded stone with bilateral notches*
W	*5*		*Strung weight**		*Circular or semi-circular fragment of stone with large central biconical perforation. Edges of perforation usually ground smooth, possibly to avoid cutting the string. Heavier than spindle whorl: >c. 100g. Possible uses: line weight for fishing; strung weight to secure roofing material on buildings (from contemporary ethnographic examples); loom weight*
W	*6*	*0*	*Stone ball**	*Stone ball: general*	*Spherical or sub-spherical stone ball. Shaped naturally, probably river pebbles. Sometimes with a flat facet*
W	*6*	*1*	*Stone ball**	*Slingstone*	*Spherical or sub-spherical deliberately shaped stone ball. No flat facet. May have percussion damage on any part of stone*
W	*98*		*Other weight**		
X	MISCELLANEOUS				*Any artefact not attributable to another class*
X	3	0	Mineral crystal		A mineral crystal, eg calcite rhomboid or quartz hexagonal crystal
X	4	1	Pigment: raw nodule	Raw nodule	Unworked pigment
X	4	2	Pigment: abraded nodule	Abraded nodule	Pigment with signs of abrasion
X	*7*		*Token/gaming piece**		*Sub-round pebble: part of group/set*

Table 22.1 (continued from the previous three pages) Classification and definitions of ground stone items.

Class	*Type*	*Sub-type*	*Type*	*Subtype*	*Definition*
X	*8*		*Fossil*		*Truncated stone containing fossil, sometimes polished*
X	*9*		*Retouching tool**		*Ground and polished artefact, round section, tapering to a blunt point, sometimes with a thumb-grip, sometimes made of rare stone. Possibly used to retouch chert tools*
X	99	1	Miscellaneous worked stone	*Angular/tabular*	Any artefact not attributable to a given type. Flat, angular/tabular
X	99	2	Miscellaneous worked stone	*Rounded*	Any artefact not attributable to a given type. Rounded surface
Y	CORES AND DEBITAGE				***Any by-product of ground stone artefact manufacture***
Y	1	0	Core	Flaked core	Stone from which at least 3 flakes have been detached or which has been pecked into shape prior to further reduction
Y	2	0	Debitage	Flake: general	A flake, with visible bulb of percussion and platform, of a material used for ground stone artefacts. Primary vs. secondary cannot be determined
Y	2	2	Debitage	Flake: secondary	A flake struck from a previously flaked, pecked or abraded artefact (such traces appear on dorsal surface)
Y	4	0	Debitage	Debris/ fragments	Indeterminate fragments/debris, where it is not possible to be sure whether material is worked or unworked
Y	*5*	*0*	*Debitage: group*	*Large*	c. *100 stones or more, found within a radius of* c. *1m. Largest dimension 50–120mm, sub-rectangular or triangular, thickness 10–30mm, weight* c. *50–250g, often with one or more arrises on dorsal surface, usually* c. *50% with percussion bulbs*
Y	*6*	*0*	*Debitage: group*	*Medium*	c. *100 stones or more, found within a radius of* c. *1m. Largest dimension 25–50mm, angular, fairly flat, thickness 3–10mm, weight* c. *25–50g, sometimes with percussion bulb and/or dorsal arris*
Y	*7*	*0*	*Debitage: group*	*Gravel*	*10–25mm, angular, weight 10–25g, not individually recognisable as worked, and more likely to be recognised in flotation heavy residue than in excavation*
Y	*8*	*0*	*Debitage*	*Grit*	*<10mm, <10g. Very unlikely to be recognised in excavation and almost certainly only recovered from flotation heavy residue*
Z		UNWORKED			
Z	1	0	Unworked nodule/block	General	Raw material blocks or nodules, unworked, but brought onto site from elsewhere
Z	1	1	Unworked block	Angular or tabular	Angular or tabular raw material block (possibly quarried or broken)
Z	1	2	Unworked nodule	Rounded	Rounded raw material nodule or boulder (suggesting river-rolling or weathering by wind)

Based on Wright *et al.* (2013). Changes from Wright in italics. Asterisk: types classed as tools.

recorded a sub-set of 20 artefacts by high-definition 3-D photography to enable further examination away from the field, illustration of key attributes, and for publication.

Raw material and its probable source have been identified in most cases and grouped according to their rock type (Table 22.2). The advice and assistance in this of Kamal Haji Karim, Department of Geology, University of Sulaymaniyah, is gratefully acknowledged. Amy Richardson carried out pXRF analysis to compare selected archaeological artefacts with local stone in order to identify stone type and potential sources.

Usewear and surface residues

All items were examined by eye or with a hand lens, and macro-wear traces were noted. Selected items with possible microwear were examined with a digital hand-held USB microscope (Dino-Lite AM4113T, magnification ×30–×250).

In the spring 2013 season, elastomer surface peels were taken from seven artefacts to examine possible micro-usewear under Scanning Electron Microscopy (Dubreuil and Savage 2014). It became clear, however, that to pursue this avenue of research would require an extensive programme of experimental replication and identification of usewear, which was beyond the scope of my research.

Table 22.2 Raw materials for Bestansur and Shimshara GS artefacts.

	Rock or mineral type	*Description*
A	IGNEOUS ROCKS	
A1	Basalt: non-vesicular	Fine-grained, dense, non-vesicular. Black or dark grey, also dark green and green–blueish
A2	Basalt: vesicular	Fine-grained, black or dark grey, very dense, vesicular
A3	Gabbro	Medium-grained, dark-coloured, usually black or dark green. Same composition as basalt, but larger grain size
A4	Granite	Medium-coarse. Composed mainly of feldspar & quartz
B	SEDIMENTARY ROCKS	
B1	Sandstone	Variable granularity from very coarse to very fine, well cemented. Light to dark shades of brown, pink or red. Occasionally black
B2	Limestone	Hard, fine- to medium-grained. Effervesces in acid. Usually has low levels of impurities (sand, skeletal remains of marine organisms). Often contains small quartz clasts. Matrix is pale (cream to buff), but sometimes darker (iron compounds?). Detrital limestone (rare) composed of loosely cemented shell fragments
B3	Nummulitic limestone	Fine-grained matrix, holding foraminiferous fossils: concentric rings 5–20mm diameter. Formed in shallow seas, lagoons, tidal flats
B4	Chert	Microcrystalline siliceous rock. Fragments and cortical nodules. White, grey, red, black
B5	Conglomerate	Coarse-grained. Sandy silty matrix, cementing gravel-size clasts (2–4mm)
B6	Mudstone	Very fine-grained. Hardened mud of silt and clay-sized particles not visible to the naked eye. Formed in seas and lakes
B7	Siltstone	Very fine-grained. Hardened silty mud, non-laminated
B8	Calcified alluvium (calcrete)	Hard natural cement binding sand, clay and silt, which are poorly sorted. Formed by minerals leaching from upper soil horizons to lower layers, often in floodplains or desiccated former lakes
B9	Ironstone	Extremely dense nodules. Hard, not granular, non-banded and non-laminated
B10	Mixed sandstone & limestone	Large group of knapping debris; not practical to separate sandstone & limestone
C	METAMORPHIC ROCKS	
C1	Marble	Fine- to very fine-grained. White, grey, brown
C2	Quartzite	Hard, fine-grained, pink–red. Metamorphosed sandstone
D	MINERALS	
D1	Quartz	Hexagonal crystals. Hard. Pink (rose quartz), white
D2	Gypsum	Fine grained, soft: very easily abraded, Slightly soluble in water. Porous, so may stain. White, pale brown, pink
D3	Alabaster	Calcite alabaster, harder than gypsum. Fine-grained, porous. White, cream, pale pink
D4	Celadonite	Soft micaceous crystalline mineral. Dull olive green

Notes: 1 Some rock and mineral types have varieties with different characteristics. The descriptions above are of the varieties found at Bestansur; 2 Grain size for clastic sediments: Very fine <0.06mm; Fine 0.06–0.25mm; Medium 0.25–0.5mm; Coarse 0.5–1mm; Very coarse 1–2mm; 3 Grain size for igneous rocks: Fine <1mm; Medium 1–5mm; Coarse 5mm–3cm

Surface residue samples to look for pollen, phytoliths and starch grains were taken in 2013 and 2014 from several artefacts that might have been used for food-processing (Piperno 2006: 98–99) using a sampling strategy derived from other studies (Loy 1994; Pearsall 2000; Pearsall *et al.* 2004; Scott-Cummings 2011). The aim was to look for differences in the quantity and nature of residues in order to distinguish between working and non-active surfaces and to investigate potential past use. Laboratory analysis found both pollen and phytoliths (identified by Sarah Elliott), but the quantities were insufficient to draw statistically valid conclusions. The surfaces of the artefacts were not sufficiently vesicular to trap residues. They were comparatively flat and smooth, due to rock type and surface finishing, discussed below.

Cataloguing and storage

Objects broken in excavation were counted as one item. Clusters of debitage were weighed but not counted. Each size of debitage from a context or sample was recorded as one item, in order to avoid skewing analysis of overall numbers. All other items were counted and recorded individually. Cataloguing was recorded on paper forms in Bestansur and transcribed to an Excel spreadsheet, which was later integrated with the site database. The items were stored in sample bags (size permitting) with a Tyvek label detailing provenance and identification number. The GS has been stored in crates, together with copies of the catalogue, in the Expedition House, and will in due course be transferred to the Directorate of Antiquities in Sulaymaniyah for permanent storage.

Figure 22.1. Pits and quarrying debris on hill 500m north of Bestansur village. Looking north.

Results

This section gives the results of the various methods of analysis described above. It analyses the petrography, type and function, and distribution of the GS items. A total of 838 items weighing 511kg were examined and recorded, of which 414 items (49%, 330kg) were classified as recognisable tool types and sub-types. There were 39kg of cores and debitage, and 142kg of unworked raw material.

Raw material

The first stage in the life of a GS artefact was the sourcing and selection of a piece of rock, suitable for the required function of the tool. The raw materials used for GS artefacts at Bestansur are shown in Table 22.2.

Where did the stone come from? The geology of the Shahrizor Valley consists of Quaternary alluvial fan deposits (boulder, gravel, sand, silt and clay) overlying Cretaceous limestone (Karim and Surdashy 2005; Ali 2007; Karim 2011). There is a perennial spring-fed river some 100m from the excavation site, assumed to be present in the general vicinity in the Neolithic period, as it flows from a major aquifer at the junction of permeable and impermeable beds of limestone (Kometan and Balambo Formation) and shale, marl and sandstone (Shiranish and Tanjero Formations) respectively (Chapters 3 and 6). Many of the stone items are limestone and sandstone pebbles/cobbles, showing signs of water wear and smoothing. Similar stones, as well as siltstone and mudstone, are visible today in the river and on its banks. There is a low hill between the two parts of Bestansur village, 500m northwest of the dig site and extending three kilometres northwest. This hill has outcrops of pale grey, honey-coloured, and dark limestone, frequently in bedding planes 20–40cm thick. The hill shows extensive non-mechanical quarrying, of unknown period (Fig. 22.1), although some pits may have been made for tank and gun emplacements in the late twentieth century.

Hand-specimen, microscopic and pXRF analysis suggest the archaeological limestone and sandstone is from these sources. This is supported by the presence on the site of large blocks, up to 45kg, of limestone raw material. These are more likely to be from local sources, as their weight makes them difficult to transport over long distances. It would be expected that stone from more distant sources would have been reduced to a smaller preform before being brought to the site.

The overwhelming selection of stone for GS tools was sedimentary rocks (92% by number of objects, 97% by weight). Most objects were local limestone

Table 22.3 (continued on the next page) Artefact Types by raw material (frequency and weight).

Artefact type	*A1 Basalt non-vesicular*	*A2 Basalt vesicular*	*A3 Gabbro*	*A4 Granite*	*B1 Sandstone*	*B2 Limestone*	*B3 Nummulitic limestone*	*B4 Chert*	*B5 Conglomerate*	*B6 Mudstone*	*B7 Siltstone*	*B8 Calcified alluvium*	*B9 Ironstone*	*B10 Mixed sand- & limestone*	*C1 Marble*	*C2 Quartzite*	*D1 Quartz*	*D2 Gypsum*	*D3 Alabaster*	*D4 Celadonite*	*X Unidentified*	*Total*
A *Pounding tools*	11	0	1	1	16	86	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	118
A 1 Worktable/anvil*	0	0	0	0	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
A 2 Hammerstone*	4	0	0	0	4	53	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	69
A 3 Mortar*	0	0	1	0	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
A 4 Pestle*	1	0	0	1	7	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
A 99 Other pounding tool*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
B *Coarse grinding tools*	0	2	1	0	19	46	0	0	1	0	0	1	0	0	0	0	0	0	0	0	5	75
B 1 Grinding slab*	0	2	0	0	5	24	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	32
B 2 Handstone*	0	0	1	0	14	22	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5	43
C *Fine abrading tools*	2	0	1	0	48	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87
C 1 Abrading slab*	0	0	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
C 2 Abrader*	2	0	1	0	45	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77
C 99 Other abrading tools*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
D *Polishing tools*	3	0	1	0	9	24	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	38
D 1 Polishing slab*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
D 2 Polisher*	3	0	1	0	9	23	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	37
F *Cutting tools*	2	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
F 1 Axe/celt*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F 2 Chopper*	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
F 4 Cut-marked slab*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F 99 Other cutting tools*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
H *Vessels*	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7
H 98 Vessel fragment*	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7
W *Weights*	0	0	0	0	1	67	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	72
W 1 Macehead*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	4
W 2 Spindle whorl*	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
W 3 Net sinker - perforated*	0	0	0	0	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48
W 5 Strung weight*	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
W 6 Stone ball*	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	11
W 98 Other weight*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 22.3 (continued from previous page) Artefact Types by raw material (frequency and weight).

Artefact type	*A1 Basalt non-vesicular*	*A2 Basalt vesicular*	*A3 Gabbro*	*A4 Granite*	*B1 Sandstone*	*B2 Limestone*	*B3 Nummulitic limestone*	*B4 Chert*	*B5 Conglomerate*	*B6 Mudstone*	*B7 Siltstone*	*B8 Calcified alluvium*	*B9 Ironstone*	*B10 Mixed sand-& limestone*	*C1 Marble*	*C2 Quartzite*	*D1 Quartz*	*D2 Gypsum*	*D3 Alabaster*	*D4 Celadonite*	*X Unidentified*	*Total*
X Misc. worked stone	0	0	1	0	50	28	1	1	0	1	0	0	1	0	0	0	2	4	4	3	5	101
X 3 Mineral crystal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
X 4 Pigment	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	0	3	0	8
X 7 Token or gaming piece*	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
X 8 Fossil	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
X 9 Retouching tool*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4
X 99 Misc. worked stone	0	0	1	0	50	25	0	1	0	1	0	0	0	0	0	0	0	0	0	0	5	83
Y Cores & debitage	2	0	0	0	6	116	0	1	0	0	0	0	0	10	0	0	0	0	1	0	0	136
Y 1 Core	0	0	0	0	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Y 2 Debitage	2	0	0	0	3	17	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	26
Y 4 Debitage	0	0	0	0	2	94	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	97
Y 6 Debitage - group	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Y 7 Debitage - group	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3
Y 8 Debitage - group	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
Z Unworked	3	0	0	0	44	130	0	1	0	1	5	0	1	0	1	1	0	0	0	0	10	197
Z 1 Unworked	3	0	0	0	44	130	0	1	0	1	5	0	1	0	1	1	0	0	0	0	10	197
Total number	18	2	5	1	193	544	1	11	1	2	5	1	2	10	3	2	2	4	8	3	20	838
%	*2*	*0*	*1*	*0*	*23*	*65*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*2*	*100*
Weight (g)	4343	1720	2143	23	53866	426,371	148	2423	1276	71	300	934	42	12,947	704	65	4	821	425	1432	561	510,619
%	*1*	*0*	*0*	*0*	*11*	*84*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*100*

Asterisks denote tools.

and sandstone (88% by number of objects; 95% by weight). The limestone is hard, fine-grained, non-porous and resistant to abrasion and percussion. It was used for most types of GS artefact. Limestone, chert, basalt and granite have high compressive strength and the density made them suitable for heavy percussion. The sandstone is hard and quartzitic with varying granularity. It would make effective and long-lasting abraders and polishers. Although well-cemented, it may have been less-favoured for food-processing because of the likelihood of contamination by dislodged grit. Stones of differing abrasiveness were found in clusters of tools. The sandstone is harder than the limestone and evidence from debitage shows that sandstone was used for knapping, pecking and abrading it. A few pieces of softer mineral were found, such as gypsum and green celadonite, a mineral clay used as pigment for plaster washes on Building 8 walls (Godleman *et al.* 2016). Although ochre traces were found in deposits, on artefacts and in wall painting (Godleman *et al.* 2016) (Chapter 12), no ochre nodules have been found to date. This absence is perhaps surprising, as these ochre materials are available in the Baranand Dagh hills, within a few kilometres of the site (Karim, pers. comm.).

The nearest source for igneous rocks such as basalt, granite, gabbro and metamorphic rocks such as marble and alabaster is the Penjween area in the higher thrust zone of the Zagros, some 30–40km east and north from Bestansur (Karim 2011; Hadi *et al.* 2013; Tsuneki *et al.* 2015: 53). This area is also a possible source for chert (Chapter 20). Three percent of the assemblage is igneous rock and 0.5% metamorphic. The basalt is green or black and very fine-grained. Only two items of vesicular basalt were found. The few gabbro and granite items were mostly used as abraders or polishers. Green-coloured basalt, granite and gabbro artefacts are generally found in the upper third (by depth) of Neolithic levels of the site, suggesting they were used (or at least deposited) in its later occupancy. Fine-grained and unusual alabaster and marble were used for maceheads, pressure flaking tools and vessels, possibly for aesthetic value and/or to indicate status. These igneous and metamorphic raw materials were uncommon and are not local. Items made of non-local stone form a tiny proportion of the total assemblage, comprising only 35 tools, five pieces of unworked stone and three of debitage.

Manufacture and techno-typology

Manufacturing techniques

There is an extensive literature on the manufacture of GS tools, derived principally from ethnographic observation and experimental replication (e.g. Hayden 1987b; Pétrequin and Pétrequin 1993; Kuhn 1994; Schneider 1996; Wilke and Quintero 1996; Pritchard Parker and Torres 1998; Stout 2002; Schneider 2010). The Bestansur assemblage shows several manufacturing techniques:

- expedient tool, used as a tool but without prior modification
- preform, reduced either by truncation, flaking, or abrasion. The tool's final form may not be clear
- detailed shaping of preform by pecking or flaking
- dressed surface, completed by pecking (not percussive usewear)
- ground/polished on at least one surface.

These techniques involve different levels of investment in time, effort and skill. Not every tool will show all these stages: manufacture will have stopped when the tool reached the required shape, size and texture. The techniques will have been sequential, and the more elaborate manufacturing techniques are likely to obscure evidence of simpler techniques. Figures 22.2 and 22.3 show examples of some of these stages from the Bestansur assemblage. Figure 22.4 shows the number of tools in each worked Class made by these techniques.

Pounding tools were mostly unmodified or truncated to the appropriate shape and size. Their size and weight were intrinsic aspects of their function,

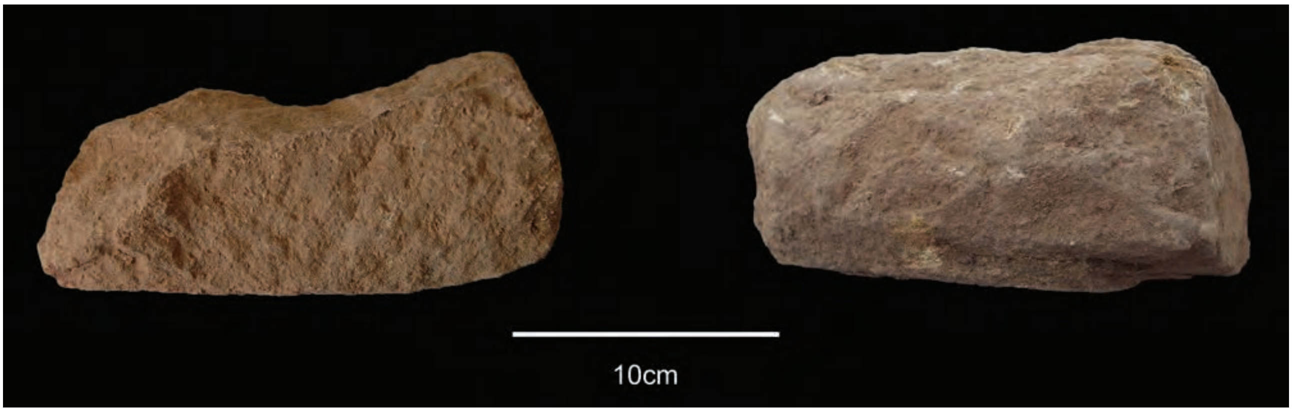


Figure 22.2. a) Pestle pre-form BF2256.50. No visible use-wear; b) Detailed shaping of pestle BF2790.04. The uneven surface would have improved grip for processing wet materials such as plants. Percussion damage (use-wear) to both tips.

Figure 22.3. a) Grinding slab BF2712.01 has been shaped and dressed (pecked) to give a flat but rough working surface; b) Alabaster macehead SF21 ground and polished, with drilled perforation. Some post-depositional caliche at upper left.

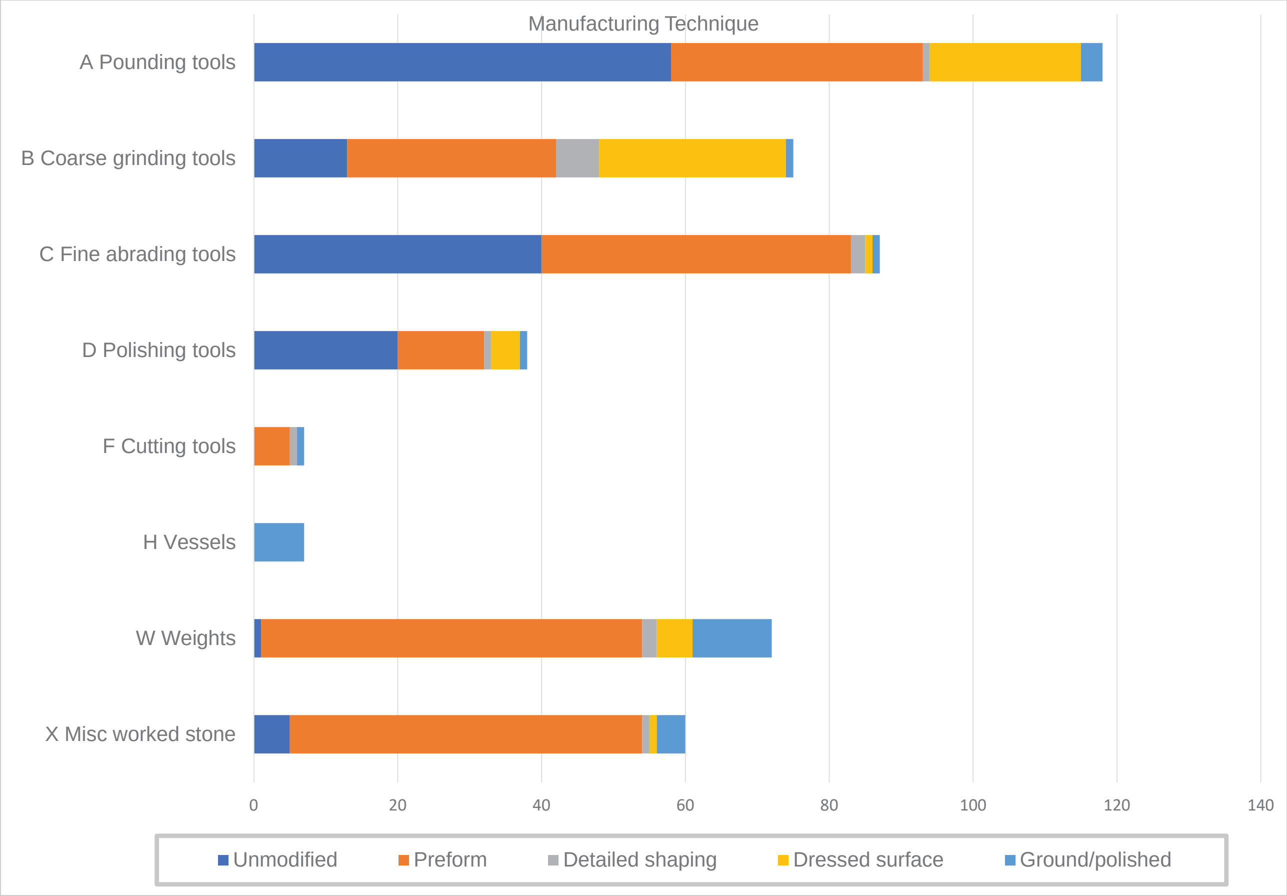


Figure 22.4. Manufacturing techniques for each class, by number of tools.

with detailed shaping less so. They show little consistency in shape or dimensions. Coarse grinding tools were more likely to be rough pre-forms, with some having a prepared working surface which may have been curated to resharpen it. Fine abrading tools were also mostly unmodified or truncated. Many of these were water-shaped river cobbles, giving a naturally smooth working surface which would have been effective for polishing and burnishing surfaces such as floor and wall plaster and for working easily damaged materials such as thin leather. River stones have two advantages. First, water-wear and rolling may have eroded them to approximately the required shape, reducing production time (Pétrequin and Pétrequin 2000; Strasser 2004: 62). Second, natural erosion processes may have removed weathered surfaces and friable material (van Andel and Sutton 1987: 20; Strasser 2004: 62). The small number of cutting tools were given sharp edges by flaking or truncation, which could be repeated as necessary to give a fresh cutting edge. Vessel fragments (Chapter 21) were finished to precise shapes by grinding and polishing. The majority of weights were roughly shaped by truncation with detailed shaping and grinding reserved for those such as slingstones which needed to be spherical. Overall, the great majority of items were manufactured with the minimum necessary investment of time, skill and effort. Very few GS tools were actually finished by grinding.

Techno-typology

A range of activities can be inferred from analysis of stone typologies as well as their contextual association with other materials. A summary of the Bestansur GS objects by class and type is presented in Table 22.3. Their range of functions is summarised below, with a more detailed analysis by sub-type in Mudd (2016), and in the CZAP online database.

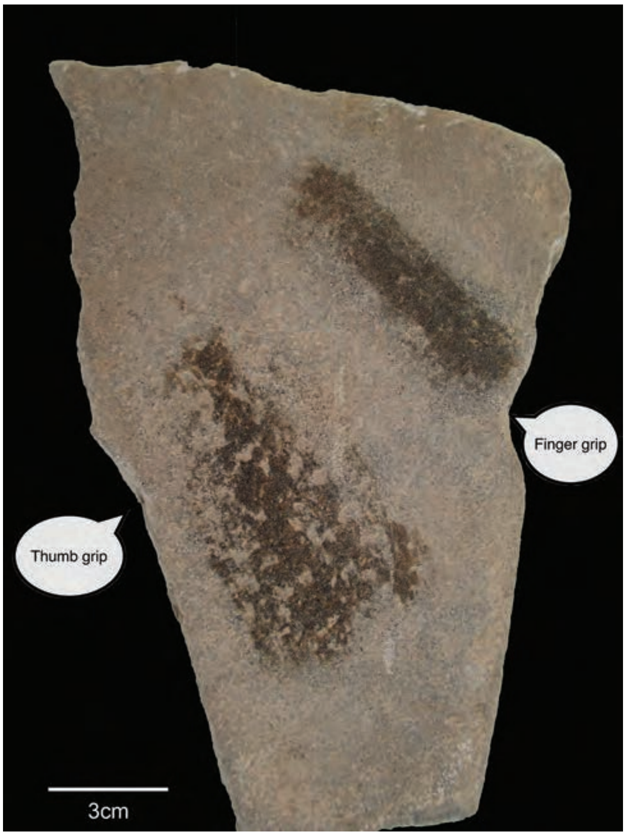


Figure 22.5. BF2267.34; wetted to show percussion marks at left-hand side of working surface.

POUNDING TOOLS (CLASS A)

The site has a wide range of upper (handheld) and lower (stationary) stones used for pounding. The 20 lower stones (anvils/worktables) were mostly heavy, with weights of 1–10kg. A few were smaller, with longest dimension less than 10cm. Many of the 69 hammerstones, predominantly made of limestone, were expedient, with little manufacturing beyond truncation to the required size and shape, although a few were reduced to a sub-spherical shape. The heaviest weighs 1–3kg, but the majority weigh 250–350g and could have been used with one hand. Not all were for heavy pounding: eight irregular stones weigh less than 50g and show small scars from pecking. A small anvil (BF2267.01) has finger-grips and showed light percussion damage (Fig. 22.5). Eight of the ten mortars are limestone and with an average weight of 4–5kg were not easily mobile. There was very little consistency in the dimensions or shape of mortars. One massive 31kg boulder mortar (SF521, Fig. 22.6) had been re-used as a doorpost pivot.

Two fragments (SF184, SF185, Fig. 22.7) of a very large round mortar with a central depression in the bowl were found together in a hearth (C1347, Space 28 Trench 9), in a cluster with a quadrant fragment of a bowl mortar (SF241, Fig. 22.8). The working surface had been used in two ways: a large outer depression shows macro-traces of reciprocal (back-and-forth) grinding, while the central round depression indicates a circular grinding motion. This could have been the result of different stages in processing or of using the stone to process different substances (cf. Hamon 2008a: 23–24). Mortar fragment SF449 (Fig. 22.9) would have been perfectly circular before it was broken. Its wall height is the same ±2mm round the rim.

There are more pestles (28) than mortars (10) and the two types were not generally found together. Nearly all the pestles are limestone or sandstone with just one of gabbro and one basalt. The majority are well-formed, shaped and pecked. River-worn cobbles were favoured as raw material, as these could easily be truncated into tools with a square or cylindrical section. Only one had been ground smooth. This might be because a rougher surface gives a better grip, particularly when processing wet material. None of the pestles has decorated surfaces. All categories of pestles have some percussion and/or grinding damage but much lighter than that on the hammer-stones, showing that they had a different mode of use: lighter pounding and pulverising. Only two pestles show bipolar use-wear, and only one has pigment traces (red; SF369 C1559). Five smaller pestles weigh less than 100g and a few over 1.5kg. The majority, however, weigh 200–800g, and could have been used single-handedly for a reasonably

Figure 22.6. Boulder mortar SF521, reused as doorpost pivot (C1763, Space 28 Trench 7). Bowl diameter 140mm. Looking west, scale = 10cm.

Figure 22.7. Bowl mortar fragments SF184 and SF185.

Figure 22.8. Fragment of bowl mortar SF241

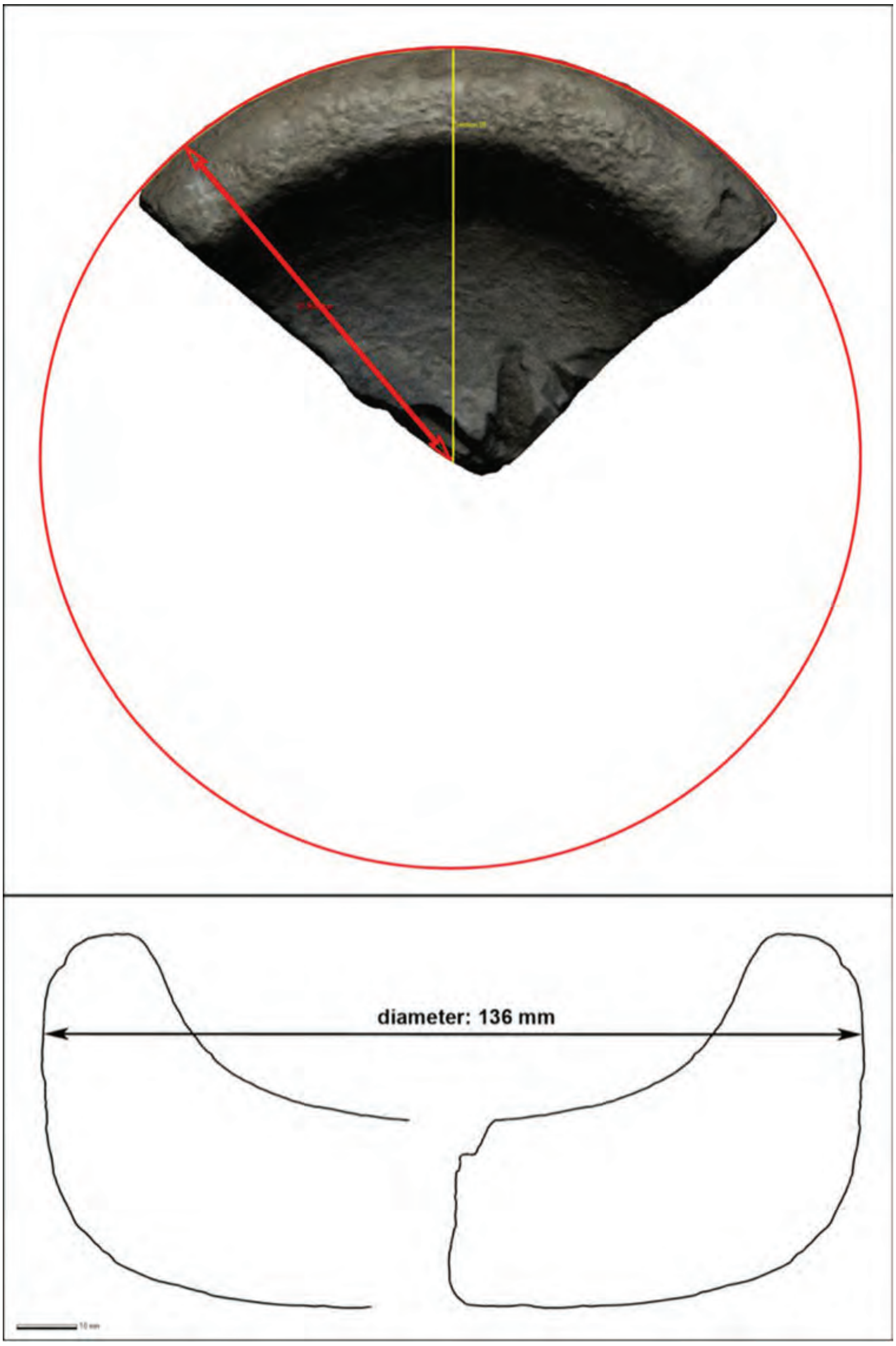


Figure 22.9. Reconstruction of mortar fragment SF449.

long period. Many of the hand-held pounding stones were found in areas where other stones and debitage suggest stone-working. One basalt brick-shaped pounding stone had been re-used in a floor surface in the uppermost Early Neolithic level of Trench 2. Some of the pestles are similar in style to examples from Jarmo, Çatalhöyük and many other Neolithic sites in Southwest Asia.

The pounding tools are likely to have been multipurpose. There are frequent scatters of bone fragments from larger mammals, smashed to obtain marrow and rendered to extract grease, a valuable dietary component on its own, or combined with other ingredients as pemmican (Morrison 2012). Grease rendering could have been used to manage seasonal caloric shortages or changes in the availability of game, or as a convenient means of carrying small-volume high-value food on hunting or foraging trips.

Figure 22.10. Grinding slab SF28 with saucer-like depression. See also Fig. 22.31.

Grease and marrow could also have been used to seal wooden vessels, and to waterproof and stop cracking in leather vessels and shoe soles. Tallow may have been used for lighting. Russell and Martin (2012) argue that at Neolithic Çatalhöyük, bone marrow and grease extraction were supra-household activities which also contributed to social cohesion.

Coarse grinding tools (Class B)

The 32 grinding slabs are the lower stones used in a reciprocal (to-and-fro) grinding process. They show a range of shapes, dimensions and probable function. Nearly all are limestone or sandstone, with two made of vesicular basalt and another of conglomerate. One sub-type, general grinding slabs, consists of tabular pieces with naturally flat parallel bases and upper surfaces, so little reduction would have been required other than truncating the sides to the required size. They would have been stable on a floor. The long axis of these grinding slabs ranges from 83mm to 409mm, and the short axis 53–249mm. Seven have a pecked upper surface with no macro-wear. They were classified as roughouts, although it is possible that they had been repecked to renew the working surfaces. Pecking, or repecking, one or two relatively small GS tools would generate little recognisable debitage and debitage would not, in any case, distinguish between initial pecking (manufacture) and repecking (curation). However, several of these pecked stones were found in external spaces with other GS tools suggestive of stone-working in association with worked animal bones.

Several sub-types of quern were identified. Nearly all are made of hard limestone or sandstone tabular slabs. The *chaîne opératoire* is the same for most sub-types. A piece of stone was selected, preferably with parallel upper and lower surfaces. The sides were truncated and flaked to make a sub-rectangular roughout. If necessary, the lower surface was flaked or pecked flat to give a stable base. The upper surface was also worked to make it flat (or angled downwards, for trough querns). Finally, the working surface was pecked to roughen it. The five saddle querns have working surfaces which are flat or slightly concave on the long axis and flat or slightly convex on the short axis, allowing ground material to fall off to their sides, and would thus have needed a mat to catch it. None shows the deeper longitudinal concavity of wear which would be expected from long use. Dimensions range from 206–415mm (long axis) and 111–240mm (short axis). Two further saddle querns have saucer-like circular depressions (6mm deep and 110mm diameter in each case) ground into their working surface which would have retained the material being ground and allowed it to be pulverised with a pestle (Fig. 22.10). The depression is similar to that seen in some quernstones from Çatalhöyük (Wright 2008 figs 8.10 and 8.11 nos 7, 8 & 10).

The six trough querns have sloping working surfaces to allow ground material to fall off. Whilst most querns show macro-wear (crushing, not striation), none is worn out. There are three quern fragments not classifiable to a specific sub-type. One of these is made of vesicular basalt. Its irregular shape makes it difficult to find comparanda from other Early Neolithic sites. It was found in topsoil and it is possible that it was made and/or deposited in a later period. A second fragment, from a secure Neolithic context, is made of an unusual gravelly conglomerate.

The upper, hand-held stones used in coarse grinding are mostly limestone and sandstone, although a higher proportion are sandstone (32%) compared to the lower grinding stones (15%). The majority are flat discoidal or flat square/sub-rectangular, of a size (longest dimension <157mm) which could be held in one hand. Five smaller irregular stones (33–66mm) could have been finger-held. Four of these show traces of red pigment on most of their surface and it is likely that they were used to abrade pigment nodules directly rather than grinding them on a lower stone. A cuboid hand-stone (SF47), of gritty green gabbro, is unusual in shape and material. Unlike flat stones, which have one grinding surface, it has six potential grinding faces, as well as its rounded edges and corners.

Fine abrading tools (Class C)

This class divides into grinding slabs (8) and hand-held abraders (77). Their mode of use would have been similar but the slabs were probably too large

Figure 22.11. Quadrant abraders.

to be comfortably hand-held. Most were expedient tools, unmodified or simply truncated to shape. Only one is well-formed, with a circular depression containing red pigment traces. From their association with other artefacts, fine grinding tools were used in stone-working, in shaping bone artefacts and possibly in wood-working and making shell artefacts such as beads. Nearly all were found in external occupation/activity deposits.

It may be wrong to read much significance into the morphology and sub-types of the abraders. Very few had been manufactured beyond preliminary truncation and there is no indication that they had different functions relating to their shape: the key to their use is the abrasive working surface. The abraders do, however, exhibit a range of hardness and of grittiness and it seems likely that they were used for different stages of manufacturing other items, analogous to the different grades of modern sandpaper.

The quadrant-shaped abrader is a common sub-type on the site (47 examples), though not recorded at other Southwest Asian Neolithic sites. The raw material is a flat water-worn river slab, usually sandstone, found today in the river-bed in slabs about the shape and size of a pitta bread, an oval *c.* 15cm long and 2cm thick. The stones selected for these abraders vary in granularity, suggesting that they were used in a reduction sequence, and probably for working different types of material. The sandstone is large-grained and hard, whereas the siltstone and mudstone are fine-grained and gritty. The stones are almost certainly manufactured simply, by being snapped in half and then in half again (Fig. 22.11).

This provides a quadrant which is easily hand-held, with its sides forming a relatively long abrasive surface. Wear is visible on prominences of the edge – few have wear on the flat surfaces. Ten of the stones have use-wear; a further 37 show no macro- or microscopic wear traces. Occasionally the edges show black patches of wear from the material being ground. These abraders are found widely across the site (Trenches 1, 2, 3, 5, 7, 10, 11 and 14), mostly in association with stone- and bone-working tools and debris. Groups were found in C1243 and C1248 (external stone-working areas in Trench 7). The pieces in these groups do not usually

Figure 22.12 Grooved abrader BF2263.01.

Figure 22.13. Elongated polisher BF0228.02 (C1029 Trench 7).

refit, suggesting that sets of stones were chosen for their different abrasive qualities.

The assemblage contains a broken discoidal handstone which has been reused as an abrader and comes from a stone-working area in Trench 7. It has a shallow, wide, U-shaped groove 50mm long on its edge (Fig. 22.12). These grooved stones have been found on many Epipalaeolithic and Neolithic sites in Southwest Asia and are generally known as 'shaft-straighteners'. Several functions have been suggested – shaping wooden sticks for use as arrows (Solecki and Solecki 1970; Usacheva 2013), bead-making (Wright *et al.* 2008: 148) or whetstones for sharpening bone or wooden points (Hole *et al.* 1969: 196; Mazurowski and Jammous 2000). The near-absence of this type at Bestansur is surprising, given that there are beads and evidence for the manufacture of arrowheads (Chapters 20 and 21).

Polishing tools (Class D)

These are the upper and lower (stationary) stones used for polishing soft material such as hide or leather. The hand-held stones may also have been used for functions where abrasion was not required, such as smoothing and burnishing plastered or pigmented surfaces. The working surfaces may be worn facets on the stones or the tip of a pointed stone and are identified by their smoothness. Few of the polishers appear to have been ground in manufacture: they were selected to be ready for use.

The only polishing slab is a large rectangular stone with flaked vertical sides and a flat stable base. Its working surface (376 × 249mm) is larger than that of a saddle quern and its long axis is flat not concave. Its working surface is very smooth indeed and would not have been effective for grinding. All edges on the working surface are rounded, perhaps so as not to tear soft materials being worked, such as hide or textile fibres.

The hand-held polishers are made from a range of rocks (limestone, sandstone, non-vesicular green basalt and green gabbro), all of which are fine- or very fine-grained. Most are discoidal and sub-rectangular. Their function as polishers is suggested by facets which are completely smooth or which show multiple very fine (<0.1mm) multi-directional striations. They may have been used to polish material with fine-grained inclusions such as plaster (Chapter 12). None has percussion damage. There are 16 elongated polishers, wedge- or finger-shaped pieces of river-rolled limestone or sandstone, with the tip as the working surface (Fig. 22.13). None of these polishers shows pigment residues or staining. They were mostly found in clusters with fine abraders or other polishers, not with lower/stationary stones such as mortars or grinding slabs.

Cutting tools (Class F)

A massive limestone boulder-worktable SF357 (Fig. 22.14; C1539, Space 40 Trench 10) is of particular interest as no similar object has been reported from Neolithic Southwest Asia and because analysis of the stone throws light on prehistoric hide-processing. This 35kg stone is sub-triangular in shape with one side narrowed by flaking. It has two opposed working surfaces. The stone surface is smooth and fairly even with no sharp edges. A greasy-looking sheen is present across one working surface and several irregular shiny black patches 20–40mm in diameter, which are unlike the dark stains found on stone from ashy contexts or those caused by manganese staining. Most of this surface and the shoulders shows gloss. Both surfaces have some post-depositional concretion adhering. No pigment adhesion or staining is apparent and the pale yellowish grey colour of the stone appears natural.

On the opposite working surface are multiple cutmarks and striations (Fig. 22.15). They are mostly

Figure 22.14. Boulder/worktable SF357 (see also Figs 9.27 and 21.15). Scale = 50cm.

Figure 22.16. Boulder/worktable SF357 – possible drilling template. Pattern of holes 10 × 10mm.

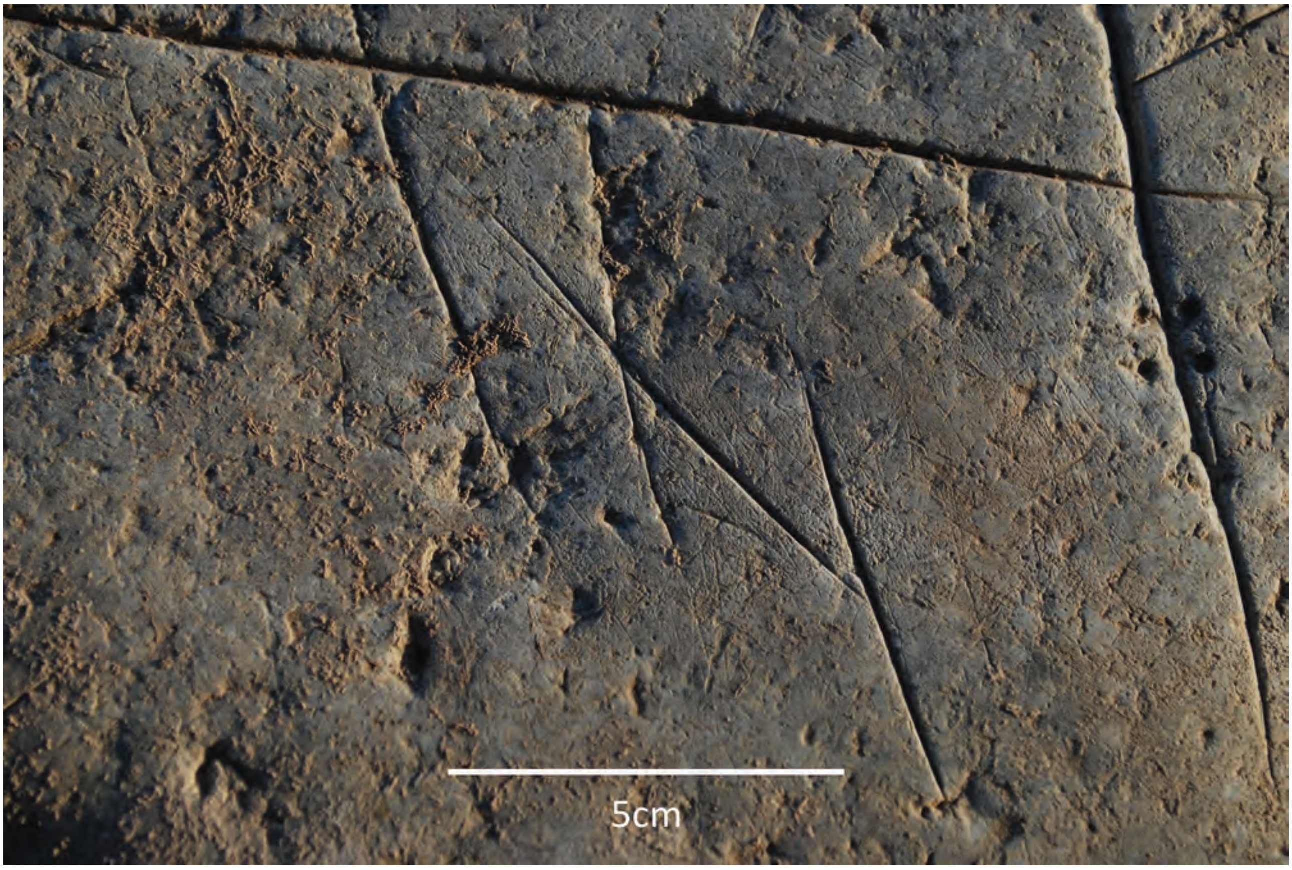


Figure 22.15 Boulder/worktable SF357 - cuts and striations.

on the flat surface, but some extend to the shoulders. The deeper cuts (2–3mm deep 1–2mm wide, up to 30cm long) are V-shaped, made by repeated scoring with a sharp blade, and the shallower cuts (<0.5mm deep) single-stroke. Some have adjacent chip scars, possibly indicative of heavy pressure on the cutting blade. The shallow striations could have been made by a fine abrasive substance, possibly sand or powdered pigment. On either side of one deep cutmark are four small (1–2mm diameter) round holes with circular internal striations (Fig. 22.16).

The ethnographic and ethnoarchaeological literature identifies four main stages in processing animal hides to make leather (Adams 1989: 269–272; Dubreuil 2001b; Hamon 2008b; Dubreuil and Grossman 2009 and references; Rifkin 2011 and references):

- Cleaning the hide (removing hair from the outside, and fat and grease from the inside) either by immersion in lye, or by scraping, or both. This stage involves rubbing with an even stone surface which will not tear the hide.
- Tanning, to stop the hide putrefying or desiccating. This can be achieved by applying plant tannins, animal fat, wood ash, powdered minerals, smoke or combinations of these substances. Ochre reduces odour, increases resistance to larval and fungal infestation and makes the hide more pliable. The tanning substances may be applied by rubbing with a stone, and the hide can be dried after this stage.
- Softening by vigorous rubbing with a ground stone in order to break the collagen fibres. A suede-like nap can be made.
- Finishing with ochre: applied at this stage it will colour and harden the hide (if this is functionally required, for example for buckets, quivers or shoe soles).

Final stages in the manufacture of leather products would involve cutting the leather to shape, piercing holes for sewing and sewing the leather pieces together. Leather clothing might be decorated with shells or beads. Studies have focused on the hand-stones used to rub the hide, rather than a possible supporting surface. Ethnographic evidence tends to suggest that hides were stretched over a frame (Semenov 1964: 89–91); only Dubreuil (2008b) and Hamon (2008b) describe the effects on a lower stone.

From this research it seems likely that that only hide-processing would have produced the surface sheen, shiny black patches and striations on the Bestansur stone. Adams reported similar experimental results of sheen and wear which matched the surfaces of hand-stones used by Hopi people to work hides (Adams 1988). One surface of the Bestansur stone may therefore have been used as a table for polishing hides to remove grease and hair, softening and stretching tanned and dried hide and the opposite surface for cutting and drilling the finished leather. The bored holes may have formed a template for drilling holes in the finished leather so that it could be sewn together in the desired shape for items such as clothing, footwear and containers. Using a template would reduce the likelihood of breaking or blunting a borer. Processing of textile fibres for products such as matting, or grinding minerals, would produce a similar distribution of polish and percussion scars (C. Hamon, pers. comm.), though not the cutmarks or drilled holes. The stone was found in an open space in front of Building 5. Hide processing and making leather products might involve the use of chert blades and scrapers and bone needles, but these are absent from this context. It is possible that the stone was not used in this location, or that other materials were cleaned away after use. A red ochre patch was found in the context.

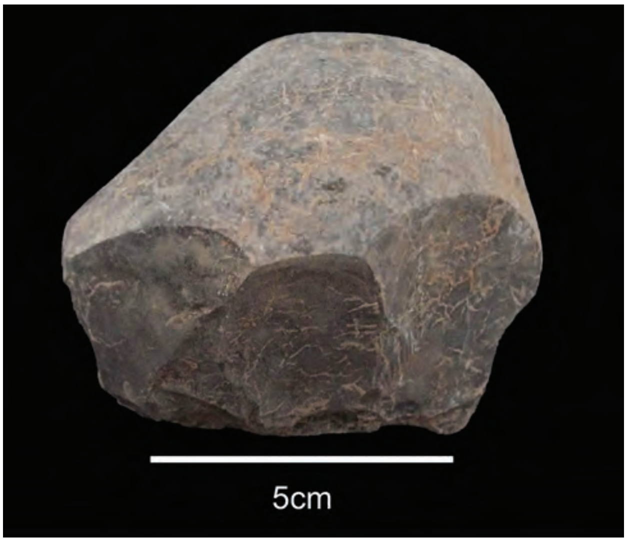


Figure 22.17. Basalt chopper BF0802.01.

In the cutting tools class are five choppers. Two are made of basalt and the others of limestone (Fig. 22.17). They are heavy river cobbles (152–781g), truncated and flaked to give sharp, though not acutely angled, edges. They are similar to the 'pics' used in stone-working in contemporary Guatemala described by Hayden (1987b). Four of the five were found in external areas where other GS tools and debitage suggested stone-working.

Only one possible axe/celt was found in the Bestansur assemblage in 2011–2014. It is made of hard fine-grained limestone, ground and polished. The flattened end has slight percussion damage suggesting that it was hammered in use. The stone tapers towards the other end but a large fragment of the tip is missing. This type of tool is common at many Southwest Asian Neolithic sites and it is surprising that only one has been found at Bestansur. A possible reason is that axes were used primarily in felling trees and chopping wood, and the inhabitants of Bestansur used dung, reeds and rushes as fuel rather than wood (Chapters 12, 13, 16 and 18). Similarly, no hoes have been found, although they might be expected in an agricultural settlement. Hoes may have been left in cultivated areas of the settlement rather than in the structured zones which have been excavated. These absences are discussed in more detail elsewhere (Mudd 2019).

VESSELS (CLASS H)

Fragments of seven vessels were found, none complete, and all found in external areas. They are discussed in more detail in Chapter 21. Six are made of limestone and one alabaster. All were found in external areas. There were no macro-traces to indicate what they contained. One has pitting on its internal surface so may have been used to process material.

The base and rim diameters of two of these fragments, when complete, are estimated at 120/160mm and 140/170mm respectively and the walls are 10–16mm thick at the base. Neither is particularly well formed though the internal surfaces are smooth. This form is known in the Northern Fertile Crescent and Zagros in the second half of the eighth and the seventh millennia BC (Kozlowski and Aurenche 2005: type 3.1.2), and there are examples from Jarmo J-II (Adams 1983: fig. 102 type BC 7, 10 & 11). The absence of complete vessels and the very small size of fragments suggest post-abandonment scavenging.

Weights (Class W)

This class includes several types of tool where weight seems to have been significant in determining their mode of action. The first is given the label of macehead, although their actual function is debated. The tool type, a spherical or piriform stone with a central perforation, is found in many places in Southwest Asia from the Early Neolithic to the Bronze Age (Kozlowski and Aurenche 2005: type 2.2.4.2). They are uncommon before the Ceramic Neolithic in both the Levant and the EFC and so their presence at Bestansur and their varied characteristics are of interest.

The first example is an oblate spheroid alabaster stone, circular to within 1mm and weighing 363g, with a slightly flattened top and base. The ball's surface is ground and polished with a conical hole drilled halfway through. A second, narrower, hole is drilled from the bottom of the first through to the other side of the ball. This hole shows polish consistent with stringing. The ball's circumference shows light percussion damage.

The second ball is a broken hemispherical object with incomplete biconical drilling and, when complete, would have weighed 700–800g. The external surface is uneven with large percussion scars presumably from manufacturing. Drilling was attempted before shaping was complete. The external surface has reddened areas from burning, and blocky scars probably due to thermal fracture. This seems likely to have been an unfinished macehead which broke due to manufacture and was then reused as a potboiler.

A third perforated stone (SF183) is possibly a macehead broken in manufacture and is much smaller than the others, weighing 35–45g when complete. Its raw material, quartzite, is unusual and not local. The top and bottom were ground flat to prepare for drilling and the two incomplete perforations were offset, not opposite each other (Fig. 22.18). It was found in association with animal bone and molluscs.

The fourth macehead is an oblate spheroid 88mm in diameter and 82mm high, weighing 542g, ground to an almost spherical shape and very highly polished (Fig. 22.19). The raw material is a fine-grained chocolate coloured marble with a bright yellow vein running through it. Nothing else from this raw material was found on site and its provenance is unknown. There is a facet on the base, ground flat and polished. This facet has a centrally drilled hole 47mm deep (halfway through the stone), 23mm diameter at the surface tapering to 1mm, and offset from the stone's vertical axis. Diametrically opposite this is a second hole, 23mm deep and 18mm diameter at the surface. This has been drilled without prior flattening of the surface. The two holes are offset and would not meet if continued. A third hole has been started but not completed. It truncates the second hole, is 8mm deep and 11mm in diameter at the surface tapering to 5mm. If continued, it would meet the first hole. There are some small percussion scars on the base. They cut through the polished surface, so are likely to be from use rather than manufacture. There is no use-wear on the round surface of the stone. It was found in the fill of an oven installation (Space 48) in Building 5, though it has not been heated. The oven had a mortar and saddle quern placed at the base and top of its fill. The exotic material, lack of use-wear on the rounded surface, and its location, suggest strongly that this was not a utilitarian object, and that its role was symbolic. To the modern eye, it seems odd that the careful selection of the raw material and its painstaking manufacture were not matched by the execution of the perforation. Whatever its significance at this stage, it was not necessary for the stone to be completely perforated.

How should we interpret these artefacts? The classification, function and significance of the stones known as maceheads are all problematic. Most commentators define them as globular or sub-spheroidal stones with biconical centrally drilled perforations, which would enable them to be strung or hafted (Wright 1992a; Rosenberg 2010 and references; Rowan and Levy 2011 and references). If hafted with a stick, this might be fixed with binding or an adhesive such as bitumen or resin to hold the stone in place (although I have found no published examples of maceheads with such residues). Shaft holes are not always straight, an obstacle for hafting though not for stringing. The artefacts are generally noted as being 50–70mm in diameter and weighing 100–200g, with perforations having a minimum diameter of 10–15mm. There are, however, numerous examples outside these ranges, and three of the four Bestansur examples are much larger and heavier. They usually have a prepared platform with the top and bottom ground flat, ready for drilling. There is a distinct preference for light-coloured raw material, particularly white limestone. They are known in the Levant, Egypt, northern Syria and EFC from the PPNB in the Levant through to the Early Bronze Age, and their characteristics and uniformity vary over time and geography. Perforated stones from published

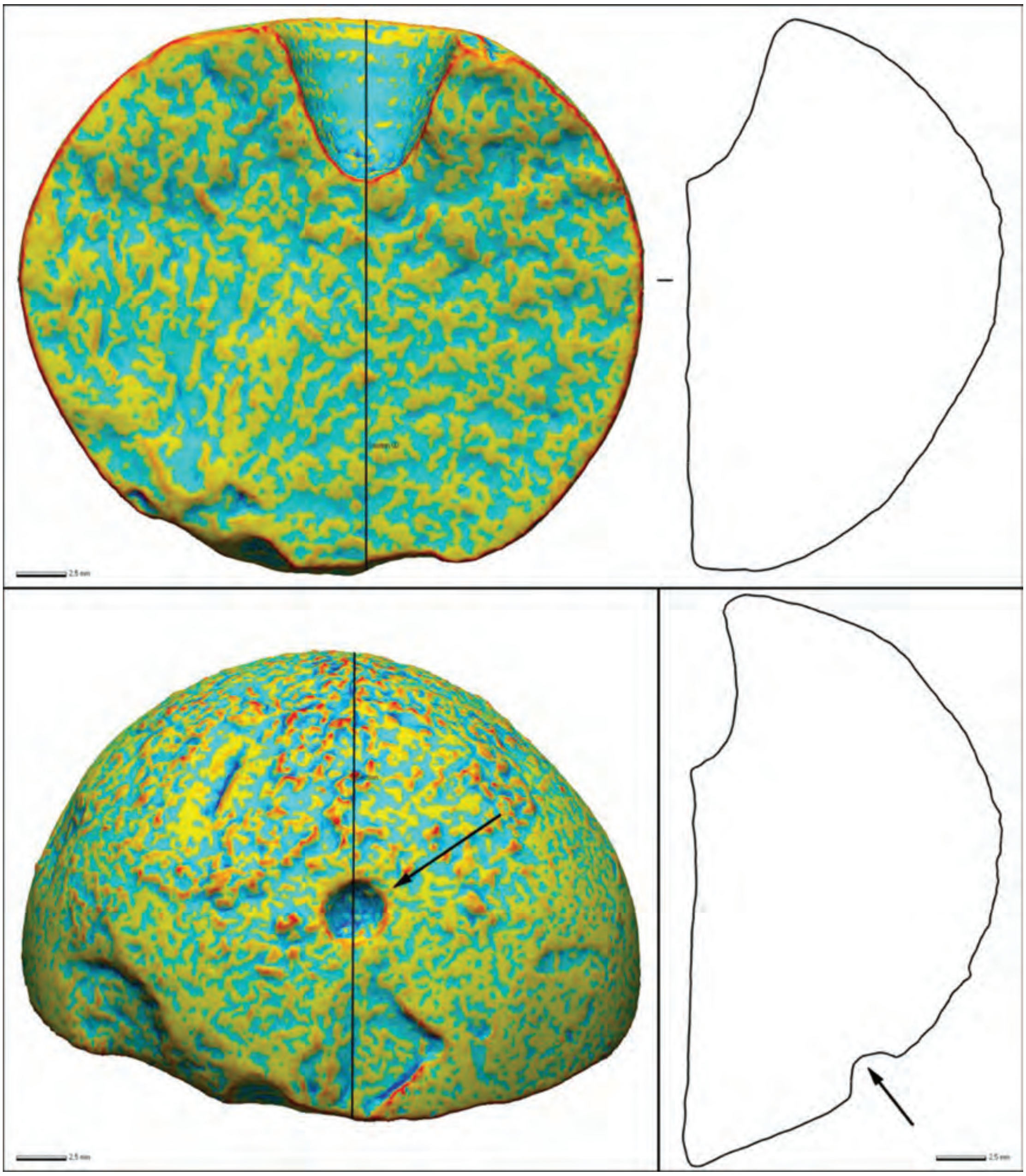


Figure 22.18. Cross-sections of macehead SF183 (false colour). The artefact was carefully shaped, then drilled. The incomplete drillings are at an angle to each other, not directly opposed. Initial incomplete drill hole shown in lower picture; second drill hole (upper picture) caused object to split.

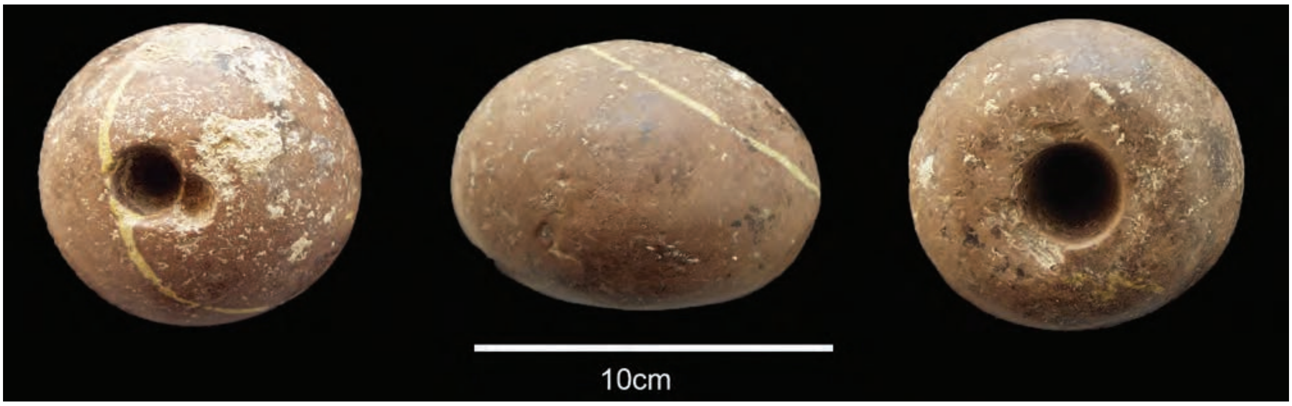


Figure 22.19. SF450 Marble macehead: upper (l) and lower (r) surfaces.

Table 22.4. Published examples of perforated stones from the EFC.

Site	*Period/ date*	*Perforated stones*	*Material & dimensions*	*Reference*
Mureybet	Natufian–PPNA	None		Cauvin 1977
Jerf el Ahmar	PPNA	Two flat discs; one stone ring [*not maceheads – DM*]		Stordeur 2004
M'lefaat	PPNA	One complete and one fragmented oblate spheroid	Limestone, biconically drilled. 97 × 36 mm; 467g. Shaft diameter 8mm.	Dittemore 1983
M'lefaat	PPNA	Four types of globular macehead identified, seven stones.	Mudstone, siliceous rock, basalt; biconically drilled. 100–120mm diameter	Mazurowski 1997
Nemrik 9	PPN	67 stones of which 42 finished/ complete. Mostly from houses. Some with burials, intentionally broken	Shale, sandstone, limestone, conglomerate, marble, siliceous. Biconically drilled.	Mazurowski 1997
Jarmo	PPN	Fourteen	7 marble. Diameter mostly 70–95mm; height 50–60mm, flatter than Bestansur examples	Moholy-Nagy 1983
Maghzaliyah	Pottery Neolithic	Flat perforated discs: three found next to each other 'apparently strung together' *[pendants not maceheads – DM*]	50mm diameter, perforation 5mm	Bader 1973
Tell Sabi Abyad	Chalcolithic	3 fragments (split in half), from house areas	Basalt, gypsum. 60mm diameter.	Collet and Spoor 1996; Huigens *et al*. 2014

This author's comments in italics.

sites from the EFC in the Neolithic and Chalcolithic are itemised in Table 22.4.

Many examples were found broken, usually in half through the top–bottom axis. If biconical drilling was incomplete, it is often suggested that the stone split in two when being drilled. There are hardly any examples of refitting pieces, however, and no examples of a damaged stone being recycled as another tool type. Detailed find locations are not often specified but of those which are, inside houses seem to be common, with a few coming from burials. This suggests that the broken maceheads were not discarded in stone-making scatters. The exceptionally high number of maceheads recovered at Nemrik 9 is especially notable.

Whilst these are the commonest characteristics of 'maceheads', there are other perforated stones which are cylindrical or biconical. Some are flat discs, and there are others which are wider than their height, with broad perforations, resembling doughnuts. A few, particularly from older excavations, are clearly beads or pendants (Braidwood *et al.* 1952; Bader 1973). Some researchers group all these together as 'perforated stones', and others divide them into functional groups such as 'maceheads', 'digging stick weights', 'spindle whorls', 'bolas balls' and 'flywheels'. However, use for pounding or as a bolas would result in a larger area of percussion damage than just a band round the circumference as seen on SF21. Strictly functional interpretations do not explain the selection at many sites of white limestone as the preferred raw material.

These classifications tend to be based on ethnographic analogy; very few studies consider macro-wear or micro-wear, or have attempted to replicate functions experimentally. An exception is Mazurowski, who used a macehead set on a wooden rod tipped with a flint borer to drill stone, bone and wooden ornaments. The added weight of the macehead speeded up the drilling and reduced the displacement of the drill point in rotation (Mazurowski 1997: 86). He suggests that this may have been one use of an artefact type which was multi-functional.

In spite of these widely varying definitions of form and function there is a surprising degree of unanimity about their significance and few researchers have explored whether the function or significance of these artefacts changed or remained the same over the four millennia in which they are known. In the context of the southern Levant they are generally regarded as a Chalcolithic and Early Bronze Age tool type, possibly originating in Mesopotamia, and there are suggestions that their morphology shows Egyptian influence by the Early Bronze Age. Golden *et al*. suggest that they may have substituted for copper maceheads at the beginning of the Early Bronze Age when the supply of copper was constrained (Golden *et al.* 2001). They have generally been studied from a morphological-typological perspective (Gopher and Orrelle 1995; Levy 1995; Rowan and Golden 2009; Rowan and Levy 2011). They are assumed to be weapons, either for actual hand-to-hand combat or as symbols of regal or divine authority and power (Yadin 1963; Sebbane 1998 cited in Rosenberg 2010; Sebbane 2009). There is some

Figure 22.20. Fishing net weights SF317 (C1514 Trench 12) in situ.

skeletal evidence for interpersonal violence (Haas and Nathan 1973; Mazurowski 1997: 86; Dawson *et al.* 2003), which might support the argument for maceheads as weapons.

A different view of maceheads has been taken by other commentators (Rosenberg 2010; Shimelmitz and Rosenberg 2013; Rosenberg and Garfinkel 2014). They point to flaws in the interpretation of maceheads as hand-to-hand weapons. The shaft hole is too narrow to contain a strong stick as a handle. A thin handle could not have sustained the shock of a blow, or of repeated blows, from another weapon. I would add that a stone which so easily and frequently split during manufacture may have been unreliable in hand-to-hand combat. The macehead itself could not inflict much injury. They tend to be small, ground and polished, with sharp edges and projections removed. The contact surface area was thus diffuse and it would be unlikely to cause penetrating injury and bleeding. Wooden clubs with sharp stone inserts (such as harpoons or spears) would have been nastier weapons and would have kept the combatant at arm's length from an opponent. I would further argue that the apparent absence of damage to the exterior of most maceheads suggests they have not been used in combat. Whilst hitting a human body would not damage the stone, high-energy contact with an opponent's macehead would almost certainly leave percussion scars. Shimelmitz and Rosenberg argue that other artefacts in this period with the potential to be used as interpersonal weapons – slingstones and transverse arrowheads – also have dull edges. The authors suggest that the maceheads in the Late Neolithic, Chalcolithic and Early Bronze Age may have been used in low-level fighting, which may not have had the intention of killing, unlike warfare. They cite ethnographic evidence of fighting between individuals, with set rules about scheduling (often during festivals or as rites of passage), selection of weapons, single or multiple participants, supervision (often by elders), visibility (often in front of an audience) and how the winner is decided. This low-level fighting can relieve interpersonal or inter-community tensions but breaches of the rules may lead to outright warfare. As Table 22.4 shows, the frequency of this weapon type in prehistoric Southwest Asia was low and thus not indicative of a society where warfare was common or organised.

The Bestansur maceheads represent a significant addition to the corpus of this artefact in the EFC. The dating of the site means that they are relatively early examples of this artefact type and there is good information about their contextual and physical characteristics. Stone maceheads in the EFC are under-researched compared to those of the Levant and have the potential to improve our understanding of intra- and inter-community relations in the long period of prehistory in which they are present. A reappraisal of known examples would be of value.

The weights class includes four spindle whorls, flat stone discs with central perforation. Two of these fragments refit. Another significant type of weights not reported from elsewhere are interpreted as net sinkers.

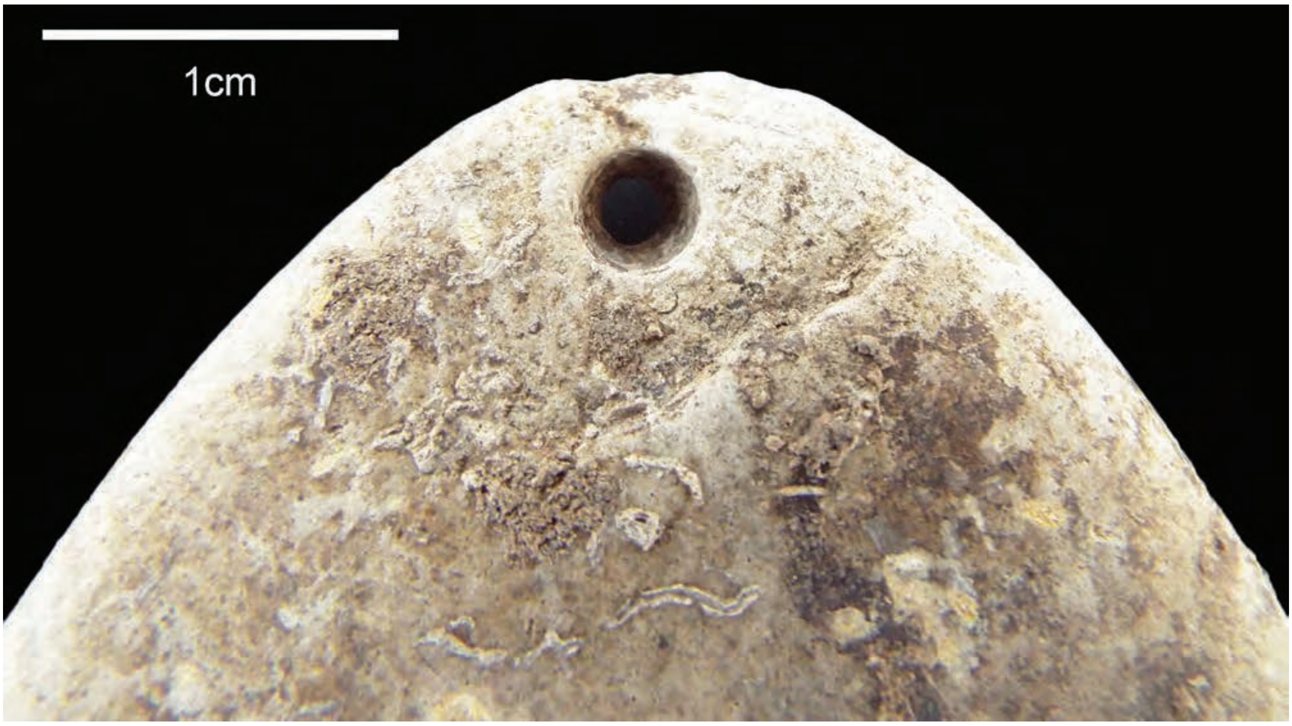


Figure 22.21. Fishing net weight showing worm casings and boring by Polychaeta. Diameter of perforation 3mm.

These are two groups of flat perforated stones, found in two caches in midden-like occupation deposits. The larger (Fig. 22.20) consists of 34 pieces of flat sub-round hard fine-grained limestone, found in a cluster. Four pieces refit making 30 original objects. All the stones are 40–60mm diameter and 6–10mm thick and weigh *c.* 75–150g. They are expedient water-worn river pebbles that have been truncated but not otherwise worked. Many were truncated more than once, to form sub-triangular or quadrant pieces. Sixteen of the 30 have perforations, presumably for stringing, close to an edge or corner, with a maximum diameter of 3–5mm, indicating that the stringing was thin. Eighteen have been deliberately broken (several have strike points) but only four of these were broken through the perforation. The 11 stones in the second cache (C1523) are very similar. Two further individual examples came from Trench 7. Many of the pieces have sinuous calcareous concretions 10–20mm long 1–1.5mm wide, which are the casings of a fresh-water worm *Polychaeta* (Fig. 22.21; Glasby and Timm 2008). There are also small indentations in the stone surface caused by worm action.

The stones are too heavy for pendants and do not show the handling gloss which would be expected from pendants that have been worn as ornaments. A more plausible explanation is that they are sinkers for a gill net, attached by stringing to the bottom of a fishing net (Muñiz 2010). A cord line, or floats, keeps the net vertical. Fish swimming into the net are trapped by their gills or fins. The worm takes 12–14 days to produce the cast which suggests that the net was left in the flowing water, with trapped fish being collected periodically. The worm casts, and small percussion marks on the artefacts, are very similar to those seen on stones on the present river-bed. Similar stones, though without worm casts, have been recorded from Ceramic Neolithic/Early Chalcolithic Sha'ar Hagolan, also close to a river (Rosenberg and Garfinkel 2014: 149–152 Type G2). A mesh impression on the base of a clay vessel fragment stylistically dated to the Ceramic Neolithic has been found on the Bestansur mound surface and has been speculatively interpreted as a fishing net (Nieuwenhuyse *et al.* 2012). The imprint is an impression of an impression: the vessel had been formed on a surface on which the netted textile had previously left its imprint. Whilst this find is from a later period, it is additional supporting evidence for the use of fishing nets in the Early Neolithic.

Four fragments of large perforated sub-round stones were found in surface levels. They were roughly made and pecked but not dressed, weighing 700–1400g. The edges of the perforation have been rounded, to prevent the string fraying. Although unstratified, these objects have prehistoric comparanda at Arslantepe (Frangipane *et al.* 2009) and in Neolithic Beidha (Kirkbride 1966) and Khirokitia, Cyprus (Frost 1984). The Bestansur examples may have been used as sinkers for fishing lines. I have seen similar stones used as thatch-weights in a village near Jarmo.

I interpret a further type of weight as slingstones. These are six nearly spherical ground limestone balls with diameters 25–33mm and weighing 18–48g. All have percussion damage to their surface.

Miscellaneous worked stone (Class X)

This class contained a range of types. Three small sub-spherical stones interpreted as possible tokens or gaming pieces, discussed further in Chapter 21. A piece of limestone containing nummulite fossils was found with another containing a lump of blue chert. These unusual objects may have been kept as curios. Five small tear-drop shaped objects, 9–52mm long were found in topsoil and cleaning contexts. Four are white alabaster and one black marble (Figs 20.14 and 22.22). All have been ground and polished, with a flattened facet at the thicker end, perhaps shaped to be held between finger and thumb, and tapered to a blunt point. Their function is unclear but may have been to retouch chipped stone tools.

Eighty-three pieces of irregular worked stone could not be attributed to a recognisable tool type. The majority are tabular/angular pieces of limestone with roughly truncated sides, with a longest dimension of *c*. 30–120mm. They were mostly found in external areas and seem likely to have been paving stones or hearth linings. Stones with these functions were noted at the Neolithic Zagros sites of Jarmo and Gird Ali Agha (Braidwood and Howe 1960: pl. 13A–B).

Cores and debitage (Class Y)

The presence of numerous cores and deposits of flaked limestone debitage show that the primary method of producing 'ground' stone tools was flaking rather than grinding. Many of these pieces show characteristic knapping traces – bulbs of percussion, dorsal arrises and flake scars, radial lines from the point of percussion. Abrasion of hard stone raw material is a very slow way of achieving the required shape. Some fragments, found with fire installations, showed thermal fracture and traces of burning and had been used as hearth base lining or cooking stones. Several clusters of debitage contained both limestone and sandstone flakes. This suggests that (hard) sandstone percussion tools were used to manufacture (slightly less hard) limestone tools. The sandstone fragments were either percussion chips or resharpening flakes.

Unworked stone (Class Z)

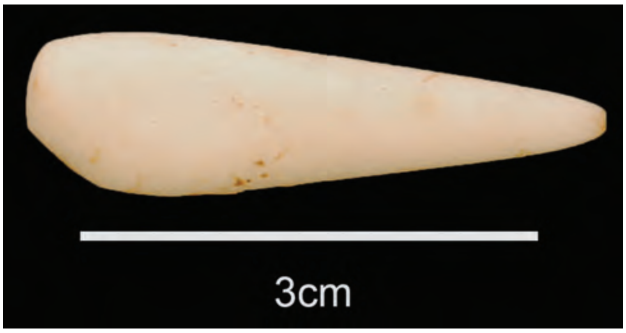


Figure 22.22. Possible retouching tool from Bestansur, SF25.

The final class consists of 197 pieces of unworked stone, nearly all limestone and sandstone, with a total weight of 140kg. The majority are river cobbles or tabular pieces from bedding planes. Although unworked, they must have been brought to the settlement by human action. None shows percussion damage or macro-wear. Most are from external areas, in contexts with ashy deposits, bone and shell, indicative of fire installations used for cooking. These stones are likely to have been used as cooking stones and potboilers.

Shimshara

Eighteen GS artefacts and a small quantity of debitage were recovered from the Shimshara excavations (Table 22.5). They are not of particular interest, except for BF2199.06, a 35mm long teardrop-shaped basalt stone with finger-grips, possibly used for retouching chipped stone (Fig. 22.23). Other stone artefacts such as beads and bracelets were also found and are discussed in Chapter 21.

Bestansur: spatial and contextual distribution

Classifying the functions of GS artefacts by techno-typology is conventional but can hide relationships between artefacts in different classes. The catalogue gives the same BF number to groups of stones found together. Sometimes these are arbitrary groups found in the same context, but some appear to be functional groups. These include groups of the same tool type in different sizes and/or raw materials. One such cluster consisted of two general abraders, one quadrant abrader and an elongated polisher. Others were sets of different tool types e.g. BF2039 which included

Table 22.5. GS finds from Shimshara. See Table 22.2 for raw material definitions.

	A1	*B2*	*B4*	*B7*	*C1*	*C2*	*Total*
A 2 Hammer-stone	0	1	0	0	0	0	1
C 2 Abrader	1	1	0	0	0	0	2
H 98 Vessel fragment	0	2	0	0	3	0	5
W 6 Stone ball	0	3	0	0	0	0	3
X 9 Retouching tool	1	0	1	0	1	0	3
X 99 Misc. worked stone	0	1	0	3	0	0	4
Y 4 Debitage	0	0	0	1	0	1	2
Total	2	8	1	4	4	1	20

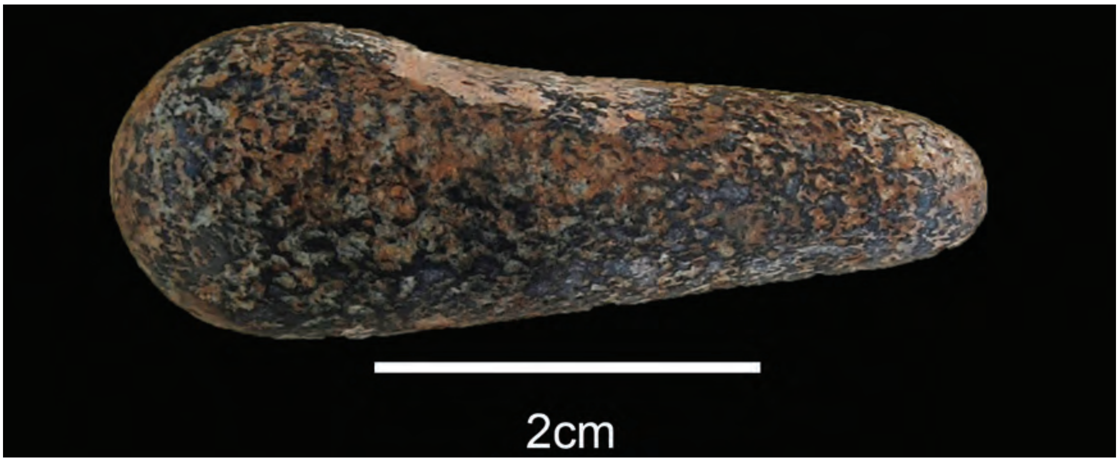


Figure 22.23. Possible retouching tool for chipped stone, Shimshara (BF2199.06 C1320).

Figure 22.24. Tool set including hammer-stones, hand-stones and polishers (BF2039).

Table 22.6. Distribution of GS items by context period (number and %).

Class	*Neolithic*	*NL/Post-NL mixed*	*Post-NL*	*Topsoil/ surface*	*Total*
A Pounding tools	80	3	30	5	118
B Coarse grinding tools	35	1	27	12	75
C Fine abrading tools	48	2	29	8	87
D Polishing tools	18	1	19	0	38
F Cutting tools	5	0	2	0	7
H Vessels	3	0	3	1	7
W Weights	57	0	12	3	72
X Misc. worked stone	71	0	29	1	101
Y Cores & debitage	120	1	12	3	136
Z Unworked	159	1	37	0	197
Total	596	9	200	33	838

Class	*Neolithic*	*NL/Post-NL mixed*	*Post-NL*	*Topsoil/ surface*	*Total*
A Pounding tools	68	3	25	4	100%
B Coarse grinding tools	47	1	36	16	100%
C Fine abrading tools	55	2	33	9	100%
D Polishing tools	47	3	50	0	100%
F Cutting tools	71	0	29	0	100%
H Vessels	43	0	43	14	100%
W Weights	79	0	17	4	100%
X Misc. worked stone	70	0	29	1	100%
Y Cores & debitage	88	1	9	2	100%
Z Unworked	81	1	19	0	100%
Total	71	1	24	4	100%

hammer-stones, hand-stones and polishers (Fig. 22.24) as well as debitage and unworked stone. The converse possibility should also be borne in mind: GS items which were excavated from different contexts but which were associated with each other in the past. Table 22.6 shows the distribution of GS items (number and %) by the chronological period of the context in which they were found. At first sight it may seem odd that more Neolithic objects were found in post-Neolithic contexts than in the mixed contexts immediately above the Neolithic layers. There are three possible reasons for this apparent leap-frogging. First, the top of the mound, containing Neolithic items, has eroded considerably, redepositing Neolithic items above the mixed layer at the base of the mound. Particles of sedimentary matrix will have been washed further downslope, leaving larger items such as GS nearer to the base of the mound (Limbrey 1975: 89–91, 236). Second, the area surrounding the mound has been subject to modern ploughing, which is known to bring heavy items to the surface (Lewarch and O'Brien 1981 and references; Schiffer 1987: 129–132). Experimental research and ethnographic observation have shown that the heavier the object, the more likely it is to be brought to, and remain on, the surface (Baker 1978). During the excavation project, the field immediately surrounding the site was ploughed annually until it was fenced off in 2016, and I found freshly uncovered GS artefacts on the field surface each season. The third possible reason is that GS objects from Neolithic layers were scavenged, reused and redeposited by later occupants of the site. The balance between these causes is unclear.

Are the Bestansur GS tools Neolithic, or do some date from later periods? Insofar as it is possible to assign GS tools to a chronological period on the basis of their morphology, all the tool types and sub-types described in the previous section are consistent with the types described in earlier classifications of GS tools from the Neolithic of Southwest Asia, particularly Wright (1991; 1992a; 1993), Wright *et al*. (2013) and Kozlowski and Aurenche (2005). The new types and sub-types described above were all excavated from Neolithic contexts. Miscellaneous worked fragments used to make floor surfaces in Iron Age contexts in Trench 7 have been excluded from my analysis. The excavation of Trench 14 showed no Neolithic occupation, and thus might be expected not to contain Neolithic GS artefacts. However, the seven GS tools found in Trench 14 were nearly all from contexts of disturbed ploughzone, and all have stylistic equivalents from Neolithic contexts in other trenches. This suggests that they were Neolithic artefacts displaced by ploughing or slope-wash. Of the seven artefacts from later contexts in Trench 14, four were indeterminate worked fragments and the three tools were recognisable Neolithic tool types. It seems safe to say that the GS artefacts analysed above are attributable to the Neolithic occupation of Bestansur, although it is possible that some may have been retrieved and reused in later periods.

Table 22.7. Number and density of GS items by trench.

Trench	*Unstrat*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12–13*	*14*	*All*
A Pounding tools	1	2	3	0	0	2	0	41	5	14	41	4	5	0	118
B Coarse grinding tools	2	2	1	0	0	0	0	33	0	4	28	4	0	1	75
C Fine abrading tools	7	4	5	3	0	1	1	38	0	0	20	5	0	3	87
D Polishing tools	0	1	3	0	0	0	0	12	0	0	15	3	1	3	38
F Cutting tools	0	0	2	0	0	0	0	2	0	0	3	0	0	0	7
H Vessels	0	0	0	0	0	0	1	1	0	1	2	1	1	0	7
W Weights	0	0	1	0	0	0	0	9	2	1	9	2	48	0	72
X Misc. worked stone	0	12	2	0	0	2	0	53	0	8	17	3	0	4	101
Y Cores & debitage	3	1	4	0	0	1	0	45	2	23	54	1	2	0	136
Z Unworked	0	7	1	0	1	0	0	93	2	4	65	11	12	1	197
Total	13	29	22	3	1	6	2	327	11	55	254	34	69	12	838
Excavated surface area of trench, m^2 (2014)		20	4	3	4	4	4	36	4	36	240	10	34	50	449
Objects per m^2		2	6	1	0	2	1	9.1	3	2	1.1	3	2	0	1.9

Figure 22.25. Space 16 Trench 7 during excavation, looking north. Scale 50cm. Grid squares c. 80 × 90cm.

One clearly anthropogenic feature of the assemblage's stratigraphy is that artefacts made of green igneous rock (gabbro and green basalt, from the Penjween area some 30–40km distant) were all found in the upper third (by height) of the Neolithic layers. Hardly any debitage from these rocks was found. This suggests that these items were brought to the site as finished goods, and that they were imported (or at least deposited) later in its Neolithic occupation.

In considering variations in GS across different sectors of the site, Trenches 7 and 10 have much higher numbers of GS than the other trenches, to some extent due to the larger size of excavations in these areas (Table 22.7). Trenches 7 and 10 also have much higher numbers of cores, debitage and unworked stone, and it is clear that the manufacture and maintenance of GS artefacts was taking place in these locations. Two locations are worthy of detailed study here.

Trench 7, Space 16

Expansion of the 2 × 2m sounding to a 6 × 6m trench in Summer 2012 revealed a large rectilinear room 2.2 × 2.4m, bounded by earthen walls, which were not themselves excavated. Within this room, in an occupation deposit C1243 and C1255, 98 GS items were deposited in discrete clusters. In order

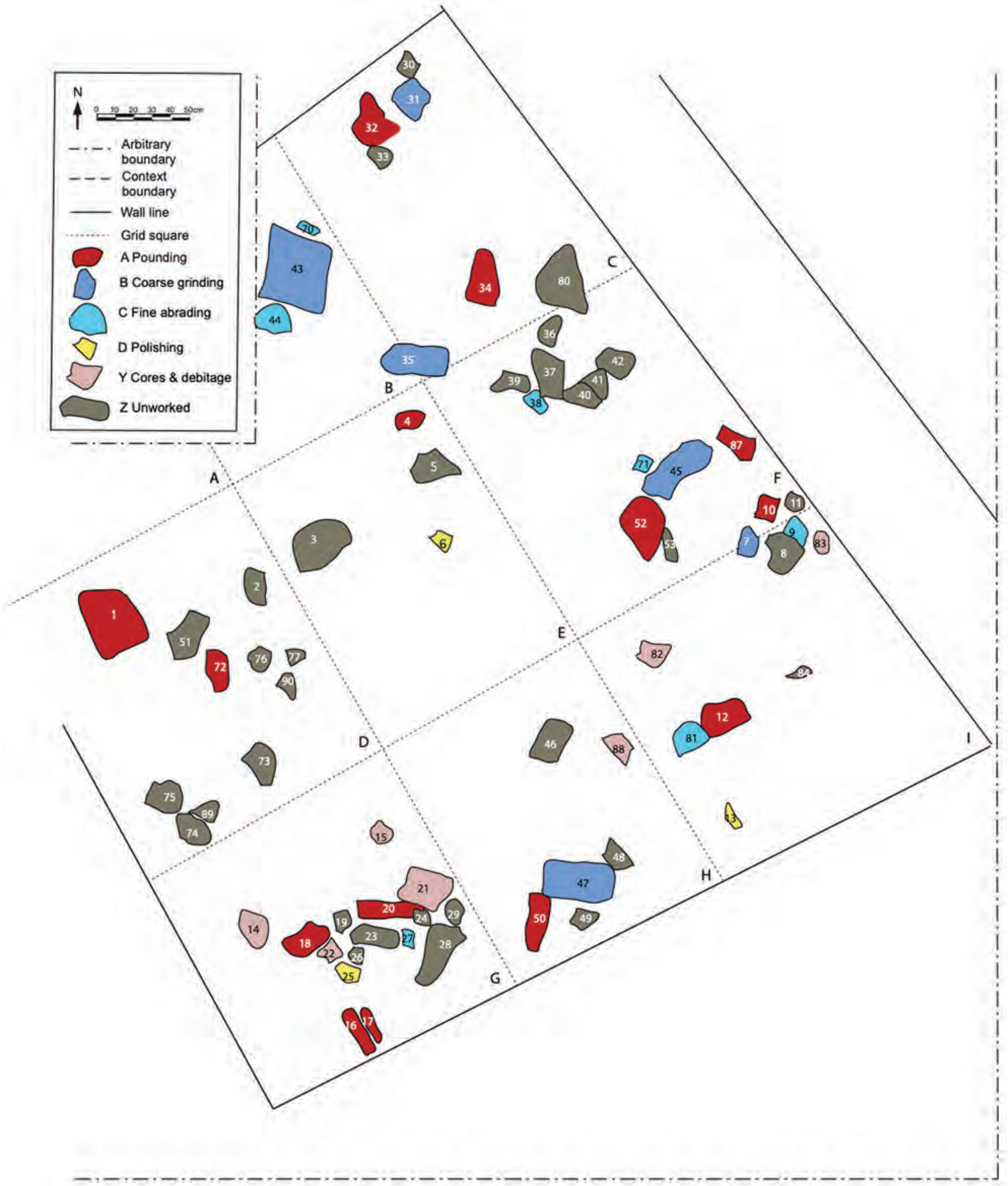


Figure 22.26. Space 16 Trench 7: GS classes.

to detect patterns in the clustering of artefacts and wet-screened and floated materials, the excavation area was gridded into nine squares A–I, *c.* 80 × 90cm (Figs 22.25 and 22.26).

The locations of 69 stones were recorded. The stones included hammer-stones, anvil, abraders, hand-stones, polishers, grinding slabs, pestles, a quern, unworked blocks, miscellaneous worked pieces and debitage. All were limestone or sandstone – there was no unusual raw material. Most of the stones were deposited in small groups (sometimes piles) of 5–15 stones, each in an area *c.* 50–100cm across. These groups appeared to be sets of stones – most had one or more percussion tools (hammer-stone, pestle, anvil/slab), and a coarse abrader. Only three groups had fine abrasion tools. Each group had one or more blanks or pre-forms for recognisable tool types and unworked stone. Chert tools were found in direct association with the GS (Chapter 20). Unworked stone was mostly in an east–west line in squares D, E and F. Debitage was found mostly in squares G, H and I. Square E has fewer GS pieces than the others. The stones are likely to represent sets of tools and materials.

The activities associated with this area are difficult to interpret. There were no large quarried blocks, so this was not preliminary stone reduction. There were many pieces of unworked stone, though most were too small to have been made into the common tool types. Levels of micro-artefacts from wet-sieving were low, with very little GS micro-debris, so we are not seeing the manufacture or repecking of GS tools. The pounding and grinding tools have all been used but did not show so much damage or wear that they required repair. There were few polishers, so this does not appear to represent hide or bead processing. There are food-processing tools but relatively few bone fragments. It seems that we are looking at tools used for a combination of different activities, not necessarily all done at the same time, for which the necessary sets of tools were kept to hand until needed. The area with fewer stones in Squares E, D and H may represent a workstation but it seems unlikely that such a large number of toolsets would be needed for use by one person. The clustering of the Bestansur stones may represent the contents of bags or baskets, perhaps associated with different individuals (A. Stroulia, pers. comm.). The deposition of the stones may have taken place over a band of time, not in one event.

There are three comparable stone groups from published Southwest Asian sites, which may help to explain the group in Sp16. The first is Zone B2 at Tepe Ali Kosh (Hole *et al.* 1969: 42–45; fig. 10). In an external area between and inside two buildings were dozens of grinding slabs, hand-stones, 'sash weights', pounders, pestles, abraders and others – a broad range of GS tools. There were flint blades, piles of butchered animal bones, fragments of mat and basket impressions. The houses contained sub-floor burials. The area was interpreted as a dump or working area after the abandonment of the houses. The second is a stone scatter outside House 1 at Nemrik 9 (Mazurowski 1997: 71; pl. lxiv). This group contained large elongated polishing stones, flint balls and grinders and Mazurowski interprets the area as a stone workshop. Because of the number of stones (unspecified, but possibly *c.* 200) he concludes that it must have functioned for a relatively long period.

The third example is from Building 77 at Çatalhöyük (Tsoraki 2018a). The building contained 413 GS artefacts from the same phase of occupation, bone tools and large quantities of faunal and botanical remains. Tool types included grinding stones, particularly large querns, pestles, polishers and axes. These were distinctively arranged on the floors and platforms of the building. Broken fragments were concentrated along the edges of the main room. The manufacturing investment in these GS tools was higher than the norm for GS on the site, and the quantity of grinding implements exceeded by far the number of implements which individual households possessed. The building had been destroyed by a burning event after the deposition of the cultural assemblage, and Tsoraki interprets the material configurations and burning as ritualised practices. The selection of GS tool types represented routines of daily life, particularly food processing and consumption, associated with the building and its occupants: a "narrative of household history".

Storage is one possible explanation for the Bestansur cache. The toolsets may have been stored during the users' absence from the site, for example for seasonal herding, and thus may represent seasonal activity. Stone tools obviously do not need to be protected from the weather but their possible organic/basket containers would have been kept dry by indoor storage. The storage of sets of tools suggests that they were regarded as private property, to be kept in a private secure location. On the other hand, the cache may represent a deliberate permanent deposition of GS tools with a symbolic meaning, like the Çatalhöyük example. In either case, it suggests also that there was a sub-group, or network, of individuals in this part of the settlement (or extended household) who used, and/or made, GS tools. I will return to this possibility later.

Trench 10, Space 50

Space 50 in Building 5 also has significant deposits of ground stone, but this room differs very significantly from Space 16. Space 50 is the largest area in Building 5, at *c.* 4.7 × 7.6. Space 50 contained multiple human burials, distributed in several phases of the building (Chapters 9 and 19). There are articulated infants in the packing under floors, disarticulated bones in the floors, and a partially articulated adult in the upper fill.

The stone deposits in Space 50 are diverse. A large, long stone served as a threshold or doorsill at the entrance to Space 50 from Space 47. A 20cm wide band of small (0.5–3cm) fragments of white limestone gravel was deposited along the internal sides of Walls 52 and 45 on a packing layer below the floor of Space 50 (Fig. 22.27). Gebel (2002) considers that wall-related stone deposits associated with burials at Late PPNB Ba'ja and Basta in Jordan may have had a symbolic significance related to the perceived magical power of walls as boundaries, an interpretation which fits well with the human burial focus in Space 50 at Bestansur.

A mixed deposit, probably wall collapse (C1746), covered the floor and contained two GS items. BF5776.01 is a long flat sub-rectangular block of

Figure 22.27. Band of gravel (C1782) lining walls of Space 50. Scale = 50cm.

Figure 22.28. Groups of stones in Space 50. BF5333: foreground; BF5775: far corner of excavation, and large stone in the threshold. Looking south; scale = 50cm.

unmodified raw material. The second, BF5773.01 (7.1kg), is an unfinished quernstone. Further debitage fragments were found in the fills above this (C1745, C1733) suggesting that GS manufacture took place in this phase of the building, or on the roof and collapsed into the fill. Two groups of stones (BF5333 and BF5775) were revealed in C1604 (Fig. 22.28). These clusters consist of:

- eight long, narrow stones, each weighing 2–5kg, water-worn but unmodified apart from a few small percussion marks on the tip of one. These were laid closely fitting, next to Wall 41, near the doorway. These carefully placed stones have virtually no macro-wear and no associated debitage. They may have functioned as a flat rectilinear platform for laying out bodies in preparation for burial;
- a green stone artefact, BF5333.09 (green gabbro, 1.4kg). This has been shaped, ground and polished, but shows no signs of use-wear. It is the shape of a roughout for a large axe, although it has no bevel or cutting edge, nor any sign of hafting. The stone is probably too brittle to have been used as a tool. It seems to be a finished artefact, though its intended use is unclear. The green stone of the axe-like object is non-local, and not common at the site. Miniature green stone axes ('herminettes') have been found close to burials at PPNB Yiftah'el (Khalaily *et al.* 2008: 7) and PPNC Atlit Yam (Galili *et al.* 2005: 9). The Bestansur stone may have had symbolic significance;
- a further group of stones in the southwest corner of the room (BF5775). This consists of two large hammer-stones with percussion scars at one end, an irregular fragment, probably debitage but large enough to be a blank for a small tool, and another large flat quern, deposited inverted, though possibly later in the life of the building.

Reports of GS tools deposited in association with Early Neolithic human burials are rare, but there are similarities with funerary levels at the ninth millennium BC site of Tell Qarassa, Syria (Santana *et al.* 2015: 122). These tools were in an abandoned house and its courtyard. The burials were associated with caches of GS tools including querns and polished axes, clay figurines and greenstone beads. The authors suggest that the querns may have been used to prepare food during funerary rituals. It seems very likely that as well as their practical functions, the stones in Space 50 have a symbolic meaning associated with the burials and the end of a phase of occupation of the building. These two loci serve to show the functional and symbolic use of GS in Early Neolithic Bestansur and are a reminder that the quotidian and ritual roles of stone were inextricably linked.

Functions of GS: summary

Using morphology, traces of manufacture, use and discard, together with spatial analysis, a wide range of probable or possible day-to-day uses for GS can be inferred:

- making stone tools
  - smashing, flaking, pecking and abrading stone in order to make other GS tools;
  - pressure flaking to make and retouch edge tools from chert and obsidian.
- obtaining and preparing food
  - as weights, to be used in hunting and fishing;
  - grinding and pounding vegetables, cereals and possibly meat, to prepare them for cooking and consumption, using mortars, querns and pestles
  - fire-stones and potboilers, to cook food;
  - as vessels and containers, to hold food;
  - hammerstones and anvils for smashing animal bone to enable marrow and grease to be extracted for their nutritional and industrial/craft value.
- making products from other materials
  - to smash and abrade animal bone which could be made into tools and ornaments;
  - to process animal hides, with possible uses such as clothes, shoes, shelter, buckets;
  - a number of grinding and abrading tools show traces of mineral pigment, which could be used for body decoration, colouring/dyeing textiles and leather;
  - to stir and apply bitumen as an adhesive e.g. for hafting tools
  - to fashion personal ornaments (beads, bracelets, necklaces, decoration for clothing) made of stone, shell and bone.
- architectural
  - as structural components (door-post pivot, threshold);
  - smashing and grinding other hard materials such as pigments and minerals in order to make plaster and colour it;
  - applying plaster to walls and floors, and burnishing it.

The placement and treatment of certain stones and patterns suggest a possible symbolic or ritual role, integrated within these practical activities.

Fragmentation

Chapman (2000: 23–27), studying pottery artefacts from the Neolithic in southeastern Europe, identified five possible causes of fragmentation:

- accidental breakage (before or after deposition)
- objects buried because they are broken
- deliberate 'killing' of objects to diminish their ritual power
- breaking and dispersing objects to ensure fertility
- deliberate breakage for re-use in enchainment, circulating objects to create and maintain relationships which link individuals, groups and places.

He considers that the absence of the missing part is strongly suggestive of intentional breakage. Breaking an object prevents it being used for its original purpose: it ends, both practically and symbolically, the life of the object, and may mark transition to an 'afterlife'. The fragmentation of GS artefacts, particularly those relating to food preparation, into quarters and deposition inverted is well-attested in North America and Europe (Walker 1996; 1999; Adams 2002: 43; 2010; Chapman and Gaydarska 2006; Stroulia 2010; Anderson-Whymark 2011; Watts 2012), and in Southwest Asia from the Epipalaeolithic onwards (Gamble 2004; Nadel 2011: 483). Inversion may be particularly significant for artefacts which contained foodstuffs. They are empty and, buried upside-down, cannot be used to hold food again. Ethnographic evidence suggests a range of implications, including the death of the stone's user (Adams 2010).

Figure 22.29. BF499.01 mortar fragment, showing impact scars on internal surface.

Many of the Bestansur GS artefacts are incomplete, having been broken in use, particularly those with a pounding mode of action such as pestles broken by end-shock, and stones thermally fractured by use in cooking or fire installations. As well as these 'wear and tear' breakages, there are some examples of apparently deliberate fragmentation of GS artefacts. All the vessel remains were fragmentary (Chapter 21). A quadrant of a mortar, from a surface in Trench 2, shows clear impact scars on its internal surface (Fig. 22.29). It was recovered inverted, with no sign of the other fragments.

SF184 and SF185, two refitting quadrants of a massive mortar, are another example (Fig. 22.30). They were recovered from a hearth installation C1347 Trench 9. The active surface was not worn out: the

Figure 22.30. Hearth installation C1347 Trench 9 in situ. Fragments of massive mortar SF184/185 (left), deposited inverted. See also Fig. 22.7. SF241 Quadrant of bowl mortar SF241, lower right. See also Fig. 22.8. Scale 50cm.

working surface was rough, and the base was thick enough to have allowed repecking. The mortar was broken in half, with hinge scars on the edges of the fractured base. This half was then broken into two pieces. The fragments were deposited upside-down in a fire installation. The other half has not been recovered. It seems very unlikely that such a massive stone could have broken accidentally, or by thermal fracture. In the same context was a quadrant of a bowl mortar SF241. Again, this could only have been broken deliberately. It is perhaps significant that all the deliberately fragmented artefacts have a grinding or food-related function.

We have no way of unravelling the meaning of the intentional breaking of the stones. But the deliberate breakage is strong evidence that the functional and symbolic roles of the stones were interlinked.

Discussion

Comparanda

The range and typology of the Bestansur ground stone are typical of the Early Neolithic in the Zagros foothills, Central and Southeast Anatolia and to a lesser extent the Levant (Table 22.8). Similar individual artefacts are seen at Jarmo (Braidwood *et al.* 1983; Moholy-Nagy 1983), the Deh Luran Plain sites (Hole *et al.* 1969), Çayönü (Davis 1982), Çatalhöyük (Baysal and Wright 2006; Wright *et al.* 2013), Nemrik 9 (Mazurowski 1997), and PPNB Jericho (Dorrell 1983). Bestansur has a few sub-types not yet seen elsewhere, but they are not so different as to represent unique cultural traits. The perforated net sinkers and sandstone quadrant abraders are simply variations in tool design in order to exploit local stone and food resources. Taken as a whole, however, the assemblage is missing some types and quantities of artefact which might have been expected from an Early Neolithic site in the EFC. There are no plates, no complete bowls or vessels, and only one (possible) grooved abrader. Unlike Jarmo and the Deh Luran sites, there are hardly any chopping/cutting tools – only one possible axe/celt (broken), and no hoes. The absence of axes is notable and correlates with the sparsity of charred wood. Relatively few artefacts at Bestansur exhibit the more intensive stages of manufacture such as pecking, grinding and polishing, and there are relatively few pieces of non-local or ‘exotic’ stone.

Processes of deposition, abandonment and post-abandonment

These processes complete the use-life of the stone tools. They are important to the interpretation of the site because they represent the cessation of the tool’s functional utility and also because they can throw light on how the settlement’s Neolithic inhabitants

Table 22.8. Number of selected tool types at selected PPN sites.

Site	Bestansur	*Ali Kosh & Tepe Sabz (PPN phases)*	*Çatalhöyük*	*Çayönü*	*Chogha Golan*	*Jarmo*	*Jericho (PPNB levels)*	*Nemrik 9 PPNA–B*	*Tell Sabi Abyad II*	*Tepe Guran PPNB–PN*
Zone	Zagros	Zagros	C Anatol	SE Anatol	Zagros	Zagros	S Levant	N Iraq	N Syria	Zagros
Complete tools (n)	368	597	1353	957	57	414	356	2696	367	155
Tool fragments (n)	46	29	2380	1813	n/a	1903	125	54	239	30
Frags as % complete & frags	11%	5%	64%	65%	n/a	82%	26%	2%	39%	16%
Grooved abrader (shaft-straightener)	1	1	21	7	2	7	8	0	0	5
Bowls & vessels: complete	0	21	14	0	0	0	43	18	2	7
Bowls & vessels: fragments	6	15	30	12	0	1323	73	0	80	27
Celts, axes	1	115	131	84	0	64	1	81	5	0
References		Hole *et al.* 1969	Wright *et al.* 2013	Davis 1982	Conard and Zeidi 2013	Adams 1983; Moholy-Nagy 1983	Dorrell 1983	Mazurowski 1997	Huigens *et al.* 2014	Mortensen 2014

Some tools reclassified by the present author using original author’s description/illustrations, to enable comparability – may differ from original author’s classification.

expressed the functional and symbolic value of the GS tools.

The absence of some artefact types, and those with a greater manufacturing investment, suggests that at the time of abandonment of the buildings which the project has excavated, items of perceived value were removed to other unexcavated areas of the settlement (and possibly to other settlements). Their absence from the archaeological record, if real, thus gives us an indication of the categories of tools which were considered important enough to retrieve. What remains is biased towards broken or discarded fragments, heavy artefacts which were inconvenient to carry, expedient or unfinished tools which could easily be replaced, and pieces whose symbolic significance required that they should be left in place. This pattern is consistent with evidence from ethnoarchaeological studies of the abandonment of activity spaces and structures (Schiffer 1987; Joyce and Johannessen 1993; Tomka 1993; Tomka and Stevenson 1993; LaMotta and Schiffer 1999). The extent of excavation so far is not sufficient to draw conclusions about whether the absence or low numbers of some tool types represent the abandonment of some spaces or buildings whilst people continued to inhabit other areas of the settlement, or whether we are seeing the complete abandonment of the settlement. A wider excavation of the settlement might find locations where these tool types are present and might throw further light on the processes and sequence of abandonment of buildings. What is clear, however, is that the abandonment seen in the present excavations was not sudden: there was time to remove, or retrieve, useful stone objects.

A significant proportion of the artefacts are fragmented, suggesting deposition at the end-of-life of the object, whether through breakage during use or symbolic. Those which remain have often been deposited in contexts with symbolic or special significance such as the burial area in Space 50 Trench 10 and Space 16 in Trench 7.

Selection and manufacture of raw materials

The GS assemblage shows adaptation to, and exploitation of, the local environment. Nearly all the stone is from local sources, the limestone outcrop and the river, within a few hundred metres of the site. There is good evidence that blanks were brought to the site for manufacturing as there is evidence of every stage of manufacture. Some of the large blanks weigh up to 45kg, supporting the inference that they were brought from not far away.

The artefacts made of non-local stone are infrequent, with a total weight of only 14.5kg. They could theoretically have been brought to Bestansur by one person in a single journey, and so they do not prove *regular* trade or exchange with a more distant supply source. The virtual absence of debitage from non-local stone is also interesting, suggesting that the artefacts were most likely to have been brought to the site already manufactured and that the place of reduction and manufacture was elsewhere, presumably close to the quarrying site. This would have eliminated carrying overland any unnecessary weight of stone, as also seems to have been the case with the chipped stone (Chapter 20). It would also ensure that the manufacturing stages with the highest risk of accidental breakage and spoiling were done before the stone was carried back to site. Two possibilities exist. First, people from Bestansur went to the distant quarry site to obtain raw material and manufacture artefacts *in situ*, bringing only the finished tools back to their settlement. Second, the finished artefacts were obtained from a different group of people who had manufactured them. In either case, artefacts made of these materials do not appear to have been subsequently curated at Bestansur. The artefacts of non-local stone were all recovered from the upper contexts (top one-third, by height) of the Early Neolithic levels, suggesting that the importation (or, at least, the deposition) of these finished goods was conducted later in the life of the settlement.

The location of large quantities of stone-working tools in Trenches 7 and 10 suggests that manufacturing and/or curation took place here, in contrast to other currently excavated locations. There are two possible explanations for this, and they are not mutually exclusive. One is that because the industry was dirty, dusty, and left sharp debris, it was done in abandoned structures, away from occupied residential buildings. The storage or discard of stone tools in Space 16 Trench 7 tends to support this interpretation, as do, in contrast, the clearing and redeposition of debitage in and around Building 5, Trench 10. The second possibility is that stone-working was done by specialists within the community. Are there hints of early craft specialisation in stone manufacture? Costin's work on craft specialisation views it as a feature of economic, rather than technological, specialisation – a way of meeting production requirements for consistent quality products to meet a demand, either from a large group or from elites (Costin 1991). Baysal (2013: 239) suggests different parameters for the development of Neolithic craft specialisation, such as the creation of a surplus of goods and labour to support and enable exchange, reciprocity (payment or gift exchange), technical skills, production based on demand, and culturally-specific typologies.

Making GS tools, however, is not a high-volume production process. We have only 414 tools from *c*. 500 years of occupation of the excavated area of Bestansur. The great majority of GS artefacts were expedient or roughly shaped, with the minimum

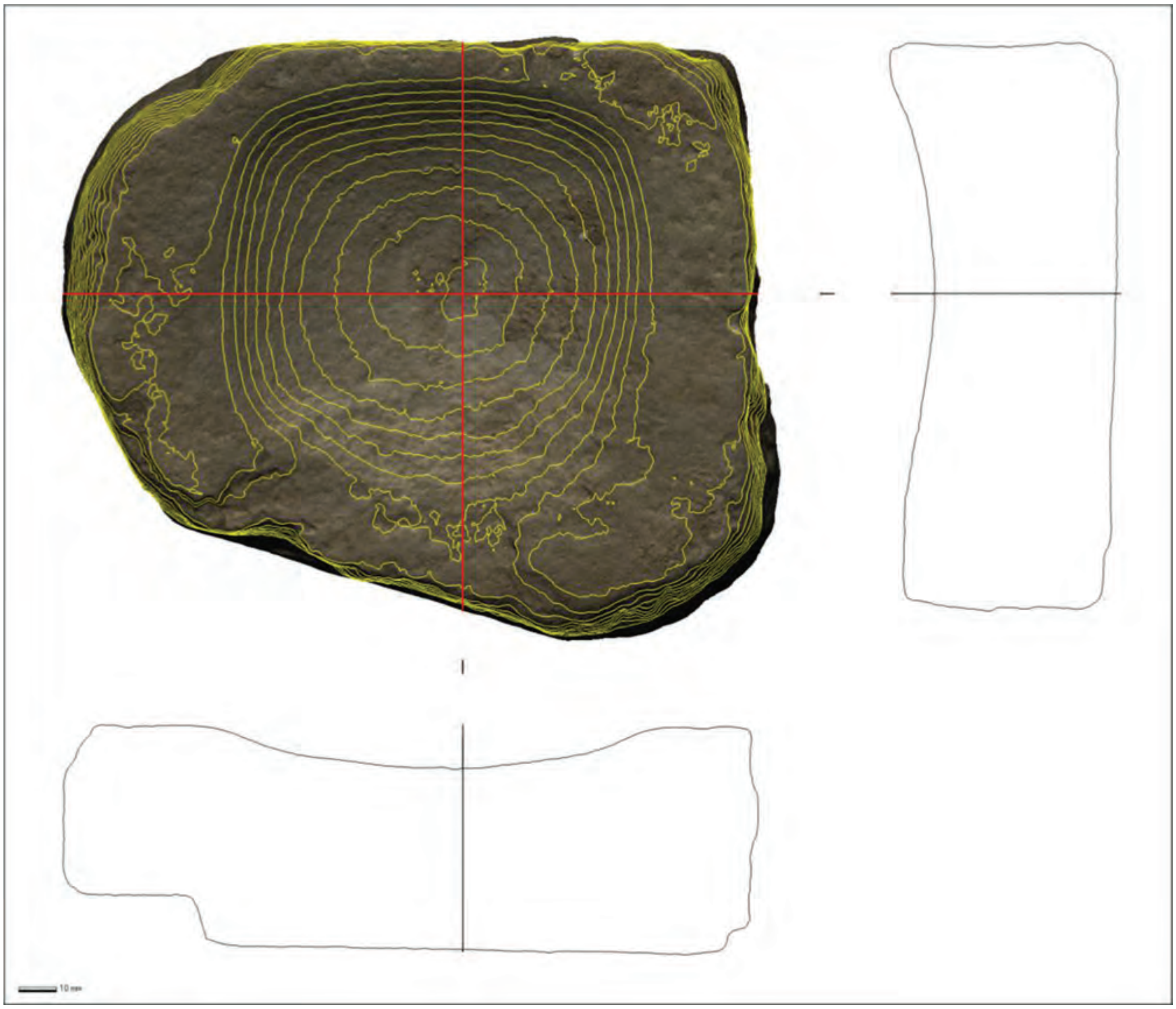


Figure 22.31. Curvature map of grinding slab SF28. See also Fig. 22.10.

investment of time and labour necessary for their function. In modern terms, their manufacture was efficient. There are, however, examples of GS artefacts carefully made to symmetrical designs, such as the mortars, vessels and maceheads. 3D reconstruction of a bowl mortar fragment BF449 (Fig. 22.9 above) shows that the outside wall of the artefact would have been completely circular.

Some of the GS tools show a degree of standardisation. Two grinding slabs BF460.04 and SF28 were found in the same location, some 40cm vertically apart, and are made of the same limestone raw material. The higher stone was probably moved by post-depositional action such as ploughing. Although SF28 was manufactured from a thicker and heavier stone than BF460.04, the working surfaces of the grinding slabs are almost exactly the same size and shape: saucer-like depressions 120mm in diameter and 6mm deep (Fig. 22.31). The lowest part of both depressions is *c.* 40mm diameter. They were designed for grinding with a rotary motion and would have held relatively small quantities of material. Neither shows signs of heavy/prolonged use-wear. The consistent dimensions of the working surfaces suggest that they were manufactured to the same design, possibly by the same maker, and used similarly.

There is little evidence of mis-hits in manufacturing or curation, although drilling holes seems to have been a challenge. There are four examples of 'maceheads' and perforated stones which have split when being drilled. These examples give a clue as to variations in the manufacturing sequence. SF21, a spherical alabaster ball, was carefully ground with a diameter circular to a tolerance of <1mm. It has a symmetrical conical perforation. SF183 (Fig. 22.18 above) was rounded before it was drilled, and a shallow initial drill hole was made, before the larger one which split it. The fresh face which was revealed is worn and damaged, suggesting the broken artefact was then reused as a percussion tool. SF45, on the other hand, was only roughly shaped before it broke.

The oblate spheroid SF450 was made of a rare and attractive brown marble with a yellow band, and ground and polished to a high standard. Perforation, however, was awkward and faulty: there are two incomplete holes drilled from opposite sides of the stone which would not have met in the middle and a third hole which was not finished (Fig. 22.19 above).

There are no locations at Bestansur which might be considered workshops, with large quantities of raw material and debitage (Wilke and Quintero 1996; Balkan-Atlı and Binder 2000; Rosenberg *et al.* 2008). The cache of stored raw material and part-made tools in Trench 7, Space 16 contained very little debitage. The relatively small amount of debitage recovered from the 17 other instances of stone-working suggest that these represent small-scale events, the manufacture of one or two tools. The concentrations of cores, debitage and unworked stone in Trenches 7, 9 and 10, and their virtual absence from Trenches 4, 5, 11 and 13, suggest that certain areas were selected for stone-working. It does not seem to have been done across all the settlement. These loci were not devoted solely to working GS. The activity was co-located with other tasks such as food processing, knapping chert, working bone, producing lime for plaster and depositing refuse. These activities may have moved around the settlement depending on the season, as found at Hajji Firuz Tepe (Voigt 1983: 297) and Çatalhöyük (W. Matthews 2005), due to variables such as climate and the birthing season for domestic animals.

The perforation of maceheads notwithstanding, the examples above show that occasionally the makers of stone artefacts at Bestansur used a higher level of standards and skills perhaps not essential to the practical function of the artefact, which may have given the artefacts and/or their makers and users, an enhanced status. From Bestansur it is difficult to identify incipient craft specialisation and even more difficult to use it as evidence for increasing social complexity (Wright 2014). The evidence presented here suggests that the Bestansur GS is the work of individuals with specific knowledge and skills, using these to exploit the resources available in their environment, in order to solve problems in their daily lives. Stone-working at Bestansur was conducted at a small domestic scale, and is visible in the context of domestic activities.

Diachronic change in the use of stone

Radiocarbon dating suggests a range of about 500 years for the eighth millennium BC use of the site (7700 to 7100 cal BC; Chapter 11), although it is not yet clear whether occupation was continuous within this timespan. Some diachronic changes can be seen in the GS assemblage. Rarer raw material and better-finished artefacts tend to be seen in the upper levels of Trenches 7, 9 and 10, though not exclusively. This may be an indication of more extensive exchange networks in the later stages of occupation. Redeposition of Neolithic tools is seen in post-Neolithic levels, although those found in the topsoil may have been moved upwards by modern ploughing.

Dorrell notes a change in the selection of tool types between PPNA and PPNB at Jericho (Dorrell 1983: 527). From the PPNA levels there were 253 pestles and 172 vessels (mortars), whereas the PPNB levels yielded 61 pestles and 210 mortars. He suggests that preparation of grains in the PPNA involved pounding and crushing because of the greater proportion of husked grains (needing dehusking), and perhaps because brittle-rachis cereals had to be harvested earlier in the season. In the PPNB, however, the emergence of naked-grain cereals and of tough-rachis varieties which could be harvested riper, and later, meant that grinding without dehusking was sufficient. Bestansur has 29 pestles and 10 mortars, but 32 lower and 46 upper grinding stones. This suggests that grinding was a more common function than pounding, although we cannot say how much of either was related to food preparation: these classes of tools are multi-purpose. It is interesting to note that the grinding stones themselves often show little sign of the wear which would be expected from prolonged use (Schmaltz 1960: 247; Voigt 1983). Most working surfaces are flat or only slightly concave.

Overall, however, it is difficult to assign individual artefacts to a specific period in the occupation of the Bestansur settlement. Stone artefacts have long use-lives and suffer very little natural degradation. Further radiocarbon dating results for stratigraphic sequences may help to give *termini ante quem* for some GS artefacts in them.

Food procurement, preparation and consumption

The range of food procurement tools and preparation utensils implies a mixed diet of meat, fish, cereals, vegetables and pulses. There is little clear evidence of stone tools designed for use in agriculture/horticulture, such as hoes and digging-stick weights. The small size and location of fire installations (a few tens of centimetres wide) and GS artefacts associated with food do not suggest that we have found locations for large-scale feasting. The evidence of food preparation and cooking within compounds suggests that these were private rather than communal activities, in contrast, for example, to early levels at Jarmo (W. Matthews 2016; 2018). Hardly any of the mortars and querns have above-average sized working surfaces which might have indicated use to process large quantities of food for feasting, but food preparation for large-scale consumption could have been a

Table 22.9. Association between identifiable activities at 28 selected locations, Trenches 4, 5, 7, 9, 10. Thus there were 18 instances of food processing or cooking (shaded cells) and GS tools were present in 13. There was evidence of animal butchery in three of the 18.

	Food processing; cooking	*Animal butchery*	*Bone working*	*Knapping chert/obsidian*	*Redeposited refuse*	*Ground stone manufacture*	*Human burial*	*Pigment grinding*	*Hide processing*	*GS tools present*
Food processing; cooking	18	3	3	8	7	1	0	2	0	13
Animal butchery	3	5	1	1	1	1	0	1	0	2
Bone working	3	1	6	4	3	3	0	2	1	5
Knapping chert/obsidian	8	1	4	12	5	3	0	1	1	9
Redeposited refuse	7	1	3	5	8	2	0	1	1	6
Ground stone manufacture	1	1	3	3	2	5	0	1	1	4
Human burial	0	0	0	0	0	0	2	0	0	1
Pigment grinding	2	1	2	1	1	1	0	3	0	3
Hide processing	0	0	1	1	1	1	0	0	1	1
GS tools present	13	2	5	9	6	4	1	3	1	18

distributed task carried out by numbers of people each using 'standard-sized' utensils.

The evidence of fragmentation of GS artefacts associated with food preparation, discussed earlier, is significant. These examples of possible breakage and formal deposition hint at commemorative ritual associated with small-scale commensal events, suggesting that eating together was, as in many modern and ancient societies, seen as an important occasion, to be celebrated and remembered. These commemorative meals may themselves have been associated with the death of individuals or the end-of-life of buildings.

Conclusions

Analysis of the GS assemblage has shown its central role in the daily economic, social and ritual life in the Zagros Early Neolithic. GS tools were used for activities such as processing food and animal products, grinding minerals, burnishing plaster walls and surfaces and in the manufacture of other tools from stone, bone and wood. Traces of their manufacture, use, curation and discard are visible as modifications to the shape of the stone, wear on its surfaces, and surface residues. Stone is one of the most durable materials: stone artefacts may have had a use-life of decades or centuries before their final deposition and entry into the archaeological record and suffer little post-depositional degradation. The potentially long use-life of ground stone artefacts means that their value in establishing the dating and chronology of a site is limited. Nevertheless, the stylistic traits of ground stone artefacts and assemblages can be used in making comparisons between sites with known dates. The results and discussion above enable us to return to the original research questions.

What do the volume, typology and distribution of GS tools tell us about social organisation and practice at Bestansur?

The range and volume of GS tools at Bestansur is consistent with a picture of a community which exploited local plant and faunal resources for food, clothing, tools, vessels and personal adornment. GS tools were used for hunting, fishing, pounding and grinding food, and cooking. GS tools were also used to make other tools, of stone, chert and bone. Table 22.9 shows the associations between identifiable activities at 28 selected locations in Trenches 4, 5, 7, 9 and 10, based on the types of material recovered in these or adjacent contexts. The associations which appear to be important are:

- GS tools co-located with food preparation and cooking: 13 of 18 instances. These were hammerstones and grinding slabs, but also some abraders, polishers, unworked blocks and debitage. These latter types seem unlikely to be connected to food processing, so it seems likely that other activities were carried out in these locations. The evidence of tool manufacture suggests that tools were made in the same location as the activities – they were manufactured on the spot.
- Relatively few (three out of 18) instances of food processing/cooking also had evidence for animal butchery. This heavy and messy preliminary

work was done elsewhere, possibly at the edges of the settlement, so that waste products could more easily be removed.

- GS tools co-located with worked bone: five out of six instances. These were mostly pounding and abrading tools, some unworked blocks and debitage. Again, tools were manufactured where they were used.
- GS tools co-located with knapping chert/obsidian: nine out of 12 instances. A range of tool types is represented not just the pounding tools which might have been needed to break large lumps of chert into more easily workable pieces.
- GS items in redeposited refuse: six out of eight instances, mostly pounding tools and debris.

We can thus see a range of activities taking place in close proximity to the use of GS tools. These activities include the manufacture and use of chipped stone tools, butchery, food processing and cooking and working bone. Most GS tools were made with the least investment of manufacturing effort, except for types such as maceheads, vessels, beads and bracelets. There are examples of GS tools made with particular skill (symmetry, well-developed grinding and polishing), but we cannot see loci with evidence of structured learning, such as a high frequency of badly-made or spoilt items resulting from the work of novices.

The absence, or low frequencies, of particular types of GS tool (axes, digging tools, complete vessels) which might have been expected on an Early Neolithic site are consistent with ethnoarchaeological evidence about curation and abandonment behaviour. Ethnographic research suggests that when people leave buildings and settlements, they take with them artefacts which are valuable or difficult to replace (Baker 1975; Gould 1987; Schiffer 1987; Cameron and Tomka 1993; LaMotta and Schiffer 1999). Finely-made alabaster vessels may come into these categories. An alternative explanation for the absence of digging tools is that such artefacts were used and discarded in plant-growing areas of the settlement not currently excavated. The lack of heavy cutting tools (axes and adzes) may be simply because they were not used, an interpretation supported by the low quantity of charred wood recovered by excavation. Similarly, reeds, rather than wood, may have been used for arrowshafts, explaining the absence of GS 'shaft-straighteners'. To reconstruct past daily life, it can be helpful to consider the objects which might have been expected in the assemblage but are absent.

The similarities in the composition of the GS assemblage, and in the morphology of GS types, suggests that there was contact with other settlements in the region, and that GS was not used as a cultural differentiator between themselves and other settlements.

Can the analysis of GS artefacts help to understand individuals or roles in Neolithic Bestansur?

Can we discern different groups or roles in the population from analysis of the typologies and location of the GS assemblage? Some activities may have been gendered: ethnographic studies of pre-industrial societies tend to associate hide and textile work with women and children and stone-working with men (Keeley 1982; Dubreuil and Grossman 2009 and references; van Gijn 2010; Rifkin 2011 and references). However, Peterson's analysis (Peterson 2002) of skeletons from the southern Levant sites suggests that in the Neolithic, bilateral (i.e. using both arms) tasks such as grinding and hide processing were shared between men and women. If the ethnographic model of stone-working as a predominantly male activity could be applied to Neolithic Bestansur, we might expect to see evidence of areas where groups of males came together to undertake craft activities. The evidence of Table 22.9 above does not support this. Whilst the *use* of GS tools took place in association with the other activities shown, there are few craft activities which take place in association with GS *manufacture* (GS manufacture in three of six instances of bone-working, in three of 12 instances of chert/obsidian knapping, and in one of three instances of pigment grinding).

There is little evidence (in the GS) of social differentiation within the settlement, although a few items, such as the beads, alabaster retouchers, marble maceheads and bracelets, may have signified status. It is equally possible that more mundane items, such as querns, denoted gender, position or roles (Bloch 2010) within the family or social group.

What can the life-histories of GS tools tell us about the activities involved in their creation, use and deposition?

The assemblage illustrates all the stages of a GS life-history – selecting and transporting raw material, the manufacturing and curation sequence, use and re-use, disposal, retrieval and subsequent redeposition. Study of the debitage has added significantly to this analysis, as has comparison with the literature on experimental replication (Hayden 1987b; Pétrequin and Pétrequin 1993; Kuhn 1994; Schneider 1996; 2010; Wilke and Quintero 1996; Pritchard Parker and Torres 1998; Stout 2002) and site formation processes (Schiffer 1987; Cameron 1991; 1993; Cameron and Tomka 1993; LaMotta and Schiffer 1999). Ethnographic analogy has also suggested possible interpretations, such as hide-working, not immediately obvious from the archaeological material (Adams 1989: 269–272; Dubreuil 2001b; Hamon 2008b; Dubreuil and Grossman 2009 and references; Rifkin 2011 and references).

The great majority of the stone used at Bestansur is good quality stone suitable for making tools, from rock outcrops and the riverbed within a few hundred metres of the settlement, and the availability of this resource might have been one of the factors involved in selecting the site. The evidence of raw material blocks, part-finished tools and manufacturing debitage shows that the tools were made in the settlement, in distributed locations not a central workshop. Later in the occupation of the settlement, a small number of GS artefacts made of green-coloured gabbro, basalt and granite were imported from 30–40km distant as finished goods, with no manufacturing debitage found. The importing of finished goods made of unusual materials from a relatively long distance suggest networks and links with other settlements.

GS tools were not made in large quantities (414 tools currently excavated, from a Neolithic occupation of *c.* 500 years). Most GS tools were made with the minimum investment of manufacturing effort necessary for their function. The exceptions were the ground and polished items such as maceheads, retouching tools and alabaster vessels and bracelets. Tools made from the hard local limestone and sandstone were long-lasting and required little maintenance by resharpening or refreshing their active surfaces. Hardly any worn-out tools have been recovered, although some percussion tools were broken in use. Broken tools were sometimes reused in cooking or as paving surfaces. The GS tools left behind when buildings were vacated were those which were difficult to move (large and heavy). The more elaborately manufactured objects, such as complete vessels, were taken away. Some, however, such as the ground and polished maceheads, were perhaps meant to stay: they were large enough not to have been overlooked. These factors indicate that the eventual vacation of the building and, at some point, the settlement (or at least of the currently excavated areas) was orderly, not rushed.

The range of GS tool types likely to have been used in procuring and processing food is consistent with a broad-spectrum diet, taken from both local and more distant sources. Some animal food, such as deer and gazelle, may have been seasonally available and others (for example fish and wild pig) might have been available year-round. The grinding tools showed little wear, suggesting that grinding of food stuffs was not intensive or prolonged.

Modern investigative approaches such as residue analysis and microwear study have been applied in examining the functions of the Bestansur GS assemblage. The physical characteristics of the stone itself – hard and non-vesicular – have however limited the benefits of these approaches.

We have explored the practical functions of the GS artefacts, and identified a broad range of activities and crafts. It has been possible to infer the functions of several types of artefact such as the net weights, quadrant abraders and the hide-processing boulder, whose uses or morphologies have not been previously recorded. The absence of some types is also of interest. The shaft-straighteners and axes found at other EFC sites may not have been used at Bestansur because wood was scarce and reeds were used instead. Unbroken alabaster vessels may have been sufficiently valued to have been recovered when buildings were vacated, in contrast to the unbroken marble macehead which was deposited with a quern in the oven next to Space 50 with its burials.

How did the functional roles of GS tools relate to their social and symbolic roles?

The cache of clusters of GS tools in Trench 7, Space 16 (Fig. 22.26 above) makes a significant case study on the practical and symbolic importance of the GS tools in Neolithic Bestansur. These were sets of practical GS tools and the raw material for making them. None of the tools has symbolic features: there are no figurines, and none of the stones is incised or decorated. As discussed earlier, their deposition may represent the storage of objects associated with and perhaps used by specific individuals. The use of a private internal space suggests ownership. It is difficult to see why else GS tools would need to be stored inside a building, taking up a whole room. The fact that they were not subsequently recovered is also significant: the number and typology of tools in this space represent a considerable investment of effort in quarrying, transporting to the settlement, manufacture and curation. They still had potential value as tools as they were not worn out or broken. If, as mentioned above, alabaster vessels were sufficiently valuable to have been removed when buildings were vacated, then these useful sets of GS tools might be expected to have been retrieved also. The fact that they were not retrieved suggests their deposition was not straightforward storage, but more likely to have been consciously symbolic, though not necessarily in a single event act. The grouping of tools in sets suggests that they were used or deposited by more than one person, and that these people had something in common, perhaps as makers or users of GS tools. They may have been members of social groups or networks, such as kin groups or households. The deposition of household toolkits is consistent with the concept of commemorative history making (Hodder and Cessford 2004; Hodder 2012; 2018a; Tsoraki 2018b), by reinforcing the importance of these tools in everyday routines in the social group associated with the building, and creating a social memory to strengthen bonds of community.

Understanding the significance of the stone in Space 50 has shown clearly that the practical and symbolic uses of stone in Neolithic Southwest Asia are inextricably linked. Symbolism and ritual were part of everyday life (and death).

Can the analysis of GS artefacts help to understand individuals or roles in Neolithic Bestansur?

We have been able to identify practical activities and crafts that required GS artefacts and we have seen evidence of role-based activity such as quarrying and manufacture, hunting and fishing, cooking and hide-processing. It is difficult to identify what sections of the past population were associated with these roles, or whether these roles were exclusive to a particular group. There is little evidence from the GS assemblage for gendering in GS manufacture and use at Bestansur. There is evidence of technical skill in the selection of stone raw material and tool manufacture. A few querns, and the vessel fragments, show well-executed symmetrical forms. Apart from the maceheads, there are few mis-hits or objects spoiled in manufacture which might have suggested the involvement of novices in stone-working. It is not clear, however, whether the evidence of technical skill represents a clear division of labour which signals the beginning of craft specialisation.

What can GS tell us about continuity and change in Neolithic settlements?

We have been able to identify changes in the choice of raw material (the igneous green stone artefacts) but not in the design of GS tools over the occupation sequence excavated to date. These changes are not dramatic, suggesting that the people of Early Neolithic Bestansur were not particularly innovative in stone technology, and that already well-developed and well-designed implements were adequate for their requirements. Neither were GS artefacts used as a way of differentiating themselves from people in contemporary settlements in the Central Zagros. These traits are not unique to the Neolithic, however. Right up to the nineteenth and early twentieth centuries AD, pounders and querns have been in use in Southwest Asia and further afield which are hardly different to examples from Bestansur (Peacock 2013). GS artefacts may not be the best proxy for human innovation and diachronic change.

What can GS artefacts contribute to multi-proxy approaches?

This analysis has shown the benefits of combining inter-disciplinary approaches to the GS objects to examine their physical characteristics, spatial context and placement, positioning, their life-histories, their relationship with other categories of material culture both macro- and microscopic, and the prompting of interpretations from ethnoarchaeological observations on the production, use and deposition of GS. The study of prehistoric GS has moved on from the factual descriptive approaches of research in earlier decades, using rigorous technical methods such as microwear and residue analysis, and is now adding value to our understanding of the lives and sustainability of Neolithic people and societies. The use of analogies from ethnographic and anthropological observations inevitably means taking some risk of speculating on the basis of the actual archaeological evidence. But this is how we develop hypotheses to be proved or disproved by further research. The GS assemblage from Bestansur is important through what is absent, as well as what is present. This research has uncovered a range of aspects of daily life in Neolithic Bestansur. Many are similar to other contemporaneous sites, while some show uses of GS not previously reported. With regard to the overarching CZAP research questions, the GS assemblage helps to illustrate the environment of Neolithic Bestansur, with little wood-chopping, and the procurement of stone raw material and food resources from both local and more distant sources, with probable links to other contemporary settlements. The assemblage shows a range of activities and roles involved in GS production and use. As well as their practical quotidian use, GS artefacts played an important role in the rituals and symbols of Bestansur's inhabitants, used as a symbol in commemorative acts of deposition which built household history and strengthened the bonds of communal life.

The evidence of the ground stone, by itself and in association with the other material culture, contributes significantly to the overall research objectives of the project, and to our understanding of life in the Early Neolithic Zagros region.

23. PUBLIC ARCHAEOLOGY AT BESTANSUR

Rhi Smith, Othman Fattah, Hero Salih, Hawar Hawas, Mathew Britten, Amy Richardson and Wendy Matthews

Why public archaeology?

Why should archaeologists share the results of their research beyond the academic arena? UK Research Councils and research assessment bodies require an outreach or 'impact' element as a means of demonstrating the wider applicability and relevance of publicly funded research. Many in the archaeological profession also have a genuine desire to encourage public support, inspire the next generation of researchers, engage others with their area of research and collaborate with and contribute to the communities with whom they work. There is a growing research interest into work which goes beyond simple dissemination, where relationships are forged between archaeologists, heritage professionals and 'source communities' (Peers and Brown 2003; Habu *et al.* 2008). 'Source' or 'originating' communities are the traditional 'owners' of the land or cultural resources with which researchers work. True collaboration is achieved not as a box ticking exercise in order to gain access, but by acknowledging that research is always politically and culturally situated, and that non-academics/professionals may have knowledge and understanding which will enrich a project. In recent years public engagement with archaeology has emerged as a research field in its own right, seeking to understand the cultural and political significance of different representations of the past and ways in which deep-time perspectives can contribute to the present and future. Iraqi Kurdistan offers a particularly interesting and rewarding context in which to explore the role of archaeological research and heritage practice in evolving public archaeology and community engagement and collaboration.

Public archaeology is a growing field with strong roots in the UK (McGimsey 1972; Jameson 1997; Schadla-Hall 1999; Merriman 2004; Jameson and Baugher 2007; Habu *et al.* 2008; Skeates *et al.* 2012). It covers a broad range of research activities, including the intersections between archaeology, heritage, education, society, politics, economics and ethics. This chapter draws on a pilot project conducted in Bestansur and Sulaimaniyah in 2014 where members of the CZAP team engaged with local heritage professionals and community stakeholders. The project team trialled dissemination techniques and worked with interested parties in order to explore and establish potential directions for future collaborations, which have since been significantly expanded upon. This chapter also briefly discusses more recent collaborations in the new Prehistory Gallery in the Slemani Museum, and the accession of the site of Bestansur to the UNESCO World Heritage Tentative List in 2017.

From a methodological perspective, public archaeology draws on a number of different approaches and techniques. The positionality of the researcher and questions of site-specific cultural politics are addressed, but more work is needed in this area. Archaeological ethnography represents one strong methodological strand in this field (Hamilakis and Anagnostopoulos 2009). It involves the use of anthropological fieldwork techniques such as semi-structured interviews and participant observation to understand the relationship between different communities and archaeological projects and resources. Such techniques may be used alongside or as part of action research, which seeks to explore solutions to or reflect upon real world problems. Meskell (2012) has used the term 'hybrid fieldwork' to refer to a growth in practice which combines a range of methodologies that may complicate the relationship between archaeology and its public(s). Bestansur is a particularly important site for public archaeology as there is considerable interplay between local, regional and international heritage stakeholders, which has significant potential for future research and collaborations.

This type of fieldwork is well established in archaeological study of this period and broad region, through the Çatalhöyük Excavation Project in central Turkey which employs an overtly 'multi-vocal' approach to research (Hodder 2000; 2005a). Several projects at the Çatalhöyük site have used a mixture of methodologies from museum studies, public understanding of science, anthropology, education, and the study of contemporary spirituality (Shankland 1999; 2000; Bartu 2005; Rountree 2006; 2007; Perry *et al.* 2015). These projects demonstrate that excavation and its products are inextricably linked into a much wider network of significances, as different stakeholders seek to understand and use the site on their own terms. These studies also explore some of the challenges of producing public interpretation at a contested site in this region of the world. While the specific context of Çatalhöyük is very different from Bestansur, some important lessons can be learned from this ongoing research.

Science communication

One theme of the pilot project at Bestansur was the potential role of the excavation in advancing public understanding of science. This wide-ranging subject area explores how non-scientists form opinions and develop knowledge of diverse scientific data and practices (Kaiser *et al.* 2014). It is also concerned with improving understanding in order to increase support for funding of the sciences, to inspire diverse future generations of scientists and to help people make informed decisions regarding scientific issues which impact on their daily lives. University of Reading Archaeology student Mathew Britten undertook a case study at Bestansur regarding the potential of micromorphology as a subject for interpretation. In his research, he drew on the work of Kaiser *et al.* (2014) which identified eight dimensions of change in successful science communication: story(telling); humour; mystery and the unknown; informality, science as part of everyday life; artistic expression; participatory engagement; emotion; power, barriers and belonging.

An exploration of archaeology's role in science communication has been undertaken at Çatalhöyük (W. Matthews and Hastorf 2000). Matthews' research had also been disseminated via a project with the Science Museum of Minnesota's exhibition 'Mysteries of Çatalhöyük' (Pohlman 2004). The exhibition addressed a number of dimensions of change raised by Kaiser *et al*. (2014), such as promoting participatory engagement with micromorphology through the inclusion of a hands-on microscope interactive display. Matthews was included in the exhibition in the form of a photograph of her working at her desk, in a friendly and welcoming pose, wearing casual clothes instead of a lab coat or any other formal signifiers of authority or status. The informality of the photograph linked with the aims of the exhibition to challenge existing prejudices of scientists detached from society, portraying them rather as ordinary people who participate in socialising and the sharing of ideas (Pohlman 2004: 267). This aspect also corresponds with the Massachusetts Institute of Technology (MIT) guidelines of informality (Kaiser *et al.* 2014: 23), which specifically aim to challenge the visitor's perceptions of a scientist as an authoritative and prestigious figure outside of the visitor's realm.

Perhaps also a brave decision is the design team's preference to display female scientists, as there is much debate over the role of women in science and the statistics that women make up just 33% of professional scientific roles in the UK (WISE 2012: 15). Again the guidelines established by MIT are addressed here at the Minnesota exhibit. The decision to represent women in scientific roles highlights a minority in the profession, challenging the view of scientists as males, which is a major guideline that calls for science communication and engagement to challenge barriers and to promote the diversity of the field (Kaiser *et al.* 2014: 29). Hence CZAP's integration of social and scientific archaeology offers an opportunity to explore how archaeological excavations might facilitate an innovative approach to increasing 'public understanding of science'. The high status and number of female scientists in the team also holds the potential to affect change and open debate in the region.

The context of heritage interpretation in Iraqi Kurdistan

The pilot project took place at a time when the heritage community in Iraqi Kurdistan had recently made considerable headway in enhancing the interpretation of the region's archaeology. Slemani Museum was founded in 1961 and moved to its current location in 1980 (Fig. 23.1). During the Iraq-Iran War, 1980-88, the museum was closed. It was closed again because of the invasion of Kuwait, the Gulf War and the subsequent Iraqi Kurdistan uprising, until its re-opening in 2000. From 2007 the museum worked to build strong relationships with international organisations and in 2011 it embarked on an ambitious modernisation programme with UNESCO and the EU (Fattah 2013). The project, led by Slemani Museum Director, Hashim Hama Abdullah and Stuart Gibson, involved the development of the museum and its strategic documents, training of staff and management, and

Figure 23.1. Slemani Museum, Iraqi Kurdistan.

the creation of a new gallery dedicated to the history of writing. Claudia Haas provided two reports on the museum's educational facilities as part of the UNESCO project and they both identify the need for further space and staff. The museum offers a very promising base for the development of archaeological resources regarding Bestansur and the CZAP project.

The CZAP team continue to develop new engagement with policy makers in heritage including the Slemani Museum Director, the Director of Antiquities and Heritage, universities in Sulaimaniyah and the public and schools that visit the museum. Since 2018, we have collaborated with the museum staff, including its Director Hashim Hama Abdullah, Shazad Jaseem

Figure 23.2. Design concept and installation of the new Slemani Museum Prehistory Gallery.

Tofiq, Rebin Mohammed Rashid, and Dr Rozhen Kamal Mohammed-Amin from Sulaimani Polytechnic University, to design displays and information panels for a new Prehistory Gallery for the Slemani Museum, funded by the USA State Department (Fig. 23.2). The Prehistory Gallery incorporates materials from a range of major archaeological sites in Sulaimaniyah Province that provide key insights into the major transformations associated with human evolution and dispersal, origins of agriculture and sedentary life, and development of early urbanism. The exhibition includes artefacts and bioarchaeological materials from major Palaeolithic sites such as Hazar Merd, Neolithic sites including Bestansur and Jarmo, as well as early urban sites from the fourth millennium BC.

The new Prehistory Gallery has three major themes and five sub-themes that draw on the UN Sustainable Development Goals and are aimed at educating a wide range of business, tourism, environment, education and cultural heritage sectors in the value of heritage, the environment, sustainable practices and communities in Iraq. The three major themes are: Development, Creating Communities and Connecting Communities. The five sub-themes examine: climate and environment change and action; food security; sustainable communities and energy; living conditions and health, innovation, industry and technological skills.

The CZAP team were fortunate to be able to work with Othman Fattah in 2014, then a member of staff at Slemani Museum who had recently completed the MA in Museum Studies at the University of Leicester. Supervised by museum learning expert Viv Golding (Golding 2007; 2009; 2013) Fattah undertook a study of opportunities for heritage learning at the museum entitled 'Learning in the Slemani Museum: evaluating learning outcomes' (Fattah 2013). Fattah conducted questionnaires with school children and teachers within the museum and statistical analysis of visitor patterns in the region. This material provides useful data which may guide the further development of Bestansur's public archaeology programme.

Research aims and objectives

As the excavations in Bestansur entered their fifth season the team were keen to explore the legacy of the CZAP project for the region and for the local community. Rhi Smith attended the excavation for ten days in order to conduct a short pilot project and identify possible opportunities for future research and community initiatives. Smith's work is primarily based in the UK but she was able to draw on published work at Çatalhöyük to inform the transfer of these techniques to a Middle Eastern context. This scoping work was enhanced and extended by Mathew Britten's specific exploration of science communication at the site and beyond (Britten 2015). Britten's dissertation explored public knowledge of archaeological scientific techniques, specifically micromorphology, through a series of interventions at archaeological sites in Bestansur, Çatalhöyük and Lyminge (UK). In this way it also placed the work at Bestansur into a wider context.

The pilot project combined a number of research approaches in part to establish which would be most useful for further development. Given the short time frame, the key activities involved establishing connections, gathering data, and piloting some modest strands of public engagement. These initial steps can be used to inform a more substantial project, now under development, in collaboration with local heritage and educational professionals. Britten's project employed a range of techniques familiar from public archaeology in what Meskell (2012) refers to as 'hybrid fieldwork'.

The key aims of this project were:

- To pilot and evaluate different methodologies for recording local interactions with the site
- To pilot an outreach project with local schools
- To explore the potential for a strategic collaboration with Slemani Museum
- To begin to investigate the regional and local significances of the excavation project and the site of Bestansur.

The data set for this project is largely qualitative and consists of:

- 'Scratch notes' and a fieldwork diary written by Rhi Smith and Mathew Britten
- Photographs of public interactions on site
- Records of site visits
- Field notes taken during interviews with local stakeholders
- Clippings of local and international news coverage of the excavation.

Site visits

Given its highly visible location the site is an ongoing source of interest to the local population (Fig. 23.3). Excavations at the site also attracted official attention, drawing in several media teams from across Iraq and a visit from the then First Lady of Iraq, Hero Talabani in 2012 (Fig. 23.4). A member of the team in Iraqi Kurdistan, Hero Salih, was responsible for keeping a log of visitors to the site (invited and informal) in order to track these data. Salih took the decision to note the number of women in each group, following several discussions regarding the education of women and the visibility of female archaeologists/scientists. The project had a significant proportion of female researchers, many of whom had a scientific specialism, most notably the Co-Director Wendy Matthews. It was observed that women visiting the site would often hang to the back of large crowds and would seek out conversations with female members

Figure 23.3. Visitors to the excavations at Bestansur.

Figure 23.5. Co-Director Wendy Matthews speaks to a group of women visiting the excavations.

Figure 23.4. Visit by Hero Talabani (centre) and heritage officials from the Directorate of Antiquities and Heritage and UNESCO at the excavations at Bestansur.

Figure 23.6. School educators in History and Chemistry are given a tour of the excavations.

of the team (Fig. 23.5). This is an important access issue to factor in when planning future sessions with schools, educators, and informal audiences.

One key element of the pilot was collaboration with local teachers and educational administrators, arranged with assistance from Othman Fattah and Hero Salih. Working with the help of the Sulaimaniyah Directorate of Antiquities, Fattah was able to negotiate a meeting with the head of education in the nearby town of New Halabja for himself, Hero Salih and Rhi Smith. Two days later, 33 history teachers visited the site (Fig. 23.6) and the dig house. Four of the attendees were supervisors for the region and thus had the power to disseminate to a much wider audience of teachers, who in turn could communicate findings to their students. Smith wrote a short guide to the site which Fattah translated into Kurdish. University of Reading student Zoe Richardson was also able to produce a series of digital reconstructions in Google Sketchup which were used to help visualise the building which was being excavated (Fig. 23.7). The team decided that it was important that teachers understood the scientific procedures taking place in the field laboratories in the dig house, as well as the on-site work. The trip consisted of a simple structure which included a tour of the facilities with each specialist giving a demonstration of their work.

These interactions produced some unexpected outcomes. For example, the female supervisor of chemistry teaching for the local district organised a second trip focussing on the project's scientific methods, following an informal discussion with Wendy Matthews. The role of local members of the team (such as Hero Salih) in the excavation and in co-ordinating interpretation communicates a positive message to local visitors. The fact that it was Salih who took the initiative with recording data around the gender of visitors demonstrates the importance of collaboration with local stakeholders when developing research questions. The success of the discussions during these visits suggested that it is not just the research findings, but also the representation of the project team and the enthusiasm and communication skills of individual

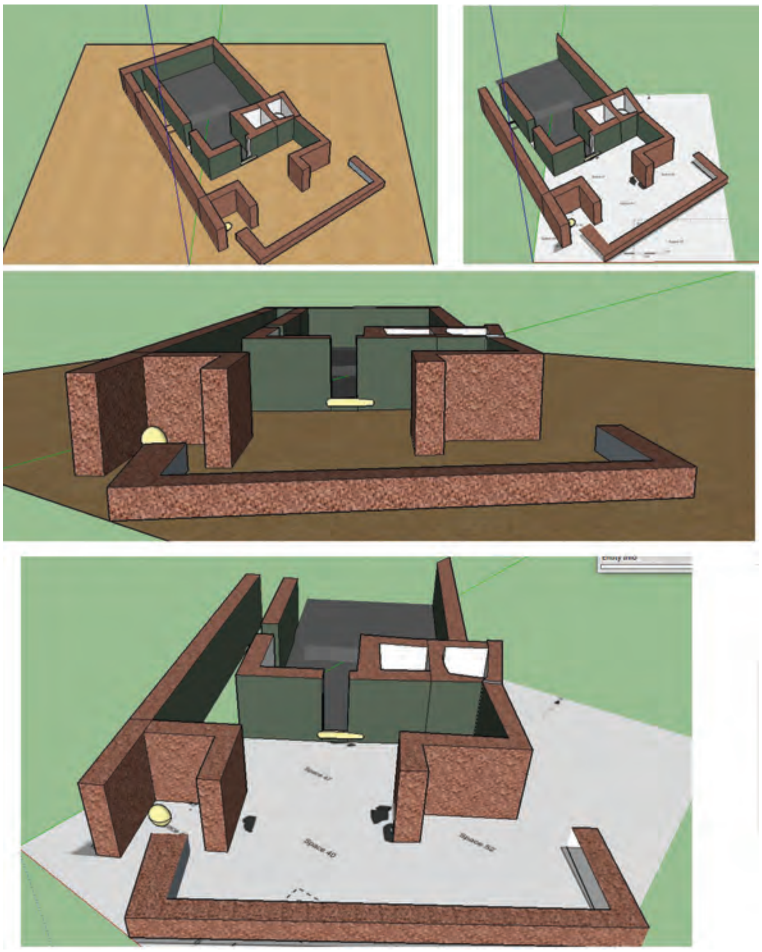


Figure 23.7. Initial reconstruction of Building 5 created in Google Sketchup.

archaeologists, which help to engage people with the project's findings.

Even from this small sample there were some interesting general findings. There were only two formally booked visits, demonstrating that word of mouth was important in attracting visitors. However, the lack of formal warning made visits difficult to manage. In future this issue could be used to make the case for a permanent public archaeological presence upon site, certainly during excavation seasons. There was also a need for translation, which sometimes made informal discussions difficult. Visitors generally tended to live locally or were teachers/students who had come in via group transportation. Visitors took lots of photographs and were extremely keen to follow members of staff on social media. Public archaeology is increasingly looking towards social media as a means of increasing knowledge and participation so this is an interesting development (Richardson 2014). There was also a great deal of local pride in the excavations, and energy to support the site amongst heritage professionals and local politicians and elected officials. It should also be noted (see below) that the local excavation workers brought a great deal of local knowledge to the project. This demonstrates the strong need for a collaborative approach towards the further interpretation of the site.

Other research methods and approaches

Interviews

Due to language problems and restrictions on time we were only able to undertake two interviews with local workers. Pilot interview questions asked workers about their previous experience of excavation work, their experiences of excavating and their views on the future of the site. One interviewee was a guard and the other a student, so they represented a range of experiences of the local staff. Discussions with the guard demonstrated the breadth of occupations simultaneously undertaken by local men who worked on the site. Working at the site was only one of a range of different activities undertaken. He also brought to the dig many years of excavation experience on similar sites. When trying to understand the relationship between local workers and the site, the complex relationship between the project and local economy needs to be considered. The wide skill set and knowledge of local workers also has to be appreciated, and previous studies as part of this project have demonstrated the potential of archaeological ethnography to enhance our understanding of the local mixed economy and landscape (Chapter 7).

Both interviewees reported a great deal of local pride in the site and that they would like to see a museum and possibly a picnic site nearby. This would also have a knock-on effect for the local economy and infrastructure (most notably roads, refuse collection) which both workers appreciated. From observing responses to questions, it seemed clear that while the workers were open to being asked questions they were more comfortable being asked their opinions on the site. As they were employees of the project, there may have been some hesitancy about responding to questions about their experiences of working on site. The desire to talk about specific interpretation products was also supported by their response to digital models of the site and a piloted site guide. Hence, in the future it might be more useful to focus on seeking their response to interpretation materials and using participant observation techniques and informal discussions to understand more about their own experiences of working at the site.

Participant observation and action research

It was generally found that a less formal approach to investigation yielded richer results and was better suited to the local context. For example, while qualitative data demonstrated relatively high numbers of women attending the site, participant observation illustrated that they were often physically marginalised. The history and traditions of the region also mean that there is some reluctance to talk freely in official contexts about personal information. Hence an ethnographic approach utilising participant observation and reflexive action research may be more effective in the long term, than an approach based on formal techniques such as interviews and focus groups.

The pilot study demonstrated that partners with a mixture of strong English and Kurdish and specialist knowledge are needed in order for interpretation to be effective. It also highlighted the different skill sets that individual team members could bring to interpretation. While the pilot resources created by team members may not be of professional design quality, the content and images were very strong and generally extremely well received by visitors and workers. This approach also allowed for updates to take place as excavations continued. This suggests that a collaborative and sustainable approach to interpreting the site can have a significant impact and that outsourcing to professional companies may not always be the best means of interpreting a site.

Science communication case-study

University of Reading student Mathew Britten undertook some specific observations regarding the potential for science communication on site. Micromorphology was chosen as the scientific method due to the recent adoption of this soil science by archaeologists. Micromorphology offers many benefits to archaeological sites, in particular the ability to gain powerful insights into activity sequences through the high-resolution analysis of intact sediment blocks (W. Matthews 2005: 108). These samples of occupation deposits or sediment accumulations are impregnated with resin, sliced and studied as highly polished thin sections (Chapters 12, 13 and 16). The undisturbed thin sections preserve stratigraphic sequences *in situ* allowing for micro-contextual study under microscopes. Close analysis can often reveal micro-artefacts, including plant and faunal remains, but also depositional layers that are not visible at a macro level of study in the field.

Micromorphology was deemed particularly useful for engagement because it invites members of the public to explore personal knowledge construction through the development of their own core skills, such as observation. Making examples of thin sections and photometric images accessible to the public affords knowledge construction through the dialogue between the archaeologist and the public, whereby the visitor may use their observation skills to familiarise themselves with microscopic elements found in thin section. The breadth of materials to which micromorphology can be applied allows further application and development of multi-scalar observation skills, from field level (macro-) observations, to micro analytical skills, enhanced by the understanding of scientific techniques. This combination, of core skill enhancement and the need to take a closer look, aimed to trigger enquiry through authentic learning using transferable skills (Rule 2006) and appeal to the enchantment of archaeology (Boulton 1930).

Thin-sections are often aesthetically pleasing, capturing colours and patterns of stratigraphy that appeal to the visual sense. Gosden's (2001: 166) theoretical approach to the aesthetics of archaeology and the sensory approaches that archaeologists take to artefacts are valid here, as thin sections become almost an artefact themselves drawing on the visual sense, as preserved tangible evidence to be studied and understood by the archaeologist. Microscopic aesthetics have proved successful with engagement in the past, due to the nature of scientific imagery lending itself to artistic persuasion (Farmelo 2004: 4). Micromorphology offers an aesthetically pleasing

CZAP

Welcome to Bestansur!

بەشی شوێنەوار ،زانکۆی ڕیدینگ، بەریتانیا
لەسەردەمی چاخی بەردینی کۆندا مرۆڤەکان وازیان لە کۆچ و ڕەو هێنا و دەستیان کردبە ڕواندنی دانەوێڵەو ، بەخێوکردنی ئاژەڵ ونیشتەجی بوون لە خانودا. ئەم ڕوداوە بۆیەکەمجار لەم ناوچەیەدا ڕویدا, لەبەرئەوەشە کە ئەم ناوچەیە زۆرگرنگە بۆلێکۆڵینەوە لەلای شوێنەوارناسەکان.

ئەم سەردەمی بەرەو کشتوکاڵی ڕۆیشتنە ڕویداوە لە □□□□□ ساڵ پێش ئێستا، لە و کاتەدا هیچ جۆرە نوسینێک نەبووە. بۆتێگەیشتن لە و سەردەمە تەنها ئەتوانین سود لەو پاشماوانە وەربگرین کە لەو مرۆڤانەوە بەجێماون لە ژێرزەیدا.

شوێنەوار

شوێنەوارناسان لێکۆڵینەوە لەوە ئەکەن کە مرۆڤەکان لەپاش خۆیان بەجێیان هێشتوە بۆنمونە بیناکۆنەکان، ئاشەکۆنەکان و پاشماوەکانی تر. کاتێک کە مرۆڤەکان بینایەک لە سەربینایەکی کۆن بنیات ئەنێن و بەڵگەکانی ئەشارێتەوە. بە تێپەربونی کات چینەکان لەسەریەکتر کۆئەبنەوە. ئێمەش بەوریایەوە هەڵیان ئەکۆڵین و سەردەمە جیاوازەکانیان دەستنیشان ئەکەین.

- شتە کانی هەمان چین بۆ هەمان سەردەم ئەگەڕێنەوە.
- شتەکانی چینەکانی خوارتر بۆسەردەمی پێشوو تر ئەگەڕێنەوە.

پرۆژەکەی ئێمە

ئێمە بۆ چینەکانی پێشوو تر ئەگەڕێن. ئەمەش ڕووبەڕووی چەند کێشەیەکمان ئەکاتەوە.

- ئێمە ئەبێت هەڵکۆڵین بکەین بەناو چەند چینێکدا.
- بەڵگەکان لەژێرخاکدان بۆماوەیەکی دوورو درێژماونەتەوە و هەموو شتەکان ڕزگاریان نەبوە.
- ئێمە ئەمانەوێت بزانین کە ئەوان چییان خواردوە، چ جۆرەدانەوێڵەیەکیان ڕواندنەوە وچ جۆرە ئاژەڵێکیان ڕاگرتوە. بۆئەمەش ڕێگاو تەکنیکی تایبەتی ئەوێت.

تیمەکەی ئێمە پێکها توە لە کۆمەڵێک شارەزا و چەند تەکنیکێکی جیاواز بەکارئەهێنن بۆ لێکۆڵینەوە لەو سەردەمەی مێژوو.

Figure 23.8. Leaflet produced by Britten and Hawas for visitors to the site.

and scientifically intriguing subject that appeals to the human desire to understand and make sense of what can be seen (Gosden 2001: 163).

In collaboration with Hawar Hawas, Mathew Britten designed a leaflet (Fig. 23.8), which was chosen as an easily distributable tool in response to the demand for more information from local workers and villagers. This leaflet was developed in discussion with the project team who provided specialist insight into the presentation of methods and site information. The leaflet was analysed through self-reflection during the production of the resource and the later editing and collaboration with the site team.

During the tour of the labs as part of the teachers' visit, micromorphology was presented alongside other scientific techniques such as flotation and heavy residue analysis, using images and examples with the assistance of a translator. It was important to present micromorphology alongside other methods because micromorphology can often be limited as a single enquiry method (Milek and Roberts 2013: 1864), and is best used in connection with other methods. The team were particularly interested to see whether a complex technique such as micromorphology could be effectively explained and capture the visitors' interest in the same way as other techniques. Observation of engaged body language and detailed questions were recorded amongst the visiting group, which suggested that they had understood and were interested by the talk. Britten's skills as a communicator should also be noted as an important variable in this experiment. Britten had been involved in voluntary education for a number of years, employed as a site interpreter on another University of Reading excavation, and has since gained employment as an education officer at a museum. Tilden (1957) suggests there is nothing better than a live person for interpreting heritage, but the nature of the message and the skills of the storyteller are also important.

Discussion and future developments

This was only a small pilot project but there are a number of ways in which it could inform the future interpretation of the site and legacy of the project. As part of this project the team talked with local heritage professionals about the objectives of Slemani Museum and the potential for future collaboration. Some staff feel that the current premises are not fit for purpose in the long term and that a new building is needed. A mock-up of a proposed building was developed as part of the UNESCO plan and is displayed in the new gallery. However, there is great potential to provide flexible materials which would work within the current galleries and a new space. For example, the museum has a large central video screen which it uses to contextualise objects but is unable to find suitable videos in Kurdish. It also has several smaller spaces in which new exhibitions in collaboration with other international teams are being held.

In terms of outreach and education, school visit days are extremely restricted and staff already have outreach activities in place which could be enhanced through a collaboration with the project. Fattah's (2013) research provides a valuable resource in shaping the future development of the museum's educational remit. It should be noted that the museum's remit and the national curriculum go beyond Bestansur and that any interpretation of the site needs to connect into wider chronologies and themes. A small site visitor centre at Bestansur has been proposed, which has implications for local infrastructure, security, and local staffing and expertise. Above all any interpretation must be collaborative, flexible, and sustainable. A visualisation project at Çatalhöyük by Perry *et al*. (2015) may offer a useful model for future development with its focus on ethnographically informed design and local sourcing of materials and expertise.

The potential for the project to develop a strong relationship with the formal history curriculum and science education in the district is also promising. Feedback from the teachers was extremely positive and the visit of chemistry teachers illustrates the potential for the site's inter-disciplinary methodology to inform cross-curricula educational outputs. Staff at the museum are now keen to use the leaflet created as part of the pilot project as the basis for a site guide. The digital models were also extremely well received and there is potential to build on this in the future.

Media interest and local feedback demonstrated that the site is growing in importance and is being hailed as 'the earliest village in Kurdistan'. At the time of writing this chapter, Iraq is facing significant challenges. In planning for public archaeology in the region it should be noted that the village of Bestansur is relatively small and it is unclear what the impact of tourist interest would be on the local economy and cultural life. Research at Çatalhöyük (Shankland 1999; 2000; Bartu 2005; Rountree 2006; 2007) demonstrates the complicated impact of a high-profile excavation site in local social dynamics and regional and national identity building. Çatalhöyük also indicates the complex role of a site of spiritual significance for a pre-Islamic site to local people and the wider world. From a public archaeology research perspective there is a great deal more which can be done to explore the multiple meanings of this site in its local, regional, national and global contexts.

In conclusion, the pilot project established that future public archaeology work in the region would need to bring with it funding resources which could help to 'make things happen' on the ground and sustain the legacy of this work in the future. It also demonstrated the potential for working with local experts and stakeholders to develop bespoke solutions rather than shipping in prefabricated models from elsewhere. In this, and other regions, politicians and the international community often focus on high status indicators of change (e.g. a new museum), where collaborative and sustainable models may have a more significant impact in real terms. In Iraqi Kurdistan both kinds of change are needed and the UNESCO project has helped local professionals to move a long way towards achieving this. In this climate co-designed and co-created research and interpretation will ensure that regional priorities are addressed, as well as wider research and impact agendas. The CZAP project has always worked in collaboration with local and regional stakeholders, and this pilot project demonstrates how this has enriched the work of all parties. A major recognition of the importance of the site for the past and for the local and global community is its accession in 2017 to the UNESCO World Heritage Tentative List with the support of the Sulaimaniyah Directorate of Antiquities and the Iraq State Board of Antiquities and Heritage, Baghdad (https://whc.unesco.org/en/tentativelists/6172/).

24. THE NEOLITHIC TRANSITION IN THE EASTERN FERTILE CRESCENT: THEMATIC SYNTHESIS AND DISCUSSION

Wendy Matthews, Roger Matthews, Amy Richardson and Kamal Rasheed Raheem

Introduction

Research rationale and context

The origins and development of agriculture and sedentism are widely recognised as one of the most significant transformations in human and global history as foundational pillars of economies and societies today (Mithen 2003; Barker 2006; Zeder 2011). In current studies of global development and transition, the consequences of agriculture and sedentism stand out as resulting in profound change in socio-ecological systems leading to "markedly different states" (Shah *et al*. 2018: 256; Folke *et al*. 2010). Such transformations in fundamental elements of ecology and society are examined in current transition studies, including "biophysical properties (e.g. nutrient or temperature profiles), ecological interactions (e.g. predator–prey interactions), human activities (e.g. resource extraction or consumption) and social institutions (e.g. laws, rules, practices)" (Shah *et al*. 2018: 256). How Neolithic communities developed the transformations from more mobile hunting-gathering to agriculture and settled life at the scale of local and regional environments and ecologies, however, appears to have been diverse and its study requires larger, multi-component datasets, particularly for under-investigated regions such as the Eastern Fertile Crescent (EFC) of Southwest Asia (Fuller *et al*. 2012b; Arranz-Otaegui *et al*. 2016b; Asouti 2017; Hodder 2018b). Analysis at the scales of micro-ecologies and particular communities and sectors of society is vital as it is at these lived scales that the diverse dynamics and impacts of wider ecological, social and technological change were enacted, adapted and experienced and need to be understood (Greene 2018; Kulick 2019).

The major aim of the research conducted in this project, as reported on in this volume and in ongoing fieldwork and analyses, is to advance our understanding of early sedentism and resource management by interdisciplinary analysis of ecology, society, technology, built environment and ways of life at a range of sites and for different sectors of communities in the Zagros region of the EFC. The Zagros mountain slopes and plains were a key heartland in the transformations to agriculture and sedentism that has been little investigated since the ground-breaking work in the 1940s–1970s until recently (Matthews and Fazeli Nashli 2013). Earlier research significantly advanced analytical methods and paradigms and provided important new data on experimentation and innovation in management and domestication of animals and plants, notably goat and barley which were native to this region, as well as in architecture and material culture (Hole *et al*. 1969; Ucko *et al*. 1971; Braidwood *et al*. 1983; Smith 1990; Harris 1996; Zeder 2012). The aim of the Central Zagros Archaeological Project (CZAP) is to build on these studies and to investigate transformations in local and regional ecologies, socio-cultural relations and practices, and networks of interaction by investigation of sites on a transect through the Zagros from the highlands to the lowlands, as these regions represent key habitats of the plants and animals that were later domesticated and are located on a major routeway that later was part of the ancient Silk Roads.

The focus of the first phase of CZAP from 2007–2011 was on the highland Zagros in Iran, where research pushed back known occupation in the Early Holocene high Zagros by 1500 years to *c.* 9800 BC. This research identified early experimentation in plant and animal management, including auditioning and collection of local grasses and animal penning, and socio-cultural developments including construction of a ritual building at the heart of the settlement and the early use of clay tokens (Matthews *et al*. 2013a; W. Matthews 2018; Whitlam *et al*. 2018; Richardson 2019). The focus in the second phase of CZAP from 2011–2017 is in the lower Zagros, in the hilly flanks investigated by the Braidwoods and colleagues (Braidwood *et al*. 1983), where we excavated two sites, 110km apart, to study local development and interactions. We conducted extensive excavations of different sectors of a settlement at the previously unexcavated site of Bestansur and rescue excavations of the basal levels of Shimshara, which had not been reached during excavations in the 1950s (Mortensen 1970) but were exposed by receding dam waters in 2012. We conducted intensive survey in the region of the Epipalaeolithic site of Zarzi to investigate Late Pleistocene–Early Holocene occupation, and we initiated palaeoclimate and paleoenvironmental research as there is little data on this period of global climate change at the end of the last Ice Age for this region, and its impact in the Zagros is highly contested (Jones *et al*. 2019). Other projects in the Zagros are also investigating the early origins and nature of transformations in this key region of Southwest Asia (Darabi *et al*. 2011; 2018; Altaweel *et al*. 2012; Riehl *et al*. 2015; Bangsgaard *et al*. 2019; Marsh *et al*. 2018; Giraud *et al.* 2019) and are considered in the discussion of results and wider debates throughout the volume and here.

The significance of transformations in the development of agriculture and sedentism and their current global impact has continued to come to the fore since the inception, in 2011, of this phase of CZAP. Agriculture and settlement in many regions of the world are currently unsustainable and less than 3% of the planet's land biomass is wild, as outlined in Chapter 1. The need for archaeology rapidly to respond to these challenges and to join the interdisciplinary efforts required to understand the inter-relations between environment, economic and social sustainability, equality and human health is also more urgent (Smith 2017; Conolly and Lane 2018). Archaeology has a major role to play in providing crucial insights into the context and cause of these transformations from their inception, and in developing longitudinal and cross-cultural perspectives on the diversity of past, present and future options and outcomes in the implementation, management and impact of agriculture and sedentism (Jackson *et al*. 2018; Isendahl and Stump 2019). In addition, real-world issues and theoretical concepts and analytical approaches from transition and sustainability studies today can provide powerful new lenses and methodologies with which to examine the impact of major transformations on diverse landscapes, species and sectors of societies in the past.

In this concluding discussion, therefore, we consider both the significance of the interdisciplinary research presented here for understanding the origins and development of agriculture and sedentism with a focus on the role of the EFC, as well as the relevance of the approaches and findings for cross-disciplinary analysis of the nature and impact of sedentism and resource management more widely. We examine how agriculture, settlement and ecological, social and technological change were developed and managed and their impact on environment, economic and social sustainability, equality and human health, which are inextricably inter-related (Lopez 2012; Greene 2018; Shah *et al*. 2018).

The discussion begins with a review of the theoretical frameworks and methodology applied and the key discoveries in the Zarzi survey and from excavations at Bestansur and Shimshara. We then examine the nature and impact of transformations in the development of agriculture and sedentism on elements of socio-ecological systems. We examine: climate and environment to investigate continuity and change in biophysical properties such as water availability and nutrients; animal and plant resources to examine ecological interactions and relations between humans and other species and predator-prey relations; human activities and resource management to study the nature and sustainability of production and consumption; social institutions and practices including settlement, community organisation, cooperation, governance, equality, everyday life and ritual, as well as health. The Zagros case-studies are compared to developments in the Neolithic in the EFC and Southwest Asia, and we evaluate their wider relevance and significance to global transformations and challenges today.

Interdisciplinary approaches to sedentism and resource management

Theoretical framework

In this research we have applied a range of ecological, socio-cultural and political theories and approaches in order to examine the complex inter-relations between environment, ecology, technological innovations, economics, social and political relations and practices and health, as advocated in current transformation and sustainability studies (Lopez 2012; Clark and Yusoff 2014; W. Matthews 2016; Shah *et al*. 2018). This interdisciplinary approach extends analysis beyond the study of particular materials and practices and examines how these resources and fields of action and spheres of life are organised, structured and inter-related, as applied in transition theory and studies more widely (Greene 2018: 1).

Contextual analyses remain at the forefront of research on the origins of agriculture and sedentism (Robb 2010; 2013; Asouti and Fuller 2013; Hodder 2018b) and form a key approach in CZAP research. Contextual analysis at multiple scales provides a robust framework for examining the diversity of the impact of transformations on different niches, species, communities and individuals and their ways of life, as in current sustainability studies (Greene 2018; Lowenhaupt Tsing *et al*. 2019). We have applied social practice theory and biographical approaches in a cross-cultural longitudinal study of the contexts and biographies of materials, practices and communities in the Zagros and Southwest Asia more widely. This approach has enabled granular analysis of the recursive inter-relations between macro-level change and everyday lived lives and practices, as well as comparative analysis of lifecycle and longer-term changes and outcomes, as explored more widely today (Greene 2018). We also consider concepts from transition theory and sustainability studies of 'pathways of dependency' and technological 'lock-in' as these enable examination of the co-evolutionary and interrelated change in particular elements as well as openness or resistance to change (Greene 2018: 2). These concepts are similar to those explored in studies of the entanglement of Neolithic transformations (Hodder 2012; 2018b) and how "human-material thing relations can reorder the world" (Robb 2013: 2). They offer additional explanatory power on the capacity for continuity or change in ecology, society and practices, and the nature and impact of transformations in different socio-ecological and technological elements. We also consider concepts of 'more-than-human' and the 'patchy Anthropocene' as these examine different worldviews as well as the rights of different species, sectors of communities and landscapes more widely, which are crucial when investigating communities of 10,000 years ago (Rutherford 2019).

A range of fundamental ecological, social and technological elements are examined in this new application of multi-scalar interdisciplinary contextual analysis of early sedentism and resource management in the Neolithic of the Zagros, similar to those also considered in current studies of transformations (Greene 2018; Shah *et al*. 2018). These elements include: macro- and micro-environments and niches; resource management and consumption for food, construction, energy and artefacts sources; the 'technologisation of daily lives' and changing routines and relations between practices, reconfigurations of space and relations within 'the home' and settlements; and evidence of co-operation, power relations and inequality, exclusion or migration. Resource use is considered not only with regard to how optimal or sustainable it was but how it was related to "accomplishing social practices" (Shove and Walker 2010: 47), and how it was influenced by intersections with normative contexts, roles and practices, economic conditions, capital/storage, technological developments, spatial planning and climate and environment (Greene 2018: 7).

Our research also draws on new approaches that highlight the limitations of conceptual frameworks that examine dichotomies and oppositions in conditions, materials, roles and practices as circumstances and impact are context-dependent and often diverse (Harris and Cipolla 2017). These interdisciplinary, non-binary and non-linear approaches have proven particularly valid in this analysis of the development of agriculture and sedentism as these transformations were slow and highly diverse, requiring multi-scalar granular analyses to enable examination of context specific processes, actors and outcomes (Willcox 2005; Fuller 2012b; Asouti 2017; Hodder 2018b). As Valla (2018: 28) argues, rather than examine sedentism versus mobility and agriculture versus hunting and gathering, it has proven more productive to investigate how past communities occupied landscapes and settlements and the diverse impacts of continuity and change in environment and practices on different locales and sectors of communities.

Other specific theoretical and conceptual approaches that have proven effective and informative in this research include consideration of: niche construction theory in examination of local environments and ecology (Zeder 2016); entanglement (Hodder 2012; 2018b) to study inter-connected linkages; biographical approaches that examine, for example, food systems from production to consumption and discard and their intersections with other cultural, economic, and political systems, as advocated by Reed and Ryan (2019) for studies of food ecology and sustainability more widely.

Opportunities and challenges: fieldwork

CZAP fieldwork and research benefitted enormously from the support of a wide range of organisations, communities, individuals and funding bodies, without whom this project would not have been possible, as detailed in the Preface and Acknowledgements. CZAP research has benefitted from a range of opportunities and also faced a series of challenges which have impacted the research and outcomes that are considered here and faced by many excavations in the region and more widely. The new fieldwork and research detailed in this volume was conducted between 2011 and 2014, and in some cases includes results from fieldwork in 2016–2017. Fieldwork and post-excavation analyses at Bestansur were interrupted in 2015 and could not be conducted at Sheikh-e Abad in highland Iran as originally planned. Excavations at Shimshara in summer 2013 could not be resumed as the early levels of the site were resubmerged by water from the Dokan Dam. Seven seasons of fieldwork were conducted at Bestansur in the spring and late summer of 2012 and 2013, and spring of 2014, 2016 and 2017. The results from this fieldwork and interdisciplinary research have provided the foundation for the funding of a third phase of CZAP investigations from 2018–2023 at all the sites investigated to date, as outlined in the Preface and Acknowledgements.

Excavation conditions were challenging due to the marked climatic and seasonal extremes in this region. The challenges included powerful storms, high winds and heavy rainfall in spring, and rapid drying out and heat in late spring and summer when temperatures reached 40–48°C. Identifying earthen walls and features at many excavation sites in Kurdistan may often be difficult (Kopanias and MacGinnis 2016). At Jarmo, 65km west of Bestansur, the Braidwoods and colleagues (1983: 162, 136) state on a range of occasions that traces of walls and room complexes were "exasperatingly incomplete" and "exasperatingly fragmentary" or that surfaces were "more ephemeral than real floors". Many of the photos at Jarmo show deep cracks from extensive drying out (Braidwood *et al*. 1983: figs 76, 78, 88). The hardness of deposits can also impede excavation of fragile remains, the effectiveness of dry-sieving and restrict the depth to which cores may be extracted (Marsh *et al*. 2018; Chapter 6).

CZAP fieldwork and sediment analyses have demonstrated that this restricted visibility and cracking and other preservation challenges are largely due to rapid drying out and the presence of shrink–swell clays in many deposits (Chapters 12, 13). These highly reactive shrink–swell clays result in either muddy conditions and spalling when wet, restricting excavation and visibility, or very hard deposits when dry that make excavation and cleaning of fine strata and boundaries as well as discernment of many features difficult. With experience we established that there is a narrow window of opportunity when deposits are moist and it is possible to observe remarkably finely stratified deposits, boundaries, features and walls and to excavate, record and sample these with good clarity, sensitivity and precision (Chapters 8, 9, 12). To create and maintain these workable moist conditions each year we constructed a shelter, kept all excavation areas covered with plastic sheeting when not being investigated to limit destruction by rain and to limit moisture evaporation, and used water-sprays when needed. At the end of each season the excavated areas were protected by plastic canvas, sacks filled with earth, and *c*. 30–40cm of backfilled earth.

Opportunities and challenges: analyses

In this research a diverse range of new evidence has been collected on transformations in climate, environment, ecology and society of the EFC in the Zagros. To provide much needed new data on climate and environment new speleothem and core samples from highland and lowland Zagros lakes and local site environs were collected and continue to be analysed (Chapters 3, 6). To study resource management and use, a diverse range of new datasets and material remains have been analysed through integrated pXRF, micromorphological, phytolith, GC-MS, charred plant and zooarchaeological research, as designed from the outset of this phase of the project (Matthews and Matthews 2010). The new datasets examined include a wide range of plant materials and human and animal coprolites that are often lost or destroyed through routine wet-screening and flotation (W. Matthews 2010; Colledge and Conolly 2014; Arranz-Otaegui 2016a; Chapters 12–13, 15–18). These analyses have provided new data on environment, animal and plant management and domestication, diet, energy sources, more perishable furnishings and artefacts such as matting and burial wrappings, and the built environment, nutrition and health (Chapters 12–13, 15–18). The extensive programme of microarchaeology and wet-screening has enabled analysis of one of the few assemblages of Neolithic fish bone, micro-fauna and molluscs from the region, adding significantly to insights on the biodiversity of resources and diet.

Extensive wet-screening and micro- and macro-artefactual analyses have also enabled identification of widespread traces of production, consumption and discard practices informing on technologies and craft, as well as recovery of many items of adornment, arguably linked to identity. This research, coupled with pXRF identification of diverse artefactual materials, has revealed remarkable insights into local and regional networks and social relations which extend over 1500km, and show that Bestansur was a major hub, on what was later part of the Silk Roads (Chapters 20–22). Initial isotopic and aDNA analyses were conducted to inform on human and animal mobility. aDNA results also show that Bestansur had social networks and connections with communities both to the east in the highland Zagros as well as to the west in the Upper Mesopotamian plains, currently being studied by Pinhasi, Reich and Lazaridis (Chapters 15 and 19).

The climatic and environmental extremes of this region affected a range of analytical results. The alternate wetting and drying and extreme heat in summer and cold in winter with sub-zero temperatures, have reduced the preservation of collagen and aDNA, and resulted in a range of failed assays in isotopic, genetic and ^{14}C dating, although some have been successful (Chapters 11, 15, 18, 19). The shrink-swell clays also affected the preservation of charred plant remains (Chapters 12, 18), and bioturbation has resulted in some translocation of charred plant materials leading to mixing of assemblages and ^{14}C dates that are often too young, as at Jarmo and other sites in the region and more widely (Reed 1958: 386; Chapter 11). Bestansur is a comparatively flat extended Neolithic site, up to at least *c.* 3–4m high. Excellent preservation conditions such as those at Çatalhöyük, Turkey, and at Sheikh-e Abad in highland Iran, which are mounded tell sites 10–20m high with up to 95% success rate in collagen retrieval and well-preserved charred plant remains (Müldner 2013; Whitlam *et al*. 2013; 2018) are arguably more exceptional than widely acknowledged (Boivin and French 1998; Arranz-Otaegui 2016b).

A major factor affecting the apparent low densities and assemblage sizes of charred plants, animal bone and micro-artefactual remains at Bestansur, despite extensive excavation and sampling of different sectors of the site, is the absence of midden deposits and building destruction levels in all thirteen of the sectors excavated at Bestansur. It is these refuse contexts at other sites that have yielded the bulk of the bioarchaeological and material remains, as at Jarmo (Braidwood *et al*. 1983) as well as Boncuklu and Çatalhöyük in Turkey where similar analyses have been conducted by some of the same researchers (Bogaard *et al*. 2009; Iversen 2015, Chapter 14). The densities of materials on floors and surfaces at these and many other sites is often low (Hastorf 2005: 150–152, table 8.8) and is more comparable to most contexts excavated at Bestansur. Braidwood and colleagues (1983: 10) at Jarmo lamented "we have no really good evidence that might specify the use to which the various rooms in the house were put" as few artefacts were left on floors. It is for these and a range of other scientific reasons that we have applied integrated interdisciplinary micro- and macro-analytical approaches to the study of a wide range of materials and resources, which despite their clear benefits are still not widely applied (Shillito 2017).

Impact and engagement

In conducting this research, we have also had the opportunity and honour to engage in a range of impact and education activities and events to highlight the long-term perspective that archaeology brings on environment, resource management and creation and sustainability of communities (Chapter 23). We have collaborated with policy makers in the national and regional Directorates of Antiquities and Heritage in Iraq in the preservation of heritage through RASHID International and a British Council Cultural Protection Fund Award and successful nomination in 2017 of the site of Bestansur to the UNESCO World Heritage Tentative List (Matthews *et al*. 2020). In an advisory role to the Slemani Museum and staff we contributed to the design and text for a new Prehistory Gallery that includes major themes on Development, Creating Communities and Connecting Communities with a focus on issues inspired by the UN Sustainable Development Goals such as climate and environment change, food security, sustainable energy and communities, innovation and industry and health. The exhibition includes materials spanning the region's important prehistory from the Lower–Middle Palaeolithic and sites such as Hazar Merd, the Neolithic settlement of Jarmo and many new artefacts and bioarchaeological remains from Bestansur, as well as materials from early urban sites in Mesopotamia more widely (https://www.slemanimuseum.org/default.aspx). The exhibition opens in 2020 with all text and labels in Kurdish, Arabic and English.

We collaborated with graduates from the Iraqi Institute for the Conservation of Antiquities and Heritage in Erbil and the Smithsonian Institution in conservation of the site and artefactual and bioarchaeological materials (Chapter 8). We were also delighted to welcome visits to the site from school children, teachers and the Department of Education, and university staff and students from Sulaimani Polytechnic University, City Planning Department and Digital Heritage Research Group, University of Sulaimani, Department of Archaeology, Salahaddin University, Department of Archaeology, and the American University of Sulaimani, as well as local, national and international visitors.

Key discoveries from survey and excavation

New CZAP fieldwork and research has significantly enhanced our knowledge of the role of the Zagros region for developments spanning the Lower Palaeolithic to Neolithic. The importance of this region was established by pioneering investigations in the 1920s–1960s (Garrod 1930; Braidwood *et al.* 1983) and more recent research (Altaweel *et al.* 2012; Darabi *et al.* 2013; 2018; Matthews *et al.* 2013a; Giraud *et al.* 2019). CZAP research is the first to investigate the Neolithic in the lower Zagros of Iraq since the Braidwoods' excavations at Jarmo in the 1940s–1950s. We selected the two Neolithic sites in order to investigate ecology and society at settlements on two of the largest plains in the region, Bestansur on the Shahrizor Plain and Shimshara on the Rania Plain. Both sites had access to major water-sources, routeways and ecozones including plains, wetlands, and mountains up to 2000m high within 20–30km.

Zarzi Survey

Our survey in a 15km^2 area surrounding the

Epipalaeolithic type-site of the EFC, Zarzi cave (Garrod 1930; Wahida 1981; 1999), identified an open-air Epipalaeolithic site opposite the cave, confirming a prediction by Wahida (1981; Chapter 4). This open-air site, Zarzi 2, is in a prime location overlooking the Chemi Razan River on a knoll facing the arc of cliffs that create the large amphitheatre of gentle rocky slopes in which Zarzi cave is sited, Zarzi 1. The presence of a large boulder mortar and a range of lithics suggest the open-air site may have been occupied repeatedly over many seasons. The open-air site of Zarzi 2 and slopes in front of Zarzi cave will be excavated in the next 5 year phase of CZAP to investigate and date the nature of occupation and inter-relations between these two different site types to develop a new model of Late Pleistocene ecology and communities for the EFC, as this is a key period in experimentation in sedentary settlement and resource management during global warming after the Late Glacial Maximum and in the Bølling–Allerød Interstadial in particular, from 12,750–10,750 BC (Chapter 3). The sparsity of Neolithic sites along the river and adjacent lower slopes may suggest a shift in locale preference to more open plains with wetlands and fertile soils, which also had access to parkland on hillslopes as at Bestansur and Shimshara, 75km to the south and 44km to the north respectively.

Zarzi cave and the Zarzi 2 site are in an area with a long history of earlier occupation within a radius of *c.* 30km. The presence of earlier hominins in the Zarzi region is attested by the find during our survey of a Lower–Middle Palaeolithic limestone cutting tool lying on a low promontory on the lower reaches of the Chemi Razan River to the east. This cutting tool type and material is similar to those found at the open-air site of Barda Balka and cave sites investigated by Braidwood and colleagues (Braidwood and Howe 1960; Howe 2014), also within *c.* 30km in a direct line to the west. The significance of these and other Palaeolithic sites in the Central Zagros more widely is of major importance to the study of dispersal of early hominins as well as anatomically modern humans (Vahdati Nasab *et al*. 2013a). The Zagros may have been a key dispersal zone because of its high biodiversity and strong seasonal and topographically influenced mosaic of micro-ecologies and habitats (Boivin *et al*. 2013; Ghasidian and Heydari-Guran 2018; Heydari-Guran and Ghasidian 2020)

Late Upper Palaeolithic–Epipalaeolithic sites contemporary with Zarzi include Palegawra caves, open-air sites at Turkaka and Kowri Khan, and the later tenth millennium BC site of Karim Shahir in the Chemchemal, Chemi Razan and Bazian regions respectively (Braidwood and Howe 1960; Braidwood *et al.* 1983; Asouti and Baird 2015; Jayez *et al*. 2019). With regard to Epipalaeolithic open-air sites in the Iraqi Zagros more widely, up to 6.7ha settlement at Zawi Chemi Shanidar, 130km to the north, included repeatedly rebuilt stone buildings and was also in a region with a long history of occupation, as notably attested at Shanidar Cave (Solecki 1971; Matthews 2000). As the open-air site of Zawi Chemi-Shanidar is located only 4km from Shanidar cave, it is likely that there would have been some interconnections and mobility between proximate cave and open air sites, and that this contributed to the sustainability of hunter-gatherer populations and ways of life (Solecki 1981; Solecki *et al.* 2004), as appears to be the case in the Zarzi complex of sites. Future excavations of the Zarzi sites will investigate this and other associated issues.

Shimshara

At the site of Shimshara, CZAP rescue excavations revealed formerly unknown eighth millennium BC Early Neolithic occupation levels at the base of this strategically important site on the banks of a major regional river, the Lesser Zab, where it exits a mountain pass to head south-west to the Tigris River, 170km away, with access to the fertile Rania Plain and associated routeways (Chapter 10). These levels had not been reached by Ingholt's excavation in the 1950s (Mortensen 1970) but had since been exposed by major erosion from the Dokan Dam waters, which receded in 2012–2013. We excavated two trenches, 5 × 4m and 3 × 2.5m in area, and recorded and sampled more than 25m of field-sections with up to 2.5m depth of intact Neolithic deposits. The results push back occupation at this site by several centuries into key periods of transformation in the Early Neolithic and reveal the longevity and sustainability of settlement and activities at Shimshara over a period of more than 1300 years spanning *c*. 7300–6000 BC.

The fieldwork enabled analysis and sampling of rich early midden deposits, as well as later activity surfaces associated with mudbrick buildings in Trenches 1 and 2. Of note were, first, the discovery of architectural technologies in common with sites as far afield as Çatalhöyük >1000km to the west. A rich range of plant and animal remains were recovered, including the charred remains of cultivated and gathered resources, such as lentil and pistachio, as well as well-preserved reed and grass phytoliths, animal dung fuel, and abundant fauna, including pig, sheep, birds and fish (Chapters 12–18). The materials and artefacts at Shimshara provide evidence of access to a wide range of resources and networks and technological traditions differing in some respects from those attested at Bestansur (Chapters 20–22, 24). The implications of these new discoveries are discussed in the following sections on resources, built environment, health and networks.

Bestansur

The focus of this phase of CZAP was on the formerly unexcavated Neolithic settlement at Bestansur,

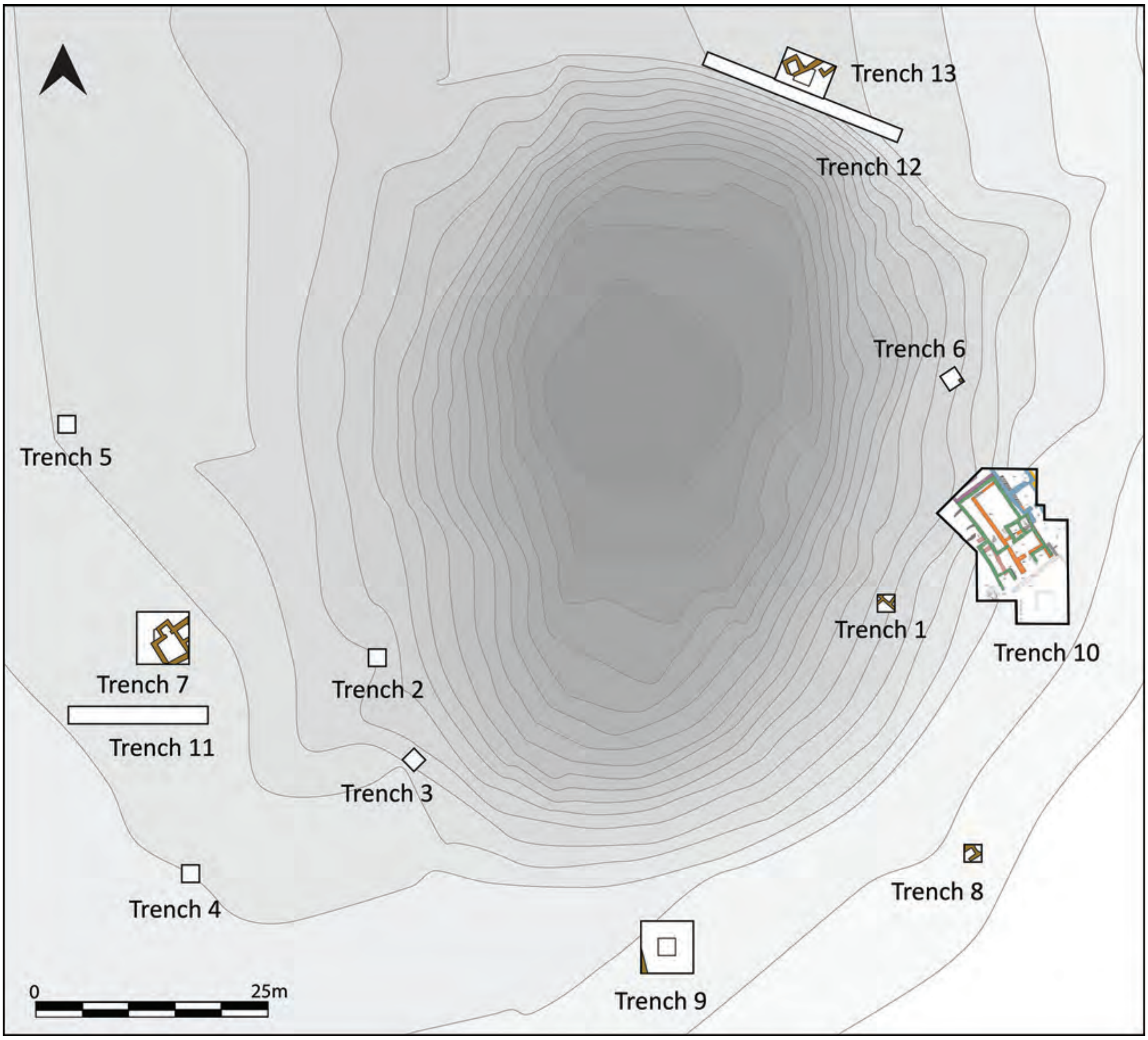


Figure 24.1. Bestansur excavation trenches and built environment.

identified as Neolithic by recent survey (Altaweel *et al.* 2012). Our own intensive survey of surface finds established that the site is at least *c.* 4ha in size (Chapter 9). We conducted a programme of site survey, geophysics and coring to investigate the nature and depth of occupation across the mound and in the immediate environs of the site (Chapters 5, 6, 9). We excavated 13 trenches to investigate ecology and society in different sectors of the settlement and community (Chapter 9). These trenches were placed at key cardinal points around the mound as well as on the flanks of the mound, based on surface finds, and were located up to 100m apart (Fig. 24.1).

We revealed that intact Neolithic levels were preserved across this 100m wide area, and probably over >*c.* 4ha, from depths of *c.* 0.3–0.5m below the surface in the surrounding fields, and 0.5–2.0m below the surface on the flanks of the mound, and are overlain by Iron Age, Sasanian and later occupational deposits. We excavated and intensively sampled Neolithic levels in 11 of the trenches and established that occupation spans *c.* >7660–7000 BC, comprising at least *c.* 4m of Neolithic settlement. Four of these 11 trenches were expanded to investigate architecture and open areas at each of the cardinal points, in Trenches 7, 9, 10 and 12/13. Trench 10 in the east of the site was subsequently selected for further extensive area excavation to investigate a Neolithic neighbourhood and sequence of elaborate buildings and high number of sub-floor burials in this and the next phase of the project.

The results from Bestansur are of major importance for our understanding of the development of agriculture and sedentism during the key period of transformation in the mid–late eighth millennium BC, when agricultural practices and sedentism were becoming more established and networks across Southwest Asia were being expanded (Zeder 2009). The site of Bestansur, at least *c.* 4ha in size, is larger than many Neolithic settlements of this period, which are often only *c.* 1ha in size (Baird 2005), and is one of the largest known sites in the Zagros, including the renowned settlement of Jarmo, 65km from Bestansur, which covers *c.* 1.6ha. Bestansur also appears to be occupied slightly earlier than the lower levels at Jarmo (Chapter 11). The architecture at Bestansur is rectilinear, multi-roomed and of a range of building sizes and plans. One building, Building 5 and its predecessor Building 8, are especially elaborate with multiple applications of plaster and traces of wall painting and pigmented matting. Building 5 has a distinctive plan in some respects comparable to buildings at contemporary sites to the west at Abu Hureyra and Tell Halula on the Euphrates, and of similar size to the largest of these at 81.5m^2 (Moore *et al.* 2000; Molist 2013). Studies of the built environment and micro-archaeological traces of activities have provided new insights into continuity and change across the community in configurations of space, social relations, everyday practices, access to resources and health (Chapters 12–14), as reviewed below.

Building 5 was host to one of the highest numbers of intramural human burials known in the Neolithic of Southwest Asia, with more than 78 individuals excavated to date below floors of Building 5 and in the packing of the underlying building, Building 8, 65 of which are reported in this volume (Chapters 9, 19). Osteoarchaeological and palaeopathological analyses of these skeletal remains are providing new insights into early sedentary demography, social relations, burial practices, diet, health and mobility, as discussed in Chapter 19 and below.

The artefacts and material culture of Bestansur are also elaborate and attest engagement in diverse local and regional networks of contact and exchange that extend over 1500km from Anatolia to highland Iran and from Armenia to the Persian Gulf/Mediterranean, at a node that was later part of the Great Khorasan Road and the Silk Roads, as reported in artefactual and pXRF analyses of chipped stone, ground stone and stone and clay objects including mace-heads, greenstone axes, carnelian and variscite beads, clay tokens and figurines, and cowrie-shell inlaid with bitumen (Chapters 20–22).

Integrated zooarchaeological, archaeobotanical and micromorphological analyses have revealed that the resource base sustaining this vibrant community was biodiverse, with use of much fewer domesticated plants and animals than expected (Chapters 12, 15–18). All of the animal remains at Bestansur are morphologically wild and charred cereal grain and pulses are comparatively scarce. Bestansur has, however, the earliest evidence to date for goat herding and management beyond their natural habitat of the highland Zagros, at *c.* 7660 BC, slightly earlier than at Ali Kosh *c.* 7500 BC (Hole *et al.* 1969). Some of the wild boar/pigs at Bestansur may have been at least partly commensal if not managed, as suid coprolites have been identified within the settlement in T12 Sp39 (Chapter 16), providing some of the earliest evidence for proximity to and possible management of wild boar/pigs in this part of the Zagros shortly after 7100–7050 BC. The nature and implications of this biodiverse and significantly wild food base, and the use of dung as fuel are discussed in Chapters 12–18, and below.

Many of the achievements and sustainability of the community at Bestansur can be attributed in part to the strategic location of the settlement in a rich ecotone with access to the second largest fresh-water spring in the region and diverse habitats and biomes and major natural routeways, as well as to adaptability in ecological strategies, resource management, technology, and social institutions and practices, as explored in this volume.

The following thematic synthesis and discussions examine how these new data and interdisciplinary analyses provide new insights into our understanding of Neolithic transformations in: resource management; sedentism, society and ritual; the human life-course and health; and material engagement and networks.

Resource management

To study developments in early cultivation and animal management and their socio-ecological and technological contexts and impacts, we conducted interdisciplinary analyses of local climate and environment and food systems and food chains to consider food from source habitat to production, consumption and discard (Reed and Ryan 2019). We examine: the scale and inter-relationship of early crop and animal husbandry practices; the relative importance of different plants and animals; household and community social roles, relations and mobility; production and consumption; agricultural and domestic technologies; and diet (Bogaard 2005; 2017; Anderson *et al*. 2017). The results have provided new insights into the sustainability of sedentism in highly productive ecozones and ecotone boundaries with access to major routeways.

Climate and environment

Climate and environment change are widely recognised as key drivers in the development of increased sedentism and early agriculture in Southwest Asia. Their roles and local impact, however, were diverse and are contested, and societies remained vulnerable to risk (Barker 2006; Mithen and Black 2011; Asouti 2017; Jones *et al*. 2019). One line of argument suggests that the climatic downturn during the Younger Dryas forced increasing management of more restricted and dwindling resources leading ultimately to domestication (Moore *et al*. 2000; Hillman *et al*. 2001). The evidence for domestication of grains such as rye during this period, however, is now questioned as they have been reclassified as wild (Colledge and Conolly 2010). The argument that there was a 'broad-spectrum revolution' (BSR) in experimentation with and use of more biodiverse lower-ranked foods that led to domestication (Flannery 1969) is also being challenged, as a range of plant remains may represent animal rather than human diet if derived from dung (Miller 1984; 1996; Spengler 2018) and some of the 'lower-ranked' foods are more nutritious than has been argued (Asouti 2017).

The concept of a broad spectrum revolution more recently has been revised and applied in explanations and interpretations of increasing evidence for use of a more biodiverse range of resources across many regions, from North Africa to Southwest Asia as well as Europe in the late Pleistocene to Early Holocene, that enabled more extended occupation at specific locales, particularly where they were resource rich (Zeder 2012; Jansen and Hill 2016; Barton *et al*. 2019; Jones *et al*. 2019). The climatic amelioration following the Late Glacial Maximum provided increased capacity for longer-term settlement and management of local resources through the greater availability of plant, animal and aquatic species, particularly during global warming in the Bølling–Allerød Interstadial and after the Younger Dryas in the Early Holocene (Maher *et al*. 2012). It has, however, been suggested that the development of sedentism and agriculture was delayed in the Zagros. It was argued that this region was colder, drier and less hospitable than the Western Fertile Crescent, based on: low-resolution lake core data that suggested a scarcity of trees (van Zeist and Wright 1963); isotopic data that suggest increased seasonality of rain and long dry summers (Stevens *et al*. 2001) and insufficient reliable rainfall for rain-fed agriculture until *c.* 7500 (Riehl 2016), all leading to ecological instability due to "marked seasonality of the early Holocene climate, its decadal-centennial scale oscillations and the resulting fragility of the regional grassland biomes" (Asouti 2017: 39), as well as an apparent sparsity of sites (Hole 1996).

New surveys and excavations by CZAP and other projects have revealed, firstly, that Early Holocene occupation in the Zagros was not delayed as initially argued based on limited investigations (Hole 1996) and, secondly, that there is emerging evidence for increased settlement and management of plants and animals contemporary with that in other regions of Southwest Asia (Darabi *et al*. 2011; 2018; Matthews *et al*. 2013a; Riehl *et al*. 2013; Whitlam *et al*. 2018; Giraud *et al.* 2019). Without new palaeoclimate and environmental data, however, many questions on the transitions in the Zagros and the role of climate and environment remain unresolved. To this end, new climate and environment data were collected and analysed from speleothems, lake and site environs cores, and on-site bioarchaeological remains in highland and lowland Zagros sites in collaboration with a range of researchers (Chapters 3, 6, 12). The following section reviews existing debates on Zagros climate and environment and highlights results from new palaeoclimate investigations and local geographical and environmental analyses of on-site resource availability from the sites excavated and their implications for Late Pleistocene to Early Holocene environments, local habitats and biomes.

The Zagros region, like much of Southwest Asia, is one of the most dynamic climatic regions in the northern hemisphere as it lies at the convergence of the westerly jet stream from the North Atlantic, the Siberian anticyclone and Indian Ocean summer monsoon (Mehterian *et al.* 2017: 187). This region is key to understanding the nature and impact of past, present and future climate change as it is particularly sensitive to variation in the strength and locations of these systems and their drivers such as external solar insolation and local and regional variation due to marked topographic gradients from lowland plains to high mountainous regions (Mehterian *et al*. 2017; Jones *et al*. 2019). Whilst westerly precipitation may reach the Mediterranean regions, the strength and location of their track to interior regions is much more variable, impacting the nature, volume and timing of precipitation and therefore water availability (Stevens *et al.* 2001; Jones and Roberts 2008; Roberts *et al.* 2018).

Early Holocene climate and environment in interior regions of Southwest Asia including the Zagros, central Anatolia and the Taurus arc remain a particular area of controversy and uncertainty. This ambiguity is due to an apparent paradox between pollen data on the one hand that attest a *c.* 3000–5000 year delay in the development of postglacial afforestation and deciduous oak woodland, initially argued to indicate climate aridity, and stable isotope data from the same cores on the other hand that suggest increased moisture availability (van Zeist and Bottema 1977; Roberts *et al.* 2008). Current explanations suggest this paradox may be due to: increased external solar insolation and seasonality resulting in an extended summer drought (Djamali *et al.* 2010) and climatic instability (Asouti 2017), as well as variation in vegetation responses and the impact of wild fires, human activity, land management and animal grazing (Asouti and Kabukcu 2014; Roberts *et al.* 2018; Jones *et al.* 2019). Until recently, the principal source of data was from low resolution sampling of cores from Lake Zeribar (1287m asl) collected in 1960 (van Zeist and Wright 1963; Wasylikowa *et al*. 2008), 44km east of Bestansur (552m asl) and 127km southeast of Shimshara (480m asl). To date, little other published data exist for the Younger Dryas to Early Holocene climate and environment in the Zagros, a crucial period of transformation examined in this research from *c.* 12,000–6000 BC. Important new published data from speleothems and coring covers either earlier or later periods (Djamali *et al*. 2008; 2009; 2011; 2017; Mehterian *et al*. 2017).

New multiproxy research on past climate and environment is being conducted by a range of researchers in collaboration with CZAP through collection and analysis of new palaeoclimate and palaeoenvironmental records. These new data sources include lake cores from both highland and lower Zagros from: Lake Hashilan in Kermanshah province, Iran (1309m asl), 35km west of Sheikh-e Abad (1430m asl) and 71km north of Jani (1280m); and Lake Ganau (510m asl) 1.4km north of Shimshara. These cores are being analysed by Maria Rabbani at the University of Reading, in collaboration with Reza Safaie, Ghasem Azizi and Mehran Maghsoudi (University of Tehran), Manfred Rösch (University of Heidelberg), Simone Mühl (University of Munich) and Elena Marinova-Wolff (State Office for Cultural Heritage, Baden-Württemberg) (Chapters 3 and 24; Mühl *et al*. 2018). Cave speleothems were collected for the first time from the Iraqi Zagros by Dominik Fleitmann and Matthew Bosomworth (University of Reading) and Mark Altaweel (UCL) (Chapters 3, 6; Marsh *et al*. 2018; Altaweel *et al*. 2019). Soil and sediment cores from the vicinity of the site at Bestansur were analysed in conjunction with analyses of the local geology, hydrology and topography (Chapter 6).

The new speleothem data from Shalaii Cave, *c.* 41km southwest of Bestansur at 739m asl, indicates that whilst there was increased precipitation in the Early Holocene, there was less precipitation and water availability in the Zagros than in the eastern Mediterranean until the early eighth millennium BC, coincident with occupation at Bestansur at *c.* 7700 BC (Altaweel *et al*. 2019). This is likely due to a more northerly position of the inter-tropical convergence zone (ITCZ) which would have prevented at least some of the precipitation and storm tracks reaching the Zagros. The high variability in multi-proxy precipitation data suggests that there was also greater interannual variation in precipitation and climate instability and marked seasonality until the early–mid-eighth millennium BC. There is some indication of abrupt climate events at 9.2ky and 8.2ky, as elsewhere in Southwest Asia (Flohr *et al*. 2016), coinciding with the later phases of occupation at Bestansur and Shimshara. This new speleothem evidence supports Riehl's (2016; Araus *et al*. 2014) argument, based on stable isotopic analysis of charred wild cereals from Chogha Golan on the lower foothills of the Zagros in Iran, that precipitation was not sufficiently reliable for extensive cereal cultivation in the Zagros until 7600–7500 BC, after the start of occupation at Bestansur (Chapter 11).

The speleothem collected in 2013 from Gejkar Cave, 64km northwest of Bestansur and 48km south of Shimshara, proved to be later in date. Analysis of this speleothem, however, has provided new insight into periods of extreme drought at *c.* 650 BC, and more recently from 2007–2010, which led to extensive crop failure (Flohr *et al*. 2017). Like other longitudinal studies, this new research provides significant data for analysis not only of past climate, environment and sustainability, but also for evaluation of the impact of current and future climate change (Mehterian *et al*. 2018).

Existing and new multi-proxy data from Zeribar, however, confirm that global climatic amelioration in the Early Holocene resulted in the transformation of a range of biophysical properties in the Zagros and provided increased capacity for transformative socio-ecological change. Key biophysical transformations of relevance to the development of agriculture and sedentism evident from Zeribar include rapid temperature increase in the Early Holocene and an increase in the abundance and diversity of plant resources that would have provided significant capacity for animal and human food, habitat and other resources. Notable plant resources included abundant grasses, which increased rapidly from *c.* 15% to 50% of pollen in Lake Zeribar by *c.* 8500 BC, and represented *c.* 40% of the pollen during the occupation of Bestansur and Shimshara (van Zeist and Bottema 1977), suggesting favourable conditions for a range of grasses such as wild barley as well as medium–smaller seeded grasses that were collected at earlier sites such as Sheikh-e Abad and Ganj Dareh in the high Zagros (van Zeist *et al.* 1986; Whitlam *et al.* 2018). Other key potential food plants attested by Lake Zeribar pollen include nut and fruit bearing trees, and legumes that increase nitrogen fixing and thereby nutrients in soils as well as provide animal and human food resources. The presence of grasslands indicates that minimum rainfall was at least *c.* 200–300mm (Chapter 3). Other factors that shaped Early Holocene environment and biomes in the Zagros included fire (Turner *et al.* 2010), animal grazing, inter-species relationships and competition, notably between grasses and oak (Djamali *et al.* 2010), as well as human impact, and collection and management of plants and landscapes for fuel, food, construction, and artefacts (Asouti 2017; Jones *et al.* 2019).

The research in this volume has provided significant new insights into the diversity of Early Holocene climate and environment at the scale of lived communities, which is central to Neolithic debates (Robb 2013; Asouti 2017) and sustainability studies more widely (Greene 2018; Shah *et al.*

2018). Analyses of the local topography, geology, hydrology, soils and the on-site palaeoecological and bioarchaeological remains from Bestansur and Shimshara and the cores for Bestansur reveal that both sites were situated by major water sources in rich ecozones and ecotone boundaries with access to diverse resources, and are currently within the boundary of rainfed agriculture.

Habitats: biodiversity and accessibility

Water is a major resource and attractor to humans, animals, plants and aquatic life with the potential to provide 'landscape anchors' for a range of species (Hammer 2014). Wetlands and riparian zones are particularly biodiverse and were selected as locales for early settlement elsewhere in Southwest Asia (Jones and Maher 2014; Jones *et al*. 2019) as well as for early cities in southern Iraq (Pournelle 2007). The settlement at Bestansur was built on gentle slopes next to the second largest spring on the Shahrizor Plain at one of the headwaters of the River Tanjero, 2.3km distant, which feeds into the Diyala and Tigris rivers. The Bestansur spring is highly reliable and only likely to fail after 3 years or more without any rainfall, as it rises at the contact of a large aquifer from the Azmar Mountain anticline and impermeable aquiclude shales and marl (Saeed Ali 2007: 141–142, fig. 4.8) and currently supplies water to a range of towns and villages across the Shahrizor Plain. Shimshara is located on a conglomerate outcrop on the banks of a major river, the Lesser Zab, with year-round water discharge, peaking in the spring.

Both Bestansur and Shimshara were located on ecotone boundaries with access to diverse topographic zones and habitats comprising springs, rivers, wetlands, fertile plains and foothills within 3km and mountains up to 2000m within 26–30km, < 1 hour and 1 day's walking distance respectively. Zarzi open-air site (*c.* 643m asl) is located on a knoll above a river, 0.5km from Zarzi cave site (*c.* 677m asl), which is on the opposite side of the river surrounded by a large amphitheatre of rock faces. Both sites had access to the river, waterfalls, riparian vegetation and wetland edges as well as foothills. Adjacent agricultural land, by contrast, is currently less fertile than the Shahrizor and Rania Plains with thinner soils. The Zarzi region, however, also has access to upland plains with orchards of old fruit and nut trees, within 1–3km of both sites, at *c.* 1000m asl.

The habitats and resources in each of these settlement environs were not only biodiverse but also 'patchy', offering access to a wide range of landscapes and resources and capacity for diverse activities, livelihoods and dwelling spaces. In analysis of any major transformations, it is important to consider whose lives may be beneficially affected and whose may be negatively impacted, marginalised and displaced (Lowenhaupt Tsing *et al.* 2019). With the transformation from a predominantly mobile hunting-gathering lifestyle to sedentary agriculture, the potential for transformations from often more communal access to land and resources to more restricted land access and ownership is high and argued to have been characteristic of Southwest Asia (Robb 2013). Increasing ownership and privatisation of resources, however, is not predictable nor a pre-requisite for domestication and sedentism as there is evidence in Southwest Asia and more widely for a range of communal resources and practices in the Neolithic (Bogaard 2005; Asouti and Fuller 2013; Robb 2013), which is examined in the following discussions on resources, lifeways and networks.

Plant management and utilisation

Plant and faecal matter preservation and taphonomy: integrated archaeobotanical approaches

Charred plant remains preservation and taphonomy

One of the major challenges in this research has been the scarcity and poor preservation of the charred plant remains recovered by water-flotation at Bestansur, and to a lesser extent Shimshara, especially as so many litres of on-site deposits were floated (Chapter 18). These sites are the first Early Neolithic sites to be excavated in decades in the Iraqi Zagros, and very few archaeobotanical assemblages exist for the EFC more widely (Charles 2008). Charred plant remains occur in very low concentrations at 0.79 items per litre on average. In addition, four charred lentils and four wheat grains selected for dating proved to be intrusive from Iron Age levels of *c.* 900 BC (Chapter 18). In this context, it is notable that lentils were a preferred crop of the Iron Age Neo-Assyrian empire in the early first millennium BC, grown in large quantities across the empire through state-organised irrigation schemes (Rosenzweig 2016). We can assume that lentils were cultivated by the Iron Age occupants of Bestansur, who were episodically under Assyrian control (Cooper *et al*. 2016–2017), and that charred examples found their way into Neolithic strata through insect hoarding and burrowing. Although intrusive charred plant remains are present at many archaeological sites including Jarmo (Nesbitt 2002), the scarcity of charred plant remains and presence of intrusive materials at Bestansur has limited the extent to which conclusions can be drawn from the flotation results.

In comparison to other sites in the Zagros, seed densities at Bestansur were lower. At Sheikh-e Abad in the highland Zagros, contemporary densities in Trench 3 were 1.4 seeds per litre, and up to 24.3 per litre in ash-rich deposits in Trench 2. At Ganj Dareh contemporary seed densities were *c.* 9.2 per sample (*c.* 10–16 litres). Van Zeist and colleagues (1984: figs 3.3 and 3.6), however, note and illustrate that some cereals and grasses were not well-preserved and are described as "generally poor" and "mainly broken". This includes native barley *Hordeum spontaneum*, which DNA studies suggest was domesticated in this region (Morrell and Clegg 2007; *Saisho and Purugganan 2007*), as well as *Stipa*, which is better preserved at neighbouring Sheikh-e Abad but in some cases exhibits signs of grinding (Whitlam *et al*. 2016; 2018). Seeds and grains may be broken by grinding, an activity that is widely evidenced by the abundant ground stone at Bestansur (Chapter 22) which may also therefore, be a factor in their poor preservation. Whether some of the charred seeds originate from dung is also a major question and challenge (Miller 1996; van Zeist *et al*. 1996) and is suggested from some *Poa* seeds at Sheikh-e Abad, for example (Whitlam *et al.* 2018). Wild foods with parenchymatic tissue such as tubers may also not have survived flotation well as they are reported by a range of authors to disintegrate in water, although they may be recovered by programmes of dry sieving depending on deposit type and conditions (Arranz-Otaegui *et al*. 2018b: 264, 271).

Integrated archaeobotanical analyses: micromorphology, phytolith, GC-MS and pXRF analyses

By contrast, through an integrated archaeobotanical approach that includes micromorphology, phytolith and GC-MS analyses, we were surprised by the abundance, preservation and diversity of non-charred plant remains in deposits and faecal material at both Bestansur and Shimshara, not only from dung burnt as fuel but also from human and wild boar/pig coprolites. These integrated micro-contextual archaeobotanical analyses are providing important new insights into environment, ecology, plant management, fuel, artefacts such as mats and basketry, as well as human and animal diet (Chapters 12, 13, 16). These results were provided by an intensive, innovative combination of field and laboratory analyses conceived from the outset of the project (Matthews and Matthews 2010), building on earlier collaborative research at Çatalhöyük (W. Matthews 1996; 1998; 2005; Bull *et al.* 2005; Shillito *et al.* 2011; 2013a) and in the high Zagros (W. Matthews *et al.* 2013h; Shillito *et al.* 2013b). We conducted rapid pXRF analyses in the field to screen for areas with elevated phosphorus indicative of organic materials such as faecal matter and refuse. We then targeted these and other microstratigraphic deposits macroscopically visibly rich in phytoliths, ash and yellowish organic matter indicative of omnivore coprolites for spot smear-slide analysis in the field laboratory to identify presence and types of phytoliths and faecal spherulites. A suite of samples was then taken for integrated micromorphological, spot phytolith and GC-MS analyses in the specialist laboratories in the Universities of Reading and Bristol.

Micromorphological analyses have established that charred plant remains represent only 22% of plants preserved in deposits and only those that have been burnt at low temperatures <*c.* 300–500°C, above which carbon is burnt off (Boardman and Jones 1990). A wide range of other non-burnt plant remains as well as plants burnt at high temperatures of >300–500°C are preserved as impressions of plants that have since decayed, and as desiccated and mineralised remains, phytoliths and calcitic ashes. The scarcity of charred plant remains is due not only to bioturbation and impact of local shrink-swell clays as argued in Chapter 18, and confirmed as affecting at least 20–30% of deposits, but also to routinely high-combustion temperatures that exceeded 600°C and occasionally 850°C based on the common presence of ash and melted silica (Canti 2003) and to use of a wide range of plant parts. Many of these remains, moreover, are not from seeds and wood, which routinely withstand flotation, but are from stems and leaves, and occasionally roots, and in some cases are in ruminant or omnivore faecal matter, all of which are often under-represented in flotation samples (Colledge and Conolly 2014; Chapters 12, 13). Phytoliths are abundant at Bestansur in thin-section and in spot samples, comprising up to 20.2 million per gram of sediment, and are well-preserved often as articulated multi-cellular remains.

Other factors affecting the scarcity of charred plant remains include: the absence as yet of excavated middens; the thinness of many occupation deposits at less than 0.5 to 2–5cm; the high percentage of largely sterile silty clay packing layers, *c.* 3–30cm thick, that were laid in many interior and exterior areas; and the infilling of rooms with construction debris, rather than refuse, as is common on sites; as well as possible degradation of charred remains structure in the alkaline soils (Braadbart *et al.* 2009; Chapter 12). These deposit types, however, indicate considerable management of waste and the built environment, as discussed below.

Future analyses

To improve identification and recovery of charred plant remains in the next phase of CZAP, we are conducting integrated stereo-binocular and SEM analyses of charred plant remains from water-flotation as well from spot sampling of archaeobotanical blocks in controlled environments in field and specialist laboratories, with the aid of new comparative reference collections and experimental burning, led by Charlotte Diffey. We are also applying these analyses to studies of charred plant remains *in situ* in archaeobotanical blocks that have been collected throughout all phases of CZAP. SEM analyses have enabled identification of fragile plant remains such as tubers and leaves as well as foodstuffs at a range of sites (Carretero *et al.* 2017; Arranz Otaegui *et al.* 2018b: figs 3–4).

These reference collections will also aid continued identification of the well-preserved anatomy of plants in micromorphological thin-section, which are providing important micro-contextual information on whether plant remains are derived from dung, fuel, matting, or food preparation for example (Chapter 12). The impact of bioturbation at the micro-scale of different individual plant remains types will also be examined in thin-section and by SEM. We will continue to examine residues from ground stone and look for traces of starch and phytoliths in dental calculus to inform further on plant processing and consumption.

Plant resource management and use

Charred plant remains

Although there is some uncertainty about how representative the charred plant remains from flotation are of Neolithic or later levels, the following observations can be made based on the samples analysed in detail in Chapter 18, particularly as more recent radiocarbon dating in the new phase of CZAP has established that at least some charred plant remains recovered by flotation are Early Neolithic in date, in agreement with dated bone samples (Chapter 11). At both Bestansur and Shimshara potentially domesticated cereals, predominantly wheat, and pulses were identified alongside a range of wild plants comprising wild grasses, including wild barley, and pulses, including bitter vetch, as well as nut/fruit and club-rush.

At Bestansur cereals and pulses were present in 94.3% and 100% of samples respectively. Glume wheats were the most abundant cereals and may have been domesticated. These wheats included two-seeded emmer (*Triticum dicoccum*) and einkorn (*T. monococcum* L.). Barley (*Hordeum vulgare* L) was relatively rare at 8.6% and was represented almost exclusively by grain. Pulses were present in 77.1% of samples, many of which were lentil or indeterminate. Nut/fruit fragments occurred in 60% of samples. Other wild and potentially weedy seed taxa identified at the site include medium-seeded and small-seeded wild grasses, small-seeded legumes, *Bolboschoenus glaucus* Asteraceae sp. and *Galium* sp. Regarding contextual variation, the high proportions of glume bases and wild/weed taxa recovered in external areas may suggest such areas were used for the processing of crops and/or the disposal of crop processing by-products.

At Shimshara, charred plant densities were slightly higher than at Bestansur, with an average of 0.89 items per litre, although charred plant preservation was also poor. Pulses and cereals were present in 100% and 76.5% of samples analysed respectively. Identified charred plant remains include emmer wheat, lentil and bitter vetch, all of which were plausibly cultivated at the site. Wild barley (*Hordeum* cf. *spontaneum*) was present in 11.8% of samples. Two seeds of flax are also of interest, as flax has also been found at Maghzaliyeh and Ali Kosh (Table 18.8). Nut/fruit taxa were present in 82.4% of the assemblage and included predominantly *Pistacia* with some almond. *Bolboschoenus glaucus* and wild grasses were also identified.

At both sites a narrow range of taxa, including *Galium* sp., *Bolboschoenus glaucus, Papaver* sp. and small-seeded legumes may represent potential arable weeds. However, as with wild grasses their presence needs to be considered with respect to the multiple pathways by which these arrived on site, for example through intentional collection as food, within animal dung burnt as a fuel, as craft/construction material, and taphonomic processes (Savard *et al*. 2006; Charles 2008; Whitlam *et al*. 2018).

Amorphous charred matter is present at Sheikh-e Abad and Bestansur and may represent foodstuffs (Whitlam *et al*. 2018: 826), which are increasingly attested and identifiable as porridge and bread remains for example at other sites (Carretero *et al.* 2017; Arranz-Otaegui *et al.* 2018a), pending ongoing SEM analyses.

Integrated micromorphology, phytolith and gc-ms analyses

Integrated micro-contextual archaeobotanical analyses are contributing significantly to identification of formerly missing or difficult to detect plant remains such as: fragile leaves, stems and roots/tubers that are often lost in flotation (Chapters 12, 13 and 14; Colledge and Conolly 2014); plants in animal, human and wild boar/pig coprolites that have enabled robust distinction between diets of different species as well as dung burnt as fuel (Miller 1996); and artefacts such as basketry and matting that are also often not recovered during excavation or sampling (Barton *et al*. 2019: 547).

The scarcity of charred wood from flotation and in thin-section suggests that trees such as those represented by charred nuts/fruits and by dicotyledonous phytoliths in fuel and human and animal coprolites are likely to have been conserved as a resource for human and animal food, and perhaps for habitat for wild/boar and birds along the river as well as wild sheep and deer in parkland. Tree conservation has also been attested at Ganj Dareh, where Pistacia wood was not burnt in the early levels when nuts were a major food resource (van Zeist *et al.* 1984: 222; Chapter 12).

The phytolith and micromorphological data indicate that there were extensive wetland resources at both Bestansur and Shimshara. Wetland ecozones are emerging as key locales for Epipalaeolithic and Early Neolithic settlement (Jones *et al.* 2019), as well as the origins of cities in Iraq in the fourth millennium BC and earlier (Pournelle 2007). Wetlands provide habitats and key locales for a wide range of animals, birds, and aquatic life, as discussed below. They also provide a wide range of materials for construction and artefacts (Balbo *et al*. 2012; Ramsey *et al*. 2018). Less well known is the edibility of a wide range of wetland plants even in the more cereal-rich Levant (Ramsey *et al.* 2015; 2016; 2018). Edible wetland plants can provide a reliable if less nutritious source of food that includes: roots of the club rush, cattails, and reeds which can be consumed raw, roasted, or pounded into meal or flour; fresh young cattail and reed shoots and stems; and the seeds of all of these plants which can be eaten whole or ground to flour (Wollstonecroft *et al.* 2011; Ramsey *et al*. 2015; 2016). That reed shoots may have been consumed by humans is attested by the presence of reed phytoliths in some coprolites identified as human in Trenches 12 and 13 (Chapters 12, 13, 16). Other wild foods in coprolites include trachea and dicot. phytoliths, suggesting consumption of terrestrial thistles and perhaps green leaves. With regard to food security, therefore, sedentism at Bestansur may have been supported at least in part by wetland-oriented hunter-gatherer wild food resources and lifestyle developed since at least the Epipalaeolithic, indicating considerable long-term continuity in sustainable lifeways (Ramsey *et al.* 2016). The boulder mortar and ground stone technology at all three CZAP sites studied is also of a long local tradition and conservative in style, and was likely used to prepare these wetland and other wild food resources such as nuts, as well as cereals, with which they are often associated (Chapter 22).

Cereals and pulses from terrestrial landscapes were a part of the diet at Bestansur and Shimshara. The low densities of charred cereals and pulses in both flotation and micromorphological samples from Bestansur and Shimshara may suggest that these plants were not a dominant component of the diet, whether or not they were domesticated, although taphonomic processes may also be a major factor. Some cereal-like phytoliths have been identified in human and animal coprolites, confirming that cereals were selected for human consumption (Chapter 16). The low incidence of caries in the human teeth has been argued in the past to represent low consumption of carbohydrates and crops (Larsen 2006). Eshed *et al.* (2006) and Walsh (Chapter 19), however, have shown that caries is not a reliable indicator of a high cereal diet as the initial studies were based on non-cereal crops such as maize, and a range of other environmental and genetic factors affect the incidence of caries. Similar low frequencies of Neolithic caries include: Nemrik (Sołtysiak *et al.* 2015), Sheikh-e Abad (Cole 2013), Ganj Dareh (Merrett 2004: 233), Jarmo (Dahlberg 1960), and Abu Hureyra (Moore *et al.* 2000).

This integrated archaeobotanical and micro-contextual approach has established that renewable and sustainable sources of energy, a major challenge then as today, were provided by use of reeds, grasses and dung for fuel. Fuel was a vital resource used for a wide range of heating, cooking and craft activities. Use of dung as fuel extends back into the Epipalaeolithic (Arranz-Otaegui and Richter 2016; Arranz-Otaegui *et al.* 2017) and was an important secondary product from managed and domesticated populations which at Bestansur comprised goat, a factor which Hesse (1984) argues more widely may have been a driver in their domestication. Dung would have provided a sustainable and efficient source of energy as the plants consumed not only support this animal biomass tier, but provide a matted porous structure to dung, which once dry, burns evenly and for long periods (Sillar 1998). This second-generation use of plant resources coupled with the use of energy-efficient fire-installations, therefore, provided an important socio-ecological and technological development that supported the transformation to sedentism and domestication.

With regard to wider resource availability and transformations in resource management in the Zagros and EFC, many Early Neolithic sites were located close to water sources, associated wetlands, and ecotone boundaries that included access to plains and hilly slopes (Fig. 1.1). Bestansur and Shimshara were in particularly rich biodiverse locales. Wood was more available and used in the high Zagros at sites such as Ganj Dareh, Sheikh-e Abad and Abdul Hossein, and less frequently used in the lower Zagros at sites in more steppic environments such as Chogha Golan, Ali Kosh and Chogha Bonut, which span the tenth-seventh millennia BC (W. Matthews 2010; 2016; Riehl *et al.* 2013; Rosen 2018).

Van Zeist and colleagues (1984: 217) note that due to overgrazing in the Zagros today, “grasses have to a great extent been replaced by unpalatable species in most of the present-day steppe”. Wild grasses were an important resource at many Early Neolithic sites (Savard *et al.* 2006; Whitlam *et al.* 2018; Weide *et al.* 2018). At Sheikh-e Abad medium-seeded perennial wild grasses *Lolium perenne /rigidum, Piptatherum holciforme, Taeniatherum caput-medusae* and *Stipa* spp. form a significant component of the charred plant assemblage and may have been collected from large native stands as no weeds of cultivation were identified (Whitlam *et al*. 2018: 826). Wild barley was increasingly selected at Chogha Golan and domesticated-type barley rachis have been identified at *c.* 8250 BC, and emmer wheat at *c.* 7850 BC (Riehl *et al*. 2013; Weide *et al*. 2015). At Chogha Golan and East Chia Sabz the almost complete package of the wild forms of the founder crops are represented, including Hordeum (barley), Triticum (hulled wheats), Lens (lentil), *Lathyrus sativus* (grass pea), and *Vicia ervilia* (bitter vetch) (Riehl 2012: 100). Interestingly, some of the charred plants at East Chia Sabz are not exceptionally well-preserved (Riehl 2012: fig. 2. H-0).

Grasses, reeds and sedges, Pooideae, represent 70% of the phytolith assemblage from Bestansur, and comprise well-preserved stems, leaves and inflorescence (Chapter 13). These include phytoliths from the Cyperaceae family (sedges) and reeds (Arundinoideae subfamily), which are also commonly found in wetlands, as well as cereal-like grasses. Micro-contextual analyses confirm that cereals and reed resources (Ramsey *et al.* 2016; 2016) were used as a food source for humans and animals as present in coprolites, as well as for fuel, matting and basketry. Club rush *Bolboschoenus glaucus* was a major food source at Qermez Dere in Upper Mesopotamia (Savard *et al.* 2006), and is also attested at Sheikh-e Abad, Bestansur and Shimshara (Whitlam *et al.* 2018). All parts of this plant provide important resources that span food, fuel and artefactual and construction purposes. Club rush flourishes in wetland areas with human disturbance, suggesting a "mutualistic relationship between the wild plant and people" (Wollstonecroft *et al.* 2011) and the more-than-human world.

Analysis by Riehl (2016: 522) of regional diversity in plant remains on sites in the Eastern and Northern Fertile Crescent, using principal components analysis of charred plant remains assemblages, suggests a correlation between wild barley and nuts and fruits in drier vegetation units, and wild wheat and club rush (*Bolboschoenus glaucus*, formerly classified as *Scirpus* sp) in moister vegetation units. The comparative scarcity of wild and domesticated barley in the Bestansur and Shimshara charred plant assemblages, and presence of some wheat, supports this argument, suggesting that plant availability and use at Bestansur and Shimshara was strongly linked to local conditions and biomes associated with wetland areas, with some access to plains and slopes, corresponding to "opportunistic resource use" and development of sites with access to floodplain plants observed more widely in the Early Neolithic in the Zagros and EFC (Riehl 2016: 527). At Chogha Golan and East Chia Sabz an increase in barley size from *c.* 8650 BC may represent increased moisture or plant management and cultivation (Riehl 2012), as well as arguably increasing CO_2 levels (Jones *et al.* 2019). Riehl (2012; Riehl *et al*. 2014) and Araus *et al*. (2014) argue that there was not sufficient rainfall to rely on cereal cultivation in the Zagros until *c.* 8000–7500 BC, based on isotopic analyses and cereal kernel weights through time, and observe that it is not until 7000 BC that the Neolithic crop package was more widely adopted and adapted in the Zagros, later than the excavated occupation at Bestansur and Shimshara. Even in the Levant, founder crops only represent *c.* 42% of the charred archaeobotanical assemblages in the Early PPNB (Arranz-Otaegui *et al.* 2016b). At Sheikh-e Abad the greatest diversity in plant remains occurred at *c.* 8000 BC, including use of large seeded and small seeded Poaceae, Fabaceae, some barley, small-seeded taxa and fruits and nuts (Riehl 2012; Whitlam *et al.* 2013h; 2018) and animal dung fuel (W. Matthews *et al.* 2013; Shillito *et al.* 2013a). This evidence suggests that during the eighth millennium BC intensification of sedentism was based on a biodiverse resource base to allay risk, as in earlier experiments in sedentism in the Epipalaeolithic in other regions (Marston 2011; Ramsey *et al.* 2018), in contrast to increasing specialisation and focus in later periods, which may have been in part driven by increased over-grazing and depletion of biodiversity (van Zeist *et al.* 1984: 217).

Animal management and utilisation

Species representation: managed and wild populations and biodiversity

Perhaps surprisingly, given the sophistication of the settlement and material culture at Bestansur, all of the animals recorded were morphologically wild (Chapter 15). Bestansur has, however, yielded the earliest evidence at *c.* 7660 BC of management of herds of goat beyond their natural highland habitat. Goat were independently domesticated in the high Zagros according to indications of herd management at Ganj Dareh, *c.* 7900 BC, based on kill-off patterns (Hesse 1984; Zeder 2005) and genetic studies (Daly *et al.* 2018). The evidence for herd management at Bestansur in the lower Zagros at 550m asl is based on the sex profile which indicates retention of female dominated herds for breeding. This evidence is *c.* 250 years later than the earliest data for management of morphologically wild goat in their natural habitat in the highland Zagros at Ganj Dareh at 1370m asl, *c.* 210km to the southeast. Herd management at Bestansur is slightly earlier than the evidence for husbandry of morphologically domesticated goat at Ali Kosh, *c.* 7500 BC, and at Jarmo in the late eighth millennium BC (Hole *et al.* 1969; Zeder 2008). The Bestansur evidence is also slightly earlier than the micromorphological evidence for ruminant penning within settlements at Sheikh-e Abad, *c.* 7590 BC (W. Matthews *et al*. 2013h). Goat, however, only represent a relatively minor component of the specifically identified caprine bones at Bestansur at *c.* 20%.

The highest proportion of animal remains by NISP at Bestansur is sheep/goat at 51.3%, followed by wild boar/pig at 29.8%, and red deer at 9.7%. Other species present at less than 5–1% include: gazelle, cattle, fallow deer, wolf, fox, marten and beaver. The majority of caprines at Bestansur, *c.* 80%, were wild sheep that were hunted within their natural habitat in the hilly flanks surrounding Bestansur. Sheep are not thought to be domesticated in this region until the seventh millennium BC (Zeder 2008), suggesting that wild populations were readily accessible through hunting in this region, without herding. The high numbers of sheep at the Late Epipalaeolithic site of Zawi Chemi Shanidar at a similar elevation suggest that this region was a preferred habitat for sheep and that the practice of hunting them had a long tradition here. The pig are morphologically wild, and relatively abundant, and would also have been accessible within the environs of Bestansur, favouring the wetland and riparian habitat close to the site. Wild boar/pig, however, may have been managed or allowed to roam in the later levels of the settlement in Trench 12, post-dating 7100–7050 BC, as one omnivore coprolite has been identified by GC-MS as originating from wild boar/pig (Chapters 15, 16). Whilst the status of cattle is uncertain due to absence of metrical and age data, the earliest domestic populations identified in this region are of sixth millennium BC date (Arbuckle *et al.* 2016). At Shimshara, the highest proportion of animal remains by all indices is boar/pig, at 58% of the assemblage by NISP, followed by sheep/goat at 32.4%, of which 70% are goat by diagnostic zone (Chapter 15). Other species present at Shimshara at <3.2–0.7% by NISP include fallow deer, red deer, wolf, gazelle and fox. Current evidence based on age/sex profiling and morphometrics suggests that pig and sheep remains represent hunted wild populations which would have favoured the local riparian and grassland ecozones.

A diverse range of other wild resources were exploited, including birds, fish, land snails (*Helix salomonica*), fresh-water crab and shellfish (Chapters 15, 17). This evidence suggests that, apart from goat and perhaps wild boar/pig, the community at Bestansur had not significantly altered many predator–prey relations and was still in transition, retaining many hunting practices and traditions, as also attested by the prevalence of possible hunting tools in the chipped stone industry (Chapter 20). Molluscs in particular were an important seasonal resource and may have been consumed in communal as well as smaller scale gatherings (Chapter 17) as at a wide range of Epipalaeolithic to Early Neolithic sites in Eurasia and North Africa (Taylor and Bell 2019).

Many animals and birds would have been drawn to the abundant water at the spring head and tributary of the Tanjero River at Bestansur and the associated wetland and riparian habitat and resources, particularly during the hot summer months and during migratory periods of gazelle in the spring and autumn. As such, the location of Bestansur was a resource attractor, requiring less management and labour than sites in less ecologically rich locales (Hodder 2018a). Other sites in favourable niches include Abu Hureyra, which spans the Bølling-Allerød Interstadial to Early Holocene climate fluctuations and the downturn of the Younger Dryas (Jones *et al.* 2019). A range of co-relations between humans and animals have been identified in the development of herding and co-existence of sedentary and more mobile populations (Vigne 2009; Tornero *et al*. 2016; Stepanoff *et al*. 2017). Domestic goat, sheep and pig are all present at Jarmo by at least the Ceramic Neolithic in the seventh millennium BC (Chapter 15; Stampfli 1983; Zeder 2008; Price and Arbuckle 2015). Analysis of the seasonality of all the faunal species at Bestansur and Shimshara indicates that the sites are likely to have been occupied year-round (Chapter 15).

Animal resource utilisation

Many animal bones were fragmented although in general their condition was moderately well-preserved with fresh sharp edges (Chapter 15). This fragmentation is due in part to the climate and environmental fluctuations and clay loading, but also to processing of bones for marrow and grease extraction through pounding and probably boiling, for example. Animal fat provides an important food resource which can "provide more than double the calories of carbohydrate and protein and can be a source of essential fatty acids and lipid-soluble vitamins such as A, D, E and K" (Johnson et al. 2018: 60; see also Erasmus 1986; Mead *et al*. 1986; Outram 2001; 2004). In periods of nutritional stress, particularly when access to carbohydrates is limited, fat consumption can commute the adverse and potentially fatal effects of a protein-rich diet (Speth and Spielmann 1983: 13; Speth 1989; Outram 2004; Johnson *et al.* 2018: 60). Animal fat and grease also provide a vital source of lubricant for leather and wood artefacts, aiding waterproofing of basketry, as well as a medical application in the form of lotions. Bone grease extraction requires considerable time, energy expenditure and fuel, but the grease is storable; whilst bone marrow extraction and bone-enriched stews require comparatively little effort, marrow is storable only within intact bones (Johnson *et al.* 2018: 61). The ground stone at Bestansur certainly provided a long-standing technology for such extraction, and mammal bone fragments are present within omnivore and probable human coprolites at Bestansur confirming consumption of bone-stews/marrow.

Animals are also frequently part of human social and symbolic worlds (St-Pierre *et al.* 2018). Wild boar/pig may have cohabited and become pets, as a boar/pig coprolite has been identified within the settlement at Bestansur (Chapter 16), and there is evidence for care of injured animals at Jarmo (Bendrey 2014). The role of animals in socialisation and wealth as well as more symbolic and ritual aspects of life are considered below.

Future directions

New isotopic analyses are being conducted on bones from deeper levels at the site where collagen is better preserved, as assays in this phase of the project were unsuccessful due to poor collagen preservation and mineral replacement (Chapters 12, 15). As ruminant and omnivore coprolites have been identified in a range of contexts and areas of the settlement, this will provide further insight into sources of ruminant fuel, animal management, and human and animal diet, ecology and inter-relations.

Micro-ecologies: integrated ecological and social approaches

During transformations there are often tensions between those who support and benefit from change and those whose ways of life and rights and values are threatened, leading potentially to displacement and migration (Lowenhaupt Tsing *et al.* 2019). In the transformation to increasingly managed and domesticated herds, pasture/fodder and crops and agriculture, it is the hunter-gatherer lifeways and rights that are most likely to be challenged. As a counterpoint to attractors to domestication, however, which potentially include greater food security, capital and predictability, Hodder (2018a) has highlighted the increase in labour that is likely to have accompanied domestication and sedentism. Other potential detractors and negative impacts of both agriculture and sedentism include greater exposure to disease and ill-health from increased proximity to animals, living in larger more crowded and more year-round settlements (Larsen *et al.* 2016; 2019).

It is in light of these potential trade-offs and tensions, therefore, that we should evaluate the apparent paradox at Bestansur between the scarcity of evidence for domesticated plants and animals and the complexity of the settlement, social relations and extensive networks, as resource production and consumption represents not only economic and environmental considerations but also social and cultural preferences and reproduction (Kulick 2019). Integrated analysis of the environs and on-site and off-site resource availability and use suggests there was ecological capacity for reliance on hunting and gathering of local resources as well as conservation of their habitats, supplemented by domesticated goat and some cultivated legumes and cereals (Chapters 12, 15–18).

The lack of evidence for domesticated sheep in the natural foothill habitat is surprising, particularly as there is evidence for increased focus on sheep at Zawi Chemi Shanidar, 130km to the north. This evidence, however, is less surprising if we consider the increasing evidence, first, for inter-breeding of wild and domesticated populations in many species, which delays the onset of morphometrics characteristic of domestication and, secondly, the kill-off pattern which suggests large males were preferentially hunted. The abundance of grasses attested regionally at Zeribar, and in on-site phytolith evidence at Bestansur, suggests there was ample grazing for sheep, as well as water, which would have provided a natural habitat for wild populations. Pig populations, like sheep, are also morphometrically wild and would have flourished in local natural habitats in the extensive wetlands and fluvial environs attested by the abundance of on-site phytoliths remains (Chapters 12–13). There is some evidence for increasing management and domestication of these populations in later levels at Bestansur and Shimshara, notably identification of wild boar/pig coprolites by GC-MS in Trench 12 at *c.* 7000 BC. As both sheep and pig raid cultivated crops, the abundance of these animals in the lower Zagros may have been one of the factors in the apparent low abundance of cultivated crops such as cereals and legumes in comparison to highland or steppe sites, although taphonomy and plant availability and use are also factors, as discussed above.

The introduction of managed goat herds at Bestansur beyond their native habitat may have been facilitated by the networks of exchange with the highland Zagros, attested by acquisition of variscite and perhaps carnelian from further east in Iran, and by some shared knowledge exchange in construction technologies and material culture, discussed below and in Chapters 12, 20–22.

The diet at Bestansur was remarkably biodiverse, utilising many plant, animal, bird and aquatic resources from wetland, riparian, grassland and parkland environments within the vicinity of the site, within 1 hour walking distance, *c.* 5km. These include mollusca such as *Helix salomonica*, which commonly occur on shrubs and close to damp areas like other edible species in other regions (Iversen 2015; Taylor and Bell 2019; Chapter 17). Biodiverse resources were utilised at a range of sites in the Central Zagros and Upper Mesopotamia in the Epipalaeolithic to Early Neolithic, suggesting enduring practices that span the transformation from hunting-gathering to early domestication of plant and animals. Land snails, notably *Helix salomonica* in particular, were collected and consumed at a range of cave and settlement sites from the Late Pleistocene and Early Holocene including Palegawra, Shanidar, Karim Shahir, Nemrik 9, Sheikh-e Abad, Jani, Jarmo and Tepe Guran, from *c.* 14,000–6000 BC (Iversen 2015; Chapter 17).

The use of biodiverse resources at Bestansur may therefore have been in the context of ameliorating environmental conditions rather than deteriorating conditions as initially argued by Flannery (1969), who first discussed the concept of a 'broad spectrum revolution', as increasingly evident across many regions of Asia and North Africa (Barton *et al.* 2019). The local strategies at Bestansur would have contributed significantly to the development of sedentary settlement as well as seasonal gatherings associated with for example, the burials of individuals from populations to both the east and west, attested by preliminary aDNA results on human remains in Building 5, Trench 10, and networks established in the exchange of materials whose origins spanned >1500km. That so many animals were morphologically wild and that cereals and pulses may perhaps not have been a significant source of plant food is perhaps surprising, although it arguably corresponds to regional trends (Riehl 2012). This evidence is contributing to new models that extend the use of significant wild resources well into the Neolithic thus questioning the outdated notion of a 'Neolithic package'. This diversification of the resource base would have contributed significantly to risk management strategies (Marston 2011; Ramsey *et al*. 2018) and suggests fission and fusion of populations (Roberts and Rosen 2002) and periodic gatherings that are likely to have sustained the networks attested at Bestansur. These trends, however, should also be seen in the light of continued values, rights, practices and lifeways of former hunting-gathering populations (Lowenhaupt Tsing *et al.* 2019). There is evidence for periodic stress in some individuals at Bestansur, discussed below, which is likely to have occurred during weaning, and perhaps in late winter when there were fewer resources.

This new evidence suggests that whilst there is considerable regional-scale diversity (Arranz-Otaegui *et al.* 2016b), there were also considerable locale specific ecologies and lifeways, which at Bestansur and Shimshara correspond to resource rich wetland, grassland, parkland ecotone boundaries (Riehl 2016; Ramsey *et al.* 2018; Jones *et al.* 2019). At a regional scale, gazelle, goat and sheep proportions generally reflect environmental/landscape settings and the preferred habitat of particular species (Chapter 15, Fig. 15.13). Goat are more common in the highland Zagros at Sheikh-e Abad and Asiab, sheep in the Zagros piedmont with open pastures at Bestansur, and gazelle in the Upper Mesopotamian steppe at Nemrik and M'lefaat. These examples of biodiverse ecological strategies and diet may offer insight into ways in which to expand the very narrow range of food resources on which a global population of more than seven billion currently depends (Reed and Ryan 2019).

Resource use: socio-technological continuity and change

The capacity for transformation in resource management and use is influenced significantly by the technology to support and develop change, as well as by social access to technology, knowledge and resources for production and consumption and local cultural practices (Green 2018). Stone hoes for cultivation are absent from Bestansur and Shimshara but were utilised at Jarmo (Braidwood *et al*. 1983) and Tepe Guran (Mortensen 2014) in the seventh millennium BC and would have significantly aided cultivation and arguably garden agriculture (Bogaard 2005). Notched sickle blades with sheen, however, are frequently found at Bestansur, originally set in hafts with bitumen, and are likely to have been used for cutting reeds, grasses and cereals, whether wild or domesticated (Chapters 20–21). Much of the chipped stone industry, however, was for hunting and carcass and food processing. The function, technology and style of this chipped stone industry is similar to that of the Epipalaeolithic, suggesting considerable ecological and cultural continuity and conservatism, and arguably sustainability. Ground stone technology for preparing food by grinding and pounding was also conservative at Bestansur, suggesting considerable continuity and existing capacity and facilities for preparation of foods and nutrition. There is, however, considerable evidence for innovation in fire installations and energy-efficient fuel use at both Bestansur and Shimshara which would have increased the sustainability of this community, discussed below.

Integrated ecological, social and contextual approaches to the study of food systems that consider continuity and change in how food was obtained, stored, processed, prepared and cooked are providing insights into how continuity and change was managed and accepted or rejected by different communities and sectors of society (Bogaard *et al.* 2005; 2017; Atalay and Hastorf 2006; Hastorf 2016; Fuller and Carretero 2018). Processing technologies and practices would have helped to preserve foods over winter by enabling salting, drying and smoking of meat and fish (Spyrou *et al.* 2019) and processing of cereal grains as needed, as suggested by presence of cereal husks in external areas associated with particular buildings such as Space 27 Trench 10 (Chapters 13, 18) and the presence of independent ground stone sets in buildings and external areas across the site (Chapter 22). Processing and cooking would have also helped to increase the release of nutrients from all foodstuffs (Wrangham 2017; Hodder 2018a). Options for storage include a range of small rooms with thick packing or stone cobble floors (Chapter 12), as well as traces of baskets, some of which were bitumen lined. A range of very specific fire installation types were developed at Bestansur that would have enabled cooking of particular foodstuffs as well as efficient use of fuel and control of burning temperature and duration. These technologies included much earlier practices of use of hot rock technologies for grilling and boiling, as well as small clay-lined installations for cooking molluscs as in Trenches 7 and 9, and large ovens used for grilling, roasting and cooking stews and as yet unattested porridges and breads, although the recipes and evidence of these are known from the Epipalaeolithic at other sites (Carretero *et al.* 2017; Arranz Otaegui *et al.* 2019).

Resource management: conclusions

The often slow but significant transformation to managed and domesticated plants globally (Fuller 2012) and in these areas of the lower Zagros may be due in part to continuity in aspects of hunter-gatherer lifeways as well as to the biodiversity of wetland locales, which enabled communities of this region to balance the risk of new practices such as herding of goats and cultivation of cereals and pulses. Pending results from further fieldwork and research, it is hoped that this discussion has at least provided new approaches and lenses with which to view developments and engage in debates concerning these important transformations towards increasingly sedentary agricultural life, which is the predominant model today, and the challenges that this brings.

Sedentism, society and ritual

Key questions in the study of sedentism that were posed in this research (Chapter 1) include how were built environment design and materials configured and shaped by changes in increasingly settled and agricultural lifeways and in human, animal, plant and material inter-relations (Fisher 2009; Bloch 2010)? Is there evidence of increasing privatisation of land and resources and greater inequality (Byrd 2000; Kohler and Smith 2018)? What was the impact of living in more permanent densely populated settlements on socio-economic and political relations, cultural practices and health (Larsen *et al*. 2006; 2015; 2019)? What changes were there in social roles and relations (Jenkins 2004)? How sustainable were these communities socially and politically?

To examine these questions, we investigated the built environment in 11 different areas at Bestansur and earlier and later levels of the Neolithic settlement in the base of the sounding in Trench 10, a deep pit in Trench 9 and a section in Trench 12 (Fig. 24.1; Chapter 9). We identified several different types of sectors in the settlement as well as both continuity and transformations in social relations and reconfigurations of space by analysis of architectural design, construction and macro- and micro-archaeological and micromorphological traces of activities within and between levels (Chapters 12–14, 16, 20–22). We also examined osteoarchaeological, palaeopathological and initial aDNA evidence for roles and life-histories of >67 individuals in this community, and ritual and burial practices.

Built environment technology and materials

With regard to transformations in biophysical properties and the technologisation of daily lives (Greene 2018; Shah *et al.* 2018), developments in architecture provided a new habitat and shelter for human activities and social relations that was markedly different from cave sites in the Palaeolithic. The experimentation and innovation in architectural materials and form in the Epipalaeolithic and Early Neolithic provided new opportunities for habitation in a much greater diversity of locales, as amply documented in the Zagros at earlier sites such as Zawi Chemi Shanidar (Solecki 1981) and Ganj Dareh (Smith 1990). The transformation from round to rectilinear architecture *c.* 8500–8000 BC across Southwest Asia provided further opportunities for additional reconfigurations of space both to modify the physical environment, as well as social roles and relations and to create symbolic places (Byrd 2000; Watkins 2004).

At Bestansur the construction of contiguous rectilinear buildings with abutting walls oriented northwest–southeast would have provided optimal protection from effects of heat and cold on exposed surfaces as well as increased wall stability in this earthquake prone zone (Fig. 24.2, Chapter 12; Shepperson 2009). The use of earthen mudbrick walls at Bestansur would have significantly enhanced habitability in this locale during cold snowy winters and extended hot summers with temperatures >40–48°C as earthen architecture is renowned for its good thermal insulation properties (Walker *et al*. 2015).

The construction of a range of different sizes and forms of fire installation in mudbrick and pisé with plaster lining would have enhanced the efficiency of fuel use and combustion and, thereby, energy resources by matching fuel load to installation size and use. This would enable burning temperatures to be rapidly reached and sustained due to the thermal properties of earth materials; and enabling easy cleaning and re-use through baked plaster-lined surfaces (Chapter 12; Clark and Yusoff 2014; W. Matthews 2016). This was a crucial technological development as sustainable energy supplies and use are vital for sedentary populations and shortages are one of the reasons for forced mobility (Henry *et al.* 2018).

Other technological innovations that would have enhanced living conditions in increasingly sedentary populations include the manufacture of fired lime to produced durable waterproof surfaces. Fired lime technology was developed by at least 12,000 BC in the Levant and was widely used in many Neolithic sites across Southwest Asia including the Zagros, notably at Chogha Golan in the tenth millennium BC (Riehl *et al.* 2013; Conard pers. comm.), and at Tepe Guran *c.* 7000–6600 BC (Mortensen 2014).

There was considerable knowledge exchange as well as experimentation and innovation in other architectural materials. Other similarities in construction technologies in the early and mid-eighth millennium BC include use of boat-shaped bricks at Bestansur and at sites to the east in the high Zagros

Figure 24.2. Earthen architecture in Trench 10 at Bestansur at the end of 2019 excavation, showing Building 5, Wall 12, and adjacent buildings and areas. Looking northwest, scales = 2m.

such as Jani (W. Matthews *et al*. 2013h) as well as far west as Boncuklu in central Anatolia (Baird *et al*. 2018). Strip-*chineh* and/or very long mudbricks were used at Bestansur in construction of Building 8, and at sites in the high Zagros such as Ganj Dareh (Smith 1990). The application of multiple layers of wall-plaster to buildings was also a widespread practice. The remarkable similarity of multiple layers of thin-white plaster on walls at Bestansur Building 5 and at Shimshara to plasters at Çatalhöyük is further evidence of shared or parallel technologies and practices (Chapter 12, Fig. 12.33). The use of dung ash in the manufacture of similar multiple applications of white plasters at Jani (W. Matthews *et al*. 2013h) indicates local adaptation of available resources in the accomplishment and materialisation of shared supra-regional social practices (Kozlowski and Aurenche 2005; Shove and Walker 2010: 47).

Socialisation

Selection of materials and development of technologies and architectural form are not only functional and for optimal or sustainable living, but also highly context-dependent and shaped by social and cultural practices (Boivin 2000; W. Matthews 2005; 2018; Fisher 2009; Shove and Walker 2010: 47; Love 2014). Even in environments where there are limited materials and choices, the selection and placement of architectural materials are key media in creating places and settings for activities, and are subsequently marked by the impact and residues from activities (Leatherbarrow and Mostafavi 2002: 23), recording continuity or change in these (W. Matthews *et al*. 1997a; W. Matthews 2010). The materiality of buildings provides a means for creating spatial divisions and boundaries that may enable or constrain access, participation and audience, and thereby social relations and the associations of groups of people with specific fields of action and roles (Robb 2010). Were there any changes in how people acted within buildings and constructed particular roles, identities and boundaries, and what evidence does this provide on social and political actions and relationships in these early settled communities?

Cooperation

Bestansur was larger than many Neolithic sites, which tend to be *c*. 1ha in size (Baird 2005). The surface lithic scatter extends over an area of at least *c*. 4ha and *in situ* Neolithic deposits and architecture have been identified in an area of >1.15ha. Although we are not yet certain as to how much of Bestansur was occupied at any one time within the Early Neolithic, the settlement appears to have been as large or larger than many Neolithic sites in the Zagros and Upper Mesopotamia, including Qermez Dere (1.6ha; Watkins 1990), M'lefaat (0.94ha; Kozlowski 1998), Nemrik (1.8ha; Kozlowski 1990); Chogha Golan (*c.* 3ha; Riehl *et al*. 2013), Sheikh-e Abad (>1ha; Matthews *et al*. 2013a); Ganj Dareh (*c.* 0.7ha; Darabi *et al.* 2019); Jarmo (1.6ha; Braidwood *et al*. 1983); Ali Kosh (*c.* 1.8ha; Hole *et al*. 1969), and Shimshara (0.8ha; Mortensen 1970). Bestansur is, however, probably smaller than the earlier Epipalaeolithic site of Zawi Chemi Shanidar (6.7ha; Solecki 1981: 1), although the buildings at Bestansur are much larger and more densely packed, and smaller than Tell Halula (*c.* 6ha; Molist 2013) and so called mega-sites such as Abu Hureyra (*c.* 11.5ha; Moore *et al*. 2000) and Çatalhöyük (12ha; Hodder 2018a).

The similar orientation of all architecture across more than 100m with building corners aligned to the cardinal points suggests shared community-wide concepts and cooperation in settlement organisation (Halperin 2017) as well as habitability (Chapter 12). The construction of abutting buildings would also have required considerable cooperation and collaboration in building construction and plot boundaries given the greater proximity to neighbours and the potential for disputes. The capacity for individuals and groups to cooperate and solve disputes is vital to the creation of communities, and it is often during the practice of daily routines and encounters when these may be resolved in addition to any formal governance and procedures (Bowser and Patton 2004). That there were mechanisms for cooperation and collaboration and allaying social tension is indicated by the scarcity of evidence for trauma and violence in the corpus of human remains from 67 individuals to date, 75% of which were juveniles and 25% were adults, at least amongst the group analysed to date (Chapter 19). There is some evidence to suggest that a range of social units associated with buildings may have accessed communal sediment resources and land for construction materials (Chapter 12). Recurring common sources include reddish brown silty clay with carbonate inclusions, dark grey silty clay, greenish silty clay and yellowish–brown silty clay, although as discussed below and in Chapter 12 there is evidence of independent practices, currently being investigated by Alessandro Guaggenti. This access to sediments and land as well as plants for vegetal temper is of significance in considering land and access rights of different sectors of communities, as well as the taskscapes with which they are associated (Ingold 2000), especially during the development of agriculture when access to land and wild resources is likely to have been changing (Bogaard 2005; Hodder 2018a; Lowenhaupt Tsing *et al.* 2019).

External areas were encountered in ten of the 11 areas with Neolithic levels at Bestansur, indicating that these were important locales for activity. External spaces provide greater opportunity for social interaction as well as everyday encounters and opportunities for discussion that are vital to social networks as well as encounters in which any tensions in daily life can be discussed before they accumulate and become problematic (Bowser and Patton 2004; Chapter 14). A range of Neolithic hunting, gathering, herding and plant management strategies and activities are likely to have involved cooperation across residential groups and sectors of the community and across different gender and age groups (Bolger and Wright 2013).

Life-course and gender

The interdependent roles of men, women and children in a community are more clearly understood if all stages in hunting, gathering, herding and plant and animal management strategies and activities are considered from procurement, through to processing, storage, preparation and consumption (Bolger 2010: 507). No indications of social distinctions based on gender have been identified to date, based on analysis of burial practices and skeletal remains, discussed below. The most prominent distinction appears to be between juveniles and adults, based on differences in the placement of their burials, with juveniles closest to the entrance of Space 50 in Building 5, and in grave goods, with infants in particular buried with beads. Similar differences are evident in the placement of burials at sites such as Tell Halula, and in some buildings at Çatalhöyük such as Building 1 (Hodder and Cessford 2004). At Çatalhöyük these differences appear to correspond to isotopic variation in diet/commensality and may suggest that burial practice distinctions relate to social distinctions in life (W. Matthews 2018).

Independent social units

Whilst there is evidence at Bestansur for cooperation across the community and with wider networks, there is also evidence for increasing independence of particular social groups and of privatisation of resources and production and consumption, as in many Early Neolithic communities in Southwest Asia (Byrd 2000). One of the primary sources of evidence is the configuration of space and key installations and facilities for daily life through the design and construction of architectural layout, access, boundaries, and the materials selected. At Bestansur, contemporary Buildings 5, 9 and 10 in Trench 10 were each constructed as an independent structural unit with their own walls and boundaries (Chapters 9, 12), as were earlier underlying Buildings 8 and 11. This delineation of well-defined buildings strongly suggests that each represents an at least partially independent social unit and well-defined fields of action (Robb 2010). This delineation of well-defined buildings contrasts with a range of other sites in the Zagros, where apparent building units share party walls, as at Ganj Dareh in highland Iran (Smith 1990), *c.* 7900 BC, and later sites such as Jarmo, *c.* 6500 BC (Braidwood *et al*. 1983, fig. 51). At these sites with shared party walls, although there are some indications of separate social units based on the distribution and redundancy of key facilities for storage as well as artefacts for food production and consumption (see also Byrd 2000), identification of discrete units is problematic due to the frequent modification of features and walls and the absence of clear divisions between units (Braidwood 1983; Smith 1990). This very lack of clear boundaries and frequent modification of them is itself arguably indicative of greater flexibility and changes in social relations and roles at Ganj Dareh and Jarmo, perhaps related to their smaller size at 0.7–1.6ha. The construction of well-defined separate abutting architectural units at Bestansur is similar to practices at Jani in highland Iran (W. Matthews *et al.* 2013h), Abu Hureyra (Moore *et al*. 2000) and Tell Halula (Molist *et al*. 2013) and later in the seventh millennium BC at Çatalhöyük in Turkey (W. Matthews 2018). The large buildings at Bestansur in Trench 10 most closely resemble contemporary buildings at Halula and Abu Hureyra in their design and size.

The at least partial independence of the social units associated with each of these buildings at Bestansur is further attested by, firstly, the different materials in which they are constructed which suggest access to different sediments and thereby land, as well as the variation in mudbrick and earthen wall construction, which suggests variation in traditions and practices. Secondly, each unit at Bestansur in Trench 10 has its own fire installation whether within the building as in Building 5 or in adjacent external areas, which themselves were at least in part bounded by walls, as in Space 44. This has major implications for energy consumption, as well as food production and consumption. The distribution of ground stone sets and chipped stone tools and debitage across different units may suggest cross-community skills in food and craft production and consumption at the scale of smaller social units (Chapters 20–22). This model does not preclude the eventuality that each unit may have come together and shared food in reception rooms in each home or external areas, or at feasts and ritual events such as human burial, discussed below.

Social stability and sustainability

Considerable social stability and habitual practices are attested by the evidence for continuity and repetition in everyday activities in many external areas and buildings at Bestansur. This evidence is represented in a wide range of the data sets examined in this research including the continuity and repetition in the types and deposition in specific locales of surfaces and occupation deposits (Chapter 12), micro-archaeological residues (Chapter 14), chipped stone debris (Chapter 20), and bone tools, for example (Chapter 21). Notable examples include in external areas, the clusters of activities in Trench 7 and repeated layers of packing and activity residues in Trench 10 (Late) and Trench 12/13 Space 39. Within buildings, examples include the repeated multiple fine plasters in Building 5 Space 50, and wall plasters on Building 8, as well as types of residues in different rooms within Building 5 (Chapter 12). There is also consistent contextual spatial variation in micro-archaeological refuse between external areas which have much higher densities of materials than interior areas within buildings that were kept very clean (Chapter 14). Plant remains patterning also appears to have varied with cereal chaff from food processing discard more common in external areas (Chapter 18).

The similarity in the plans of buildings in Trench 10 suggests that this would have afforded predictability in social practice, allaying tensions that could arise where spatial conventions are less clearly replicated and demarcated (Carsten and Hugh Jones 1984; Jenkins 2004). The fronts of these buildings had a portico entrance which provided capacity both to mark boundaries between external and interior areas as well as furnish transitions between them. Porticos are common in many traditional houses in the region today and are popular areas of socialisation. Interiors of buildings comprise an entrance room and larger main room, with small rooms for storage and use as a large fire installation (Chapters 9, 12). These plans are similar to some of the tripartite plans illustrated by Kozlowksi and Aurenche (2005, fig. 12.9) and are most similar to those at Tell Halula and Abu Hureyra, with local adaptions discussion below with regard to networks.

Emerging inequality

A range of researchers have argued that increasing management and domestication of plants and animals provided the basis for increasing inequality (Scott 2017; Kohler and Smith 2018). Even at mega-sites such as Çatalhöyük, however, others argue that communities strove to restrict any emerging inequality and that some buildings provided a focus for extended communities (Hodder and Pels 2010; Wright 2014). There is arguably some evidence for emerging social inequality at Bestansur, marked by differences in the elaboration of architecture and access to particular networks in different sectors of the community.

Building 8 and the overlying Building 5 at Bestansur were large and capable of hosting gatherings at social distances of public-near phase, as defined by Fisher (2009 table 1; Chapter 12, Tables 12.3–12.4). These buildings in the eastern sector of the settlement were elaborately plastered, in contrast to many buildings in other sectors of the site which were not plastered, including Building 4 in the southeastern sector in Trench 8, Wall 15 in the southern sector in Trench 9, Building 3 in the western sector in Trench 7, and Building 7 in the northern sector in Trench 13. The incomplete plans of these buildings preclude discussion of cross-sectoral differences in building size, layout and design, although Buildings 3 and Building 7 appear to be different in plan to Building 5 and Building 8. Building 5 is the largest known Neolithic building to date in the Zagros, at *c.* 81.5m^2, and is comparable to large buildings at Tell Halula and Abu Hureyra which are *c.* 80m^2 (Moore *et al*. 2000; Molist 2013). Building 5 is more than *c.* 2.5 times the size of adjacent Building 9, and 1.5 times the size of the underlying Building 8, suggesting aggrandisement in the role and status of the building and the individuals and groups associated with it. Whether this building was owned by a single social group or was a more communal building associated with burial and social gatherings is discussed below.

Management of goats and use of dung may have been one of the bases for emerging differences in social status and wealth (Russell 2012). Certainly, concentrations of animal pens at Çatalhöyük, *c.* 7000 BC, immediately precede a period of significant settlement expansion and are overlain by some of the most elaborate buildings at the site (W. Matthews 2018). Use of animal dung fuel was ubiquitous across all sectors of the site at Bestansur, suggesting cross-communal access to this energy resource (Chapters 12, 16).

Wild resources can also be used to accrue social capital and obligations, as well as to provide social cohesion and a focus for gatherings and feasting in support of local and social networks. Such occasions include times of major kills or culls particularly of larger animals (Hayden 2009; Rowley-Conwy 2018), as well as seasonal abundances in mollusca such as *Helix salomonica*, which have been associated with festivals as well as funerary gatherings (Chapter 17; Taylor and Bell 2019) and with fertility and rebirth. There is, however, less evidence for differentiation in access to food or fuel resources across the community at Bestansur (Chapters 12 and 15), suggesting that there may have been community wide support mechanisms and principles of sharing and redistribution, which may have normalised or balanced any emerging inequality (Marston 2011).

Waste management and health

The transformation to more sedentary living and agriculture is regarded as a major epidemiological transition, as humans were exposed to increased health risks by living in more densely populated year-round settlements and in greater proximity to animals and their pathogens (Larsen *et al*. 2019; Ledger *et al*. 2019). The built environment is one way in which humans may create or control disease reservoirs, vectors and pathways (Lopez 2012). Microstratigraphic and micromorphological analyses have provided new insights into living conditions, waste-management and health in Neolithic built environments at Bestansur and Shimshara (Chapter 12).

The scarcity of middens and laying of thick layers of sterile silty clay packing in external and internal areas and floor and wall plasters in buildings at Bestansur, particularly those associated with burial, would have significantly controlled the build-up and spread of disease from refuse and human remains. This management contrasts with a range of Neolithic sites across the Fertile Crescent where large long-lived areas of refuse accumulated next to housing quarters, notably at Aşıklı Höyük and Çatalhöyük in Turkey (Martin and Russell 2000). Refuse at Jarmo was discarded in a midden area in the north of site (Braidwood *et al*. 1983). The absence of soot on interior walls at Bestansur, in contrast to Shimshara and Çatalhöyük, suggests that fire installations were well-ventilated and indicates that disease from biofuel pollution may have varied across different communities (Fig. 12.33). The absence of penning areas within the settlement at Bestansur to date suggests that there may have been less exposure to zoonotic diseases from cohabitation with animals there than at sites such as Sheikh-e Abad and Ali Kosh where internal and external penning areas have been identified (W. Matthews *et al*. 2013h; Fournié *et al.* 2016). Dung fuel sources, however, could have been a major source of zoonotic diseases prior to combustion. Commensal pests such as rodents, including *Mus musculus* at Bestansur and other sites such as Ganj Dareh, would have provided a significant threat to stored foods, materials and to the transmission of disease. The identification of human and wild boar/pig coprolites would also have provided particularly hazardous disease reservoirs and risk. These were found in particular concentrations in Trenches 12 and 13, although low levels of omnivore coprolites have been identified in many contexts across the site in thin-section (Chapter 12). Whilst there is evidence of disease risk and burden as well as vectors or carriers such as rodents, therefore, there is also evidence of waste-management and built environment design solutions towards mitigation, whether or not the community was aware of the particular sources and pathways.

Ritual

One of the characteristics of the Neolithic in Southwest Asia was an increase in ritual or symbolic practices, paraphernalia, buildings and burial practices within settlements. Cauvin (2000), Hodder (1990; 2018b), and others have argued that ritual was a major driver in increased gatherings and focus on particular places prior to the domestication of plants and animals. It has been argued that there was less emphasis and focus on ritual in the EFC and the Zagros due, in part, to the limited investigations in the regions (Bernbeck 2004). There is, however, increasing evidence for the significance of ritual in the Zagros. Animals and their horns and skulls have a long tradition of symbolic significance in this region, from the deposit of ritual paraphernalia at Zawi Chemi Shanidar in the Epipalaeolithic to structured deposits of pig skulls, horns and red ochre at Asiab (Darabi 2016; Darabi *et al*. 2018; Bangsgaard *et al*. 2019), sheep skulls within a small room at Ganj Dareh (Smith 1990), and the discovery at Sheikh-e Abad of a separate ritual building in which five wild animal skulls with large horns attached, four of goat and one of sheep, were placed on the floor to face into the room (Matthews *et al*. 2013d). Horn cores were identified in a range of contexts at Bestansur, although none have yet been found that suggest they were used to mark special places or rituals. The rationale for the focus on wild animals may in part lie in the ritual and social significance of the hunt itself (McGranaghan and Challis 2016).

Virtually no animal figurines were identified at Bestansur or Shimshara in contrast to the high numbers in later levels at Jarmo (Broman Morales 1983). The only exception were a few small possible clay horns (Chapter 21). Few well-formed figurines greater than *c*. 1cm in size were identified at Bestansur or Shimshara in these eighth millennium BC levels (Chapter 21). Heavily stylised human figurines of seated figures are generally simple and similar to those from a wide range of other Zagros and EFC sites (Chapter 21). They included 'snail ladies', notched tokens/figurines and one with a detachable head. The scarcity of clay figurines recovered at Bestansur relates in part to the absence so far of excavated midden deposits, as these are often the richest and easiest contexts for recovery of discarded clay figurines at Early Neolithic sites of Southwest Asia, including Jarmo (Morales 1983: 370), and many sites in the Northern and Western Fertile Crescent (Voigt 2000; Kuijt and Chesson 2005). A range of very small low-fired or unfired clay-shapes, often *c*. 1–2cm^3, may speculatively have been figurines or tokens that were discarded in a form of wish-magic (Daems 2017). These unfired or lightly baked clay-shapes and figurines have proven difficult to recover intact as they are very small and fragile and often embedded in clay-rich deposits (Chapters 8 and 21). At Jarmo clay figurine material 'turned into a fine colloidal suspension' in water or cracked when exposed to rain (Morales 1983: 369–370, fig. 155.8).

Animal bone and teeth, from species including deer as well as shells, were used as beads, often in burial, and are linked to identity and adornment and likely held wider symbolic significance. Cowrie shells were used in life and death, affixed with bitumen perhaps to eyes as at other Early Neolithic sites (Chapter 21).

Burials: treatment of the dead by the living

The discovery and excavation at Bestansur of one of the highest numbers of human individuals interred below the floors of a Neolithic building, in Building 5 and the underlying packing of Building 8, at >78 MNI, have provided important new insights into burial practices, demography, social identity, health, diet and the life-course not only for the EFC but for the Neolithic more widely (Fig. 24.3; Chapter 19). Hodder (2018b), Kuijt (2000) and others argue that mortuary practices were central in creating and maintaining identities and social relationships in households and communities in the Neolithic. Baird (2005) suggests that buildings with burials were key social arenas, not only during burial ceremonies, but throughout their life-history. Building 5 and the underlying Building 8, into which some of the remains were packed, were certainly the largest and most elaborate buildings excavated to date at Bestansur, and clearly provided an important focus for activities and ceremonies within spaces that were large enough to host public-scale social gatherings, including those associated with death, burial and bereavement. Pending analysis of other buildings at the site, it remains uncertain whether Building 5 and Building 8 were specially designed as 'houses for the dead' as suggested for several other sites in the Early Neolithic Fertile Crescent. Examples of special buildings include the Skull Building at Çayönü which held the remains of >450 individuals deposited over a period of >1000 years from *c*. 8500 BC (Özdoğan 1999). It is striking that the Skull Building contains the remains of individuals of all ages except for infants below the age of 2 years, who were presumably buried or deposited elsewhere, in contrast to the Bestansur Building 5/8 complex which is dominated by infants below the age of 2 years: a clear pattern of age differentiation in death at both sites. Other distinctive burial buildings of the Early Neolithic Fertile Crescent include the Phase 8 Building at Abu Hureyra, *c*. 7000 BC (Moore and Molleson 2000), where bodies were laid out on floors in order to decay before burial in pits, with some skulls wrapped in matting, as at Bestansur, and the 'House of the Dead' at Dj'ade al-Mughara, *c*. 8000 BC (Coqueugniot 2000), where mainly infants and young adults were buried in a mixture of intact interments, groups of skulls and collections of disarticulated bones, as at Bestansur. The Bestansur Building 5/8 complex thus sits within a long and widespread tradition of buildings dedicated to death and burial across the Early Neolithic Fertile Crescent, sharing in common an elaboration of burial practices and a concern to differentiate the burial of

Figure 24.3. Bestansur Building 5, looking into Sp50 over the stone threshold from Sp47 to the stone placements at the back of the room. Sub-floor burials exposed in the centre of the room. Slope in floor due to topography of underlying west wall of Building 8 and subsidence of adjacent room fill. Looking northwest, scales = 2m.

individuals according to codes of practice, yet in each case pursuing burial traditions special to their locales.

Many of the buildings at Bestansur were kept exceptionally clean and have few macro- or micro-archaeological indicators of everyday life. There is evidence on the floors of Building 5 of both laying out of the dead in Space 50, as well as some traces of burnt food remains in Space 47 that may suggest occupation but could equally be from periodic ceremonial meals. The plan of both buildings moreover resembles that of 'houses' at Halula and Abu Hureyra, with a portico, main room and smaller rooms, although in the case of Building 5 the largest room is in the innermost reaches of the building.

Building 5, however, has several distinctive features including a currently unique plan for the EFC and arguably the Fertile Crescent more widely. The design of the building, firstly, places particular emphasis on the entrance façade, with a wide entrance flanked by large stones, one of which was covered in incised marks, as well as flanking alcoves that may have partly sheltered any individuals positioned in or marking and guarding the entrance. Secondly, the entrance to the large main room, Space 50, was marked by an unusual large threshold stone and a laid stone platform beyond, for which there are also currently no parallels. The floors of Building 5 were covered in thin plaster layers, <0.5mm, of different colours and repeated layers of pigmented mats, marked by impressions on the floor surfaces and traces of phytoliths (Chapter 12, Fig. 12.30). All of the finds on the floors and deposits in each room are unusual and arguably associated with ceremonies, including a macehead, stone bowl, tokens, unused obsidian blades and a stone muller. Many very small clay shapes that had been moulded and then 'cancelled' and occasionally burnt, perhaps associated with wish-magic as argued by Daems (2017) for similar finds at other sites, were scattered in the external area in front of Building 5. A large flat white stone was propped against the wall in the northwest corner of Space 50 with traces of burning, surrounded by a thin layer of ash. The fill of the large fire installation, Space 48, comprised a 75cm deep sequence of largely undisturbed ash formed of burnt reeds and grasses, some of which may have may have come from wrappings and mats associated with burials. Included within the ash were several human bones from appendages that may have fallen from corpses, as well as fragments of crane bones, a bird widely associated with ritual paraphernalia in Southwest Asia (Russell and McGowan 2003; Russell 2018).

Little apparently domestic debris from daily life was present in this fire installation. A macehead and upturned stone mortar were placed on top of the ash prior to closure of the building by pushing in or collapse of the walls. The underlying Building 8 was also elaborate with thick walls, multiple layers of wall plaster and some traces of whitewash and paint (Chapter 12, Fig. 12.22). The floors in the portico were covered with mats, on which there may be the impression of a carved shape or pillar base (Chapter 12, Fig. 12.22).

That these buildings could have been a focus for gatherings as well as burial of individuals from extended networks is suggested by the large size of their main rooms, the high number of individuals interred at >78 MNI, as well as the diversity of burial practices. These include both primary and secondary burials, as well as interments of neonates, juveniles and adults up to *c.* 50 years old. The secondary burials include diverse clusters of bones including separate skulls, long bones, and arrangements of bones around a cut edge. Many of these were placed in wrappings, which had traces of pigmented designs, some similar to those at Körtik Tepe (Erdal 2015), suggesting that the burial wrappings may been used to mark identity. Kuijt (2000b: 143) suggests secondary mortuary practices, which are widespread across Southwest Asia in the Neolithic, may have been one way in which the timing of ceremonies was controlled and re-enacted to coincide with other social gatherings and ritual events, or delayed until the deceased or other members of the household or community were returned to the settlement.

The dispersed occurrence of human burials and occasional single human bones in trenches across the Neolithic settlement at Bestansur, other than those in Buildings 5/8, including a double adult burial in Trench 7 and single adult and child burials in Trench 10, indicates considerable diversity in the treatment of the dead. Other Early Neolithic sites of the EFC display similar complexity and diversity in their treatment of the human dead, as attested in the >116 burials at Ganj Dareh, mainly under house floors but also in clusters in pits (Merrett 2004), adult burials under floors and in room-fill at Abdul Hosein (Pullar 1990), evidence for curation of human skulls at Tepe Guran (Mortensen 2014), and at Ali Kosh adult limb bones with beads and red pigment, interments of complete skeletons wrapped in mats, and a deposit of 13 individuals in squatting position with hundreds of beads and red pigment within a special red-painted structure (Hole *et al*. 1969; Sołtysiak and Darabi 2017). Artificial cranial shaping is widely attested at many of these sites (Daems and Croucher 2007), including Ganj Dareh, Abdul Hosein and Ali Kosh, but as yet we have no evidence for this practice at Bestansur. Future excavation of Neolithic buildings in Trench 10 and elsewhere at Bestansur, within the next phase of CZAP, will enable further analysis and discussion of burial diversity and its socio-cultural significance.

Experimentation and innovation in burial practices was a characteristic of early sedentary Neolithic communities in the Zagros and the EFC more widely (Croucher 2012). This diversity may have been due in part to the settlement of formerly diverse separate groups with differing practices within larger communities, as well as an indicator of population exchanges and mobility through extended networks. An emerging practice was the burial of particular individuals below building floors, often throughout the life-history of a building. Possible explanations for this practice include protection and memorialisation of the dead, creation of support for grievers and wider bonds amongst the living, as well as arguably health reasons (Croucher 2012).

Human life-course and health

The development of early sedentism and agriculture is argued to have been a major demographic and epidemiological transition (Barrett *et al.* 1998; Larsen 2006; Harper and Armelagos 2013: 146; Scott 2017), which arguably began in the Epipalaeolithic (Stutz and Bocquentin 2017). Increasingly sedentary lifeways and agriculture have potentially positive impacts on sustainability and health, by increasing food security and human fertility, and laying the foundations for increased population growth (Bocquet-Appel 2015). At the same time, however, populations were increasingly exposed to diseases from newly domesticated animals and commensals, and from living together in more densely populated settlements (Larsen 2006; Larsen *et al*. 2015; Pinhasi and Stock 2011; Harper and Armelagos 2013: 146). Lived experiences during the transition to farming itself are likely to have encountered a range of risks and stresses, including the appropriation of land and resources of local hunting and gathering populations and ultimately their marginalisation and migration (Marston 2011; McHugh 2019). In recent studies of Neolithic populations, there is increasing evidence for local and regional variation in the prevalence of morbidity, physiological stress and mortality, as well as in the effectiveness of disease prevention and mitigation strategies (Larsen *et al.* 2015) as health is not only biologically, but also socially, economically and culturally constructed (Lopez 2012).

A key aim in this research is to examine the impact that early sedentism and plant and animal management had on human demography and health, across different sectors of society and on different lifeways. The excavation of more than 80 human individuals at Bestansur has provided an important new dataset for examination of these issues. Sixty-seven of these individuals have been analysed and reported on in this volume to investigate demography, gender, palaeopathology, diet, health, and the life-course (Chapter 19).

Demography and gender

Of the individuals buried in B5/8 at Bestansur and reported in this volume, 75% are juveniles and 25% adult. Whilst the high number of infant and juvenile burials may suggest high fertility and/or fecundity, their early death is an indicator of the vulnerability of these age groups to disease and ailments associated with diarrhoea and malnutrition. The presence of some perinatal and neo-natal infants suggests risk at the time of and shortly after birth, perhaps due to maternal stress and problems in childbirth (Eshed *et al.* 2004). Many of these infants were buried whole, perhaps suggesting they may be from local or proximate populations.

The number of burials within Space 50, at >78 MNI, and the high incidence of secondary burials suggests some may have died elsewhere and subsequently been brought to Building 5 for final deposition, or some may have died at Bestansur and parts of the body shared and buried elsewhere. The demographic profile of those buried below floors at Bestansur is most similar to that at Abu Hureyra (Moore and Molleson 2000), perhaps suggesting some shared lifeways, risks, concepts of burial practices or similarity in purpose of the buildings excavated at both sites.

Both males and females are equally represented at Bestansur amongst the individuals whose sex can be identified, indicating no apparent gender difference in who was selected for burial, within or without Buildings 5 and 8. Similarly, there is little evidence of gender differentiation based on evidence of work-related stress and health, although childbirth was clearly a major risk to health and life. There is no indication of gender differentiation in the placement of grave goods. There was, however, preferential placement of beads in burials with children and infants, as at a range of Neolithic sites, suggesting age-related concerns and more speculatively that these amulets had apotropaic significance as is common in a range of cultures (Chapters 19 and 21).

Life-course and activities

Life-course stages appear to have been one of the most significant criteria for social distinction at Bestansur, as attested in burial placement and grave goods. Burials in Building 5 Space 50 were partly placed and grouped according to age. The youngest individuals were placed closest to the entrance into Building 5, just beyond the antechamber to this room. Infants tended to be grouped in the southeast corner at the edge of the room. Adults were generally placed further into the room. Placement of burials by age group was common at a range of other sites, such as Tell Halula, where juveniles were also placed closest to the entrance of the main room (Molist 2013). Another marked example of placement of the dead according to age is at Çatalhöyük in Building 1, which had the largest number of interments at the site at 62 MNI. Of the infants and juveniles, 86% (19/22) were placed in the northwest platform, while 93% (13/14) of adults were placed in the eastern platform. A separate group of burials, 66% (8/12) of which were secondary and the remainder double burials of female and infant, were placed below the north-central floor. Analysis of the spatial distribution of the isotopic data from these individuals at Çatalhöyük suggests that each group had a different distinctive diet, suggesting that the placement of the dead related to significant associations in life, by age group and life-course, as well as by commensality and dietary preference (W. Matthews 2018). The high percentage of secondary burials in the north-central group may suggest that they died away from the site. Future isotopic analysis of the Bestansur human remains, collagen preservation permitting, will enable further interpretation of issues around mobility, diet and health in this important assemblage.

Indicators of activities on the Bestansur human remains include distinctive tooth-wear, arguably associated with reed/grass weaving and basketry (Stojanowski *et al.* 2016), of which many phytolith traces have been found at the site (Chapters 12, 19, 21). These individuals comprise seven adults at Bestansur, who would have been engaged in local crafts associated with wetland resources, for which the community and site is likely to have been renowned.

Health

Analysis of palaeopathology indicates that diseases and ill-health included indications of physiological stress, non-specific infection and malnutrition. Evidence of stress marked by dental defect linear enamel hypoplasia was identified in 11/67, 16%, of the assemblage. A significant proportion of the evidence for skeletal pathology at Bestansur is indicative of malnutrition or haemopoietic disorder. Possible causes include forms of anaemia or vitamin C and D deficiencies, in addition to possible infection through bacteria or parasites which would inhibit the absorption of nutrients (Ledger *et al.* 2019). The transition to agriculture is understood to lead to a lack a variation in diet (Larsen 1995; Bocquet-Appel and Bar-Yosef 2008). At Bestansur, however, the zooarchaeological and archaeobotanical evidence shows that a wide variety of dietary resources, both wild and domesticated, were exploited. It is possible that there were times when important dietary resources were scarce due to seasonal changes which could have caused shortages of essential food sources, an issue which requires future investigation.

Evidence of joint disorders was likely due to ageing, osteoarthritis or repeated activities. While low levels of evidence for traumatic injuries were identified within the assemblage, the healed lower leg fracture is most interesting as this suggests care in the community.

Mobility and identity

There is no evidence at Bestansur for deliberate modification or shaping of skulls such as that practised at other Zagros sites which resulted in elongated or extended head shapes and would have created distinctive identities from a young age (Daems and Croucher 2007; Lorentz 2010; Croucher 2012; Sołtysiak and Darabi 2017). The Zagros has some of the earliest examples of cranial modification, in Neanderthal skulls at Shanidar Cave (Trinkaus 1982; but see Chech *et al*. 1999 for doubts), as well as in Early Neolithic examples at Shanidar Cave, Ganj Dareh, Abdul Hosein and Ali Kosh. The absence of skull modification at Bestansur suggests that the community may not have engaged in immutable transformations to their identity that are archaeologically detectable. The discovery in 2019 at Bestansur, in Building 5 Space 50, of a substantial alabaster earspool, overlying the place on an adult skull in the location of the earlobe suggests that other ways were found through which to express identity, individuality and affiliation.

Preliminary aDNA results, currently being studied by Pinhasi, Reich and Lazaridis, indicate that a sample of individuals buried at Bestansur are genetically similar to Early Neolithic populations to both the east in the high Zagros (Ganj Dareh and Abdul Hosein) and the west on the Upper Mesopotamian steppe (Nemrik). These possible genetic connections support the artefactual evidence discussed below and in Chapter 21 for the engagement of the community at Bestansur in extended local and cross-regional networks. By contrast, evidence from the high Zagros suggests that these highland communities had greater local and eastern connections (Broushaki *et al*. 2016; Gallego-Llorente *et al*. 2016; Lazaridis *et al*. 2016). Non-local networks are important for demographic and genetic sustainability and may have been one of the benefits from mobility and social gatherings. Further aDNA and isotopic analyses are being developed and applied in the next phase of CZAP research.

Material engagement and networks

Nature and significance of networks

Networks are a major constituent of communities as they both shape and are shaped by ecological, social, political and cultural roles, relations and practices. A range of Neolithic communities across Southwest Asia engaged in increasingly extensive networks of local as well as inter-regional material and knowledge exchange. These networks included long-distance exchange in obsidian and other exotic materials, artefact styles and aspects of shared technologies, as well as plants and animals beyond their native habitats (Kozlowski and Aurenche 2005; Watkins 2008). Recent research, however, has shown that even proximate contemporary communities may selectively engage in different ecological, socio-technological and cultural practices and networks, as shown in a comparative study of the sites of Tell Halula, Abu Hureyra and Akarçay in the Upper Euphrates region (Borrell and Molist 2014). This variety in material and knowledge exchange raises questions on how and why specific individuals, groups and communities select particular resources and utilise them, how these both structured and were structured by the complex dynamics between transformations in environment, ecology, technology and social practices and production and consumption (Greene 2018).

At the same time as an increase in the extent of networks in many Early Neolithic communities, it has been argued that there was an increasing trend towards the development of separate households (Byrd 2000; Baird 2005). There was a significant transformation from ill-defined building units with shared party-walls, that suggest more communal and flexible social relations, towards well-defined building units each with their own separate walls and independent facilities for food storage, preparation and consumption at sites like Çatalhöyük (Düring 2007). Recent analyses of genetic and morphometric traits, however, have shown that the individuals buried within specific buildings are less genetically related than expected and may represent ‘practical kin’ rather than ‘biological kin’ and a range of socio-economic or cultural and politic relations (Pilloud and Larsen 2011; Chyleński *et al.* 2019). The high number of individuals and diversity of their aDNA and burial practices in the Building 5/8 complex indicate that the individuals associated with this building at least were from local and non-local groups some of whom were not genetically related and represent wider social networks.

A key aim in all phases of CZAP research is to investigate how different communities and sectors of society in the Zagros and EFC engaged in local and cross-regional networks and what was their context and impact. The focus of this second phase of CZAP was on settlement sites in adjacent major fertile plains in a region that was later part of the major routeways of the Great Khorasan Road and the Silk Roads, at Bestansur in the Shahrizor Plain and Shimshara in the Rania Plain. The results have been compared to other EFC and Southwest Asia sites, including the highland Zagros sites investigated in the first phase of CZAP (Matthews *et al.* 2013a). This new research has produced significant evidence of the major role of Bestansur as a hub in local and supra-regional networks in the Central Zagros and beyond. Much of this evidence has come from new portable x-ray fluorescence analyses of the materials of a range of artefacts, notably obsidian, chert, local and exotic stones and clays (Chapters 20–21), as well as stylistic, technological and contextual analyses of all resources and materials across a wide range of sectors of the community. The data have shown both a significant increase in networks and innovation in materials and technology, as well as elements of local and regional socio-ecological and technological conservatism, and thereby both openness and resistance to change that may relate to local preferences and networks as well as pathways of dependency and technological lock-in (Greene 2018: 2). This variability in practices and networks is evident across different materials and spheres of life such as architecture, craft and food resources, production and consumption, as well as personal adornment, and ritual and burial.

The diversity of materials, technologies and styles at Bestansur and more widely (Borrell and Molist 2014) is argued to relate to the increasing autonomy of particular local and regional networks that are represented by increasingly separate and well-defined buildings that served as places of gathering and exchange, particularly at times of plenty (Hayden 2009; Oliver *et al*. 2017; Gamble 2017), as well as by the burials within buildings. At Bestansur, Buildings 5 and 8 were large enough to host public-scale social gatherings and the burial over time of >78 individuals (Chapters 9, 12, 19). Many burials were secondary and may have been delayed to coincide with particular gatherings, as suggested for many sites across Southwest Asia in the Early Neolithic (Kuijt 2000). There is some evidence of spatial or chronological variation in the use of beads, as the very small stone disc and cylinder beads only occur in the northern sector of the site in Trenches 12 and 13, and the eastern sector in Trench 10 (Chapter 21), and fish was more prevalent in the north of the site in Trenches 12 and 13, perhaps suggesting intra-community variation in cultural practices and dietary preferences (Hastorf 2016).

The evidence for distinctive community-wide practices and cooperation in construction and settlement organisation discussed above, suggests that it was both local as well as the supra-regional networks that sustained the community at Bestansur, and its role as a network hub. The evidence for emerging differences in building size and the high number of burials in Building 5 suggest that some of the increasingly autonomous units had access to large social networks and acted as a gathering place for members and that smaller units, such as Building 9, may have been in some form of dependency (Lane 1994). Rosenberg and Rocek (2019) have argued for Early Neolithic Southwest Asia that such larger social networks may represent sodalities that could requisition resources from and for communities. An alternate explanation, however, might be that larger buildings such as Building 5 were more communal and were a focus for the wider community affording greater capacity for public-scale gatherings of larger groups and networks. Borell and Molist (2014: 226) argue that "Within the settlement, through inter-household interaction, villagers were connected with one another, shared material culture, knowledge, information and ideas. They established effective social networks and links, a 'safety net', which incorporated both rights and obligations and which were maintained fresh and active over generations". They argue that at Tell Halula there were common-pool resources supported by "collective action to monitor, sanction and ritually integrate social groups" (Borrell and Molist 2014: 227), an articulation which appears to fit very well for Early Neolithic Bestansur.

Gatherings and networks could have afforded the spaces and conditions for experimentation, learning and evaluation of changes in environmental niches and ecology as well as socio-technological systems. They are likely to have facilitated intra and inter-community decision-making, and to have provided the basis for "catalyzing transformative change" as observed in current studies of transitions (Shah *et al.* 2018). Networks and gatherings often include travel to celebratory events, perhaps such as the burials at Bestansur, and for shared cultural practices and feasting. Ritual action as well as development of specialist production can be powerful mechanisms either for social change and forging of broader scales of identity providing the opportunity to break from traditional behaviours, or on the other hand can further inscribe tradition and practice (Semple 2018). The formal layout of Building 5 may have provided a setting to encourage cohesion and regulate practice and codes of behaviour at gatherings (Semple 2018).

Networks and openness of communities can also lead to examples of innovative practice and ways of testing and navigating change and tackling "institutional rigidity and path-dependence" (Shah *et al*. 2018: 254), such as that articulated as 'entanglement' by Hodder for other regions (2012; 2018a). Many Early Neolithic communities, however, appear to have been making a wide range of choices in evaluating what would work for them and what they wished to retain in accomplishing both ecological and social goals and values, in ways similar to those highlighted more widely today in consideration of resource use (Shove and Walker 2010: 47). In transformation, some individuals or groups within communities and networks may be winners and others losers, with the potential for trade-offs or consolidations of power (Shah *et al.* 2018). Whilst the introduction of goat-herding at Bestansur would have resulted in some changes to networks and local movement of people and animals, the continuity of hunting and gathering suggests that many of the hunter-gatherer networks and rights were respected and may themselves have been instrumental in developments in cultivating plants and domesticating animals in the cultural life and exchange of plants and animals (Hastorf 1998). It could be argued, by comparison to modern studies of transition, that the Bestansur community was in the process of 'first-order' transformations with enhanced ecological and social capacity, networks and usable resources and products, with some evidence of potential second-order changes emerging in new social organisation and differentiation between buildings and the individuals and groups associated with them (Shah *et al.* 2018).

Tokens and exchange

Clay and stone tokens in the Zagros, as found also at Bestansur, have been interpreted as representing early numerical symbols as a precursor to writing (Schmandt-Besserat 1992; Chapter 21). They may represent changes in distribution of wealth and units for exchange within the development of networks and exchange mechanisms, which often underlie major transformations (Green 2018). Twelve ball tokens made from local clay were found in the eastern sector in Trench 10 and are common on many Neolithic sites across Southwest Asia. A rarer type, in the form of a drum made from local clay, also in Trench 10 external area, Space 29, is local to the EFC and known from sites in Upper Mesopotamia such as Maghzaliyah, and to the east in the high Zagros at Sarab, as well as more locally at Jarmo (Kozlowski and Aurenche 2005: fig.7.6). Three clay cone tokens or schematic figurines are also made of local clays and are similar to forms in the high Zagros at Ganj Dareh. Many unfired or low-fired clay objects of <*c.* 1cm in size occur notably in the eastern sector in Trench 10, in external areas, and may be discarded tokens.

In the Zagros there is argued to be a correlation between the development of tokens and the domestication of goats (Schmandt-Besserat 1992). Ownership of goat herds at Bestansur may have provided additional capital in the development of networks, both as markers of wealth, as well as in the provision of primary resources (meat, sinews, marrow, bone, hide, horns) and through more sustainable secondary products such as dung for fuel and potentially manuring (Portillo *et al.* 2020). Seasonal abundance from hunting and gathering, however, also provided potentially surplus resources for gathering and feasting, often at times when the weather would have been more clement for movement of people, plants and animals. Many of these managed and wild resources would also need to have been processed and preserved for leaner seasons, and are activities that are also often more communal (Bolger 2010).

Routeways and environment

A range of local and wider networks are also likely to have related to the ecological preferences and movements and migrations of animals, for example. Of particular note is the earliest evidence to date at Bestansur for the movement of goat beyond their natural habitat in highland Iran, at *c.* 7660 BC. Other migrations and possible transhumances include movement of sheep following seasonal pastures, as well as migrating gazelle (Chapter 15). As highlighted by Heydari-Guran (2015: 48–49) the Zagros region is of immense importance in the prehistory of communities in the EFC. The fertile intermontane valleys with rivers fed by the many karstic springs and run-off from high mountain peaks >1500–4500m are inter-connected by a network of watercourses. In addition, there are passes through the parallel mountain ranges and a network of routes that later became the Great Khorasan Road and the Silk Roads. Many transhumant routes are present in this region, from the plains and lower Zagros to upland plains of the high Zagros, often following a seasonal winter–summer migration pattern (Potts 2014). Of special note for their respective periods of occupation, Zarzi is less than 10km from the Lesser Zab that connects with the Tigris like the Greater Zab on which Shanidar and Zawi Chemi Shanidar are located. The parallel intermontane valleys and passes arguably would have rendered passage between the Shahrizor Plain, on which Bestansur was located, to the high Zagros and Kermanshah region where many Neolithic sites are located, less challenging than a direct topographic line would suggest. Shimshara is also connected by the Lesser Zab to the Tigris, which flows through the eastern flank of the Mesopotamian plain and may have provided a routeway connecting to locales with communities attested by newly discovered evidence of eighth millennium BC charred grain in Lower Mesopotamia (Altaweel *et al*. 2019).

The assemblages: contextual variation and emerging social difference

Four hundred and thirty Neolithic artefactual finds of particular significance, classified as Small Finds, were recorded at Bestansur, including 142 objects of bodily decoration, 56 clay objects, 98 fragments of worked bone and 43 stone objects, plus 45 from Shimshara (Chapter 21). The distribution of these finds varies across different sectors of the site. Bone tools were common in the south of the site in Trench 9, but not found in the west in Trench 7. Most of the clay objects were found in Trench 10. Traces of more perishable organic materials such as reed matting, and woven basket impressions in bitumen were also recovered, as well as pigmented burial wrappings notably in Buildings 5 and 8. Rarer more elaborate artefacts, which may have conferred and marked status, occur across different sectors of the site. These include probable 'maceheads' and perforated stone discs in both the western sector in Trench 7 and eastern sector in Trench 10. Stone bowl fragments were found across eastern, northern and southern sectors of the site, but notably were of marble in Trench 10 Building 5 Space 50, sub-floor.

Local material engagement and networks

Resources and craft skills

Local resources that had been brought to the site at Bestansur included a variety of clays, yellowish, reddish, greenish and grey in colour, used for mudbrick, mortars, wall-plasters and figurines and tokens and beads. Local limestone was used for much of the ground stone (Chapter 22), possibly for carved stone bowls, as well as for fired lime. Bone was skilfully worked to create beads and tools. River gravels were used for perforated net sinkers, and to cover external surfaces. The traces of grass and reed mats, baskets and burial wrappings, some pigmented, and associated tooth-wear on several skeletons from manufacture of such items, suggest that this was an important local industry (Chapter 12, 19, 21). A range of other craft activities are attested including leather-working, matting and basketry, lithic and ground stone production (Chapters 14, 20–22). Little debitage from working of marble or alabaster has been recovered, but objects such as alabaster bracelets may have been finished at the site, based on the presence of Çayönü tools and debitage in external areas (Chapter 12, 20). A large incised stone was probably used for leather-working or making mats or wrappings (Chapter 22), perhaps associated with burials as it was placed next to the wall of the large portico to Building 5, where >78 individuals were buried below floors and in packing of the underlying Building 8. External working areas, such as that in Trench 7 revealed clustered workspaces associated with the creation of composite materials such as retooling of sickles and arrows. The reed shafts at Bestansur may have provided a local and regionally valued source of arrow shafts. These crafts are likely to have provided finished goods not only for local communities but also for exchange in wider networks, and thereby added social and economic value and a resource base (Algaze 1989). With regard to technological innovation, the introduction of specialist heavy duty obsidian tools for stone bowl production would have provided new facilities for creation of material and finished goods locally at Bestansur. The stone bowls at Bestansur are thick walled and straight-sided and are rare but occur at a range of Early Neolithic sites across the Fertile Crescent.

Long-distance material engagement and networks

Materials and artefacts

Potentially exotic materials identified macroscopically and by pXRF at Bestansur include some types of chert, obsidian, marble, chalcedony, carnelian, variscite, bitumen, cowrie shells and serpentine (Chapters 20–22). Obsidian was exchanged in very small quantities in the Zagros in the Middle Palaeolithic to Epipalaeolithic and was present at Zarzi and Palegawra for example (Frahm and Tryon 2018), although the predominant chipped stone sources were local and regional chert sources. In the Younger Dryas and Early Holocene, however, very little obsidian reached the Zagros, particularly the high Zagros, with a few examples only at Abdul Hosein, East Chia Sabz and Asiab (Chapter 20). The increased quantities of obsidian at Bestansur and Shimshara in the eighth millennium BC, therefore, are of particular interest. pXRF analyses have shown that the predominant source at Bestansur was Nemrut Dağ, as at Zarzi (Frahm and Tryon 2018), suggesting a long history of exchange associated with Nemrut Dağ sources. Other less frequent sources of obsidian include Bingöl B, Suphan Dağ and Sarıkamış South (Chapter 20). Whilst Shimshara has much more obsidian than Bestansur, and was closer to sources, the areas investigated through rescue excavation did not yield as wide a range of exotic materials as Bestansur, with no examples of carnelian for example. Marble and alabaster which were used for making of stone bowls, bracelets, knapping tools, small balls and maceheads, would have been sourced from at least 50km to the east in the metamorphosed limestone facies of the Zagros (Chapter 21). Whitish clays for whitewash on walls of Building 5 may have been sourced up to 20km distant.

Bitumen was used in hafting, affixing cowrie shells in funerary contexts, basket lining and as a bituminous stone, suggesting local knowledge and use of its properties (Chapters 20–22). pXRF analyses suggest the source was from Mesopotamian eastern plains at the base of the Zagros. New fieldwork in Lower Mesopotamia has identified eighth millennium BC cereal grains in the region of Uruk, raising the probability of early sites buried below alluvium in the central and southern Mesopotamian plains (Altaweel *et al*. 2019). Materials from the Persian Gulf which may have come from routes along the plain include cowries, although these may also have come from the Red Sea or Mediterranean. Marine shells were exchanged across the Fertile Crescent from the Epipalaeolithic (Bar-Yosef Mayer 2005) in extended social networks (Richter *et al*. 2011), and were widely used in manufacture of beads at Bestansur. Future isotopic analyses will be applied to establish whether these are from local fossiliferous sources or from the seas bordering the Fertile Crescent.

Networks: inter-regional

Bestansur has yielded the easternmost example of polished axes or celts, which had previously only been found in later levels at Jarmo and at M'lefaat and Abu Hureyra (Kozlowski and Aurenche 2005: fig. 2.2.5.2). This artefact is evidence of the major west–east networks in which the community at Bestansur were engaged. With regard to more everyday items, Bestansur's chipped stone industry and ground stone industry are part of the EFC cultural and ecological spheres, based on similarities in style, technology and uses. The basic technology is dominated by bladelet pressure production in the so-called M'lefaatian tradition of the EFC (Kozlowski 1999: 51–75). The widespread distribution of obsidian Çayönü tools, including many examples from both Bestansur and Shimshara, and their strong association with polished stone bracelets and bowls, suggest the existence of networks of craft knowledge and experience spanning the entire Northern and Eastern Fertile Crescent. It is especially significant to be able to delineate regional variation in craft traditions through comparison of the Bestansur and Shimshara chipped stone assemblages. Thus, the sickle blades, diagonal-ended bladelets and Çayönü tools from each site all show small but regular and distinct differences that hint at regional cultural preferences or traditions within a context of trans-regional connectivity.

Regarding more specialist, time-intensive and decorated artefacts, Bestansur has not so far yielded artefacts such as decorated stone shaft-straighteners or significant quantities of stone bowls, prevalent in sites in Upper Mesopotamia, the Levant and Anatolia. Part of the explanation may be ecological, in that the community had ready access to reeds that were probably used as arrow shafts, and reeds, grasses and sedges that were used for matting as well as baskets and containers, which were in a range of cases pigmented and decorated, or lined with bitumen. The zig-zag patterns of many of the carved stone vessels at other sites, moreover, resemble elaborate finely woven baskets, which require considerable skill and are known to be waterproof as well as in some cases anti-microbial.

The largest and most elaborate polished beads were made from carnelian and occur in the eastern and northern sector of the site in Trenches 10 and 13. Carnelian was widely exchanged across the EFC from the Epipalaeolithic but appears to have been especially prized in the eighth millennium BC. Similar but less well-finished beads made from chalcedony may have held lesser value. Beads similar in style to those of carnelian and chalcedony were made from locally sourced orange limestone and most frequently found in the western sector of the site in Trench 7, suggesting some differential access to local and supra-regional networks by particular sectors of the community at Bestansur.

One major resource that has not been found at Bestansur nor Shimshara is that of metal, which has been identified in contemporary sites in the late eighth millennium BC at Halula and Çayönü (Molist 2013). Green stone beads of variscite and serpentine have been identified by pXRF analyses at Bestansur. These stones originate from areas to the east of Bestansur, probably in Iran. Speculatively, as they are of similar colour and durability as metal, they may be an example of use of different materials for similar or substitute purposes, not dissimilar to the variety of materials used to manufacture similar reddish/orange beads in carnelian, chalcedony and local limestone.

Irrespective or origin, the use of a range of personal adornments at Bestansur that resembled materials widely used across the EFC, illustrates that the community at Bestansur was a participant within a range of cross-regional networks. Such sharing of symbols of identity likely provided the opportunity both for marking affiliation with wider social worlds, as well as potentially local distinctive identities, both of which are often fundamental to effective and sustainable networks.

The next, third, phase of CZAP, from 2018–2023, is building on the networks research reported in this volume through a range of approaches including by mapping local and exotic resources using DEM and GIS. The modelling includes analysis of topography, geology, soils and hydrology to study resource choice and networks (Asouti *et al*. 2018) and will be supported by more extensive coring and field-mapping. We will continue pXRF analyses which have proven exceptionally informative and we are investigating the applicability of other portable materials analyses. Future datasets will be integrated, analysed and interpreted through systematic application of Social Network Analysis (Coward 2010; Collar *et al*. 2015), by which means we will investigate the roles of social actors and material objects as nodes connected within networks of relationships.

Conclusions

With regard to contributions to understanding the development of agriculture and sedentism and transformations in multiple fundamental elements of socio-ecological systems (Shah *et al*. 2018), we can draw out several major conclusions from this second phase of CZAP research on the Early Neolithic of the EFC (2011–2017).

First, **climate and environment** in the Early Holocene EFC, as elsewhere, were ameliorating and thus provided sufficient change in **biophysical properties** after the Younger Dryas climatic downturn to support Early Neolithic developments. These biophysical transformations included sufficiently enhanced temperature, water availability, nutrients, and plant and animal biomass to support biodiverse ecological strategies and increased year-round sedentism. At Bestansur and Shimshara, the communities selected key 'landscape anchor' points (Hammer 2014) that were foci for a wide range of species in locales with reliable water supplies and biodiverse resources in wetland/riparian habitats with access to grassland and parkland ecozones.

Secondly, the **ecological interactions and relations between humans and other species**, including predator–prey relations, incorporated both continuity in use of a wide range of hunter-gatherer resources and lifeways, as well as significant changes in relations with animals such as goat. Bestansur has yielded the earliest evidence for the management of goat herds beyond their natural habitat in the high Zagros, as well as indications of closer relations with wild boar/pig, which was present in locales of both Bestansur and Shimshara. The inhabitants of these sites included expert hunter-gatherers with intimate knowledge and experience of biodiverse landscapes and their animals and plants both locally and at considerable distances from their home bases. There is less evidence for intensive cultivation of crops at Early Neolithic sites of the EFC than in other regions, due in part perhaps to environmental variability and locally attuned resource use (Riehl 2016). It is likely that significant elements of the communities at Bestansur and Shimshara were periodically mobile, engaging in hunting, gathering and trading expeditions as indicated by the zooarchaeological remains and the material artefacts at both sites.

Thirdly, there was a significant increase in access to **a wide range of networks and exotic resources** in the eighth millennium BC in the Zagros and at Bestansur in particular, which appears to have been a regional hub. These resources and associated knowledge were used to mark both local and more wide-ranging identities, practices and relations, and to enhance resource management thus increasing the sustainability of production and consumption. Increased use of animal dung as fuel and new forms of energy efficient heating, cooking and craft installations and well-insulated earthen architecture all enhanced the long-term sustainability of these Early Neolithic communities.

Fourthly, regarding **social institutions and practices**, there was a major reconfiguration of settlement with much larger concentrations of population and Neolithic activity within an area of at least 4ha at Bestansur. The construction of denser abutting buildings with shared orientation suggests the development of community organisation, cooperation, and governance. There is some evidence of emergent inequality, as well as increased importance in burial as a major focus in the creation of social bonds and the enhancement of local and more wide-ranging networks. These emergent practices and changing social relations are represented by the discovery of one of the largest number of individuals interred within a building in the EFC, at >78, and the construction, elaboration and aggrandisement of the buildings to house them, capable of hosting public-scale gatherings. The remarkable continuity in everyday life, attested by repeated surfaces and accumulations within particular external and internal spaces, suggests considerable social stability as well as normalisation of any increased role of particular sectors of society.

Finally, with regard to **health,** the built environment at Bestansur was designed and maintained in such a way that potential disease reservoirs, carriers and pathways were in part controlled and interrupted, for example by extensive repeated laying of thick packing in exterior and interior areas. Palaeopathological analyses indicate some disease and stress in early childhood in particular, but there is as yet little evidence of trauma and violence. We may provisionally conclude that life for the Early Neolithic occupants of Bestansur and Shimshara may have been impacted by a range of negative factors such as seasonally variable availability of high-quality foodstuffs, leading to malnutrition, and enhanced capacity for contagious diseases to develop and spread within denser settled populations, leading to high infant mortality and high risk in childbirth. But, once past childhood, it appears that members of the community enjoyed a high degree of social cohesion, with little evidence of inter-personal violence, and engaged in local and inter-regional networks of interaction and exchange contributing a range of expert skills and knowledge of diverse human and more-than-human worlds.

BIBLIOGRAPHY

Abdi, K. 2003. The Early Development of Pastoralism in the Central Zagros Mountains. *Journal of World Prehistory* 17 (4): 395–448.

Achtman, M. 2016. How Old Are Bacterial Pathogens? *Proceedings of the Royal Society B: Biological Sciences* 283 (1836): 20160990.

Achtman, M. 2017. Multiple Time Scales for Dispersals of Bacterial Disease over Human History, in N. Boivin, R. Crassard and M. Petraglia (eds). *Human Dispersal and Species Movement: From Prehistory to the Present*. Cambridge, Cambridge University Press: 454–478.

Adams, J. L. 1988. Use-Wear Analyses on Manos and Hide-Processing Stones. *Journal of Field Archaeology* 15: 307–315.

Adams, J. L. 1989. Methods for Improving Ground Stone Artifacts Analysis: Experiments in Mano Wear Patterns, in D. S. Amick and R. P. Mauldin (eds). *Experiments in Lithic Technology*. Oxford, British Archaeological Reports S258: 259–276.

Adams, J. L. 2002. *Ground Stone Analysis: A Technological Approach*. Salt Lake City, University of Utah Press.

Adams, J. L. 2010. Beyond the Broken, in Y. M. Rowan and J. R. Ebeling (eds). *New Approaches to Old Stones: Recent Studies of Ground Stone Artifacts*. London, Equinox: 213–229.

Adams, R. M. 1983. The Jarmo Stone and Pottery Vessel Industries, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 209–232.

Afrasiab, S. R. 2007. *Ecology, Breeding, Systematics and Behavior of Chukar Partridge,* Alectoris Chukar *(Aves-Galliformes) from Iraq*. M.Sc, University of Baghdad.

Agelarakis, A. 2004. The Shanidar Cave Proto-Neolithic Human Condition as Reflected through Osteology and Palaeopathology, in R. S. Solecki and R. L. Solecki (eds). *The Proto-Neolithic Cemetery in Shanidar Cave.* College Station, Texas A&M University Press: 159–184.

Akyol, A. A. and Demirce, S. 2005. Phosphorus Analysis of Sediments from Neolithic Çatalhöyük, Hodder, I. (ed.) 2005b. Çatalhöyük Perspectives: Reports from the 1995–99 Seasons. Cambridge McDonald Institute for Archaeological Research and British Institute at Ankara: 413–414.

Al-Barzinjy, S. T. 2008. Origins of the Chert Nodules in Kometan Formation from Dokan Area, NE-Iraq. *Iraqi Bulletin of Geology and Mining* 4 (1): 95–104.

Al-Naqshbandi, A. 1973. The Iraq Museum Laboratory. *Studies in Conservation* 18 (1): 36–42.

Alarashi, H. 2010. Shell Beads in the Pre-Pottery Neolithic B in Central Levant: Cypraeidae of Tell Aswad (Damascus, Syria), in E. Alvarez-Fernandez and D. Carvajal-Contreras (eds). *Not Only Food: Marine, Terrestrial and Freshwater Molluscs in Archaeological Sites. Proceedings of the 2nd Meeting of the ICAZ Archaeomalacology Working Group (Santander, February 19th–22nd 2008)*. Donostia, Aranzadi Zientzia Elkartea Munibe Suplemento 31: 88–98.

Alarashi, H., Ortiz, A. and Molist, M. 2018. Sea Shells on the Riverside: Cowrie Ornaments from the PPNB Site of Tell Halula (Euphrates, Northern Syria). *Quaternary International* 490: 98–112.

Albert, R. M. and Weiner, S. 2001. Study of Phytoliths in Prehistoric Ash Layers from Kebara and Tabun Caves Using a Quantitative Approach, in J. D. Meunier and F. Colin (eds). *Phytoliths: Applications in Earth Sciences and Human History*. Lisse, A.A. Balkema: 251–266.

Albert, R. M., Bar-Yosef, O., Meignen, L. and Weiner, S. 2003. Quantitative Phytolith Study of Hearths from the Natufian and Middle Palaeolithic Levels of Hayonim Cave (Galilee, Israel). *Journal of Archaeological Science* 30 (4): 461–480.

Albert, R. M., Shahack-Gross, R., Cabanes, D., Gilboa, A., Lev-Yadun, S., Portillo, M., Sharon, I., Boaretto, E. and Weiner, S. 2008. Phytolith-Rich Layers from the Late Bronze and Iron Ages at Tel Dor (Israel): Mode of Formation and Archaeological Significance. *Journal of Archaeological Science* 35 (1): 57–75.

Albert, R. M., Esteve, X., Portillo, M., Rodriguez-Cintas, A., Cabanes, D., Esteban, I. and Hernández, F. 2014. Phytcore, Phytolith Reference Collection. 2014 https://www.phytcore.org/phytolith/index.php

Albert, R. M., Ruíz, J. A. and Sans, A. 2016. Phytcore ODB: A New Tool to Improve Efficiency in the Management and Exchange of Information on Phytoliths. *Journal of Archaeological Science* 68: 98–105.

Algaze, G. 1989. The Uruk Expansion: Cross-Cultural Exchange in Early Mesopotamian Civilization. *Current Anthropology* 30: 571–608.

Alizadeh, A. 2003. *Excavations at the Prehistoric Mound of Chogha Bonut, Khuzestan, Iran: Seasons 1976/77, 1977/78, and 1996*. Chicago, Oriental Institute of the University of Chicago Publication 120 in association with the Iranian Cultural Heritage Organisation.

Alizadeh, A. 2006. *The Origins of State Organizations in Prehistoric Highland Fars, Southern Iran. Excavations at Tall-e Bakun*. Chicago, Oriental Institute of the University of Chicago Publication 128.

Allaby, R. G. 2015. Barley Domestication: The End of a Central Dogma? *Genome Biology* 16 (1): 176.

Allaby, R. G., Fuller, D. Q. and Brown, T. A. 2008. The Genetic Expectations of a Protracted Model for the Origins of Domesticated Crops. *Proceedings of the National Academy of Sciences* 105 (37): 13982–13986.

Alley, R. B., Mayewski, P. A., Sowers, T., Stuiver, M., Taylor, K. C. and Clark, P. U. 1997. Holocene Climatic Instability: A Prominent, Widespread Event 8200 Yr Ago. *Geology* 25 (6): 483–486.

AlQahtani, S. J., Hector, M. P. and Liversidge, H. M. 2010. Brief Communication: The London Atlas of Human Tooth Development and Eruption. *American Journal of Physical Anthropology* 142 (3): 481–490.

Altaweel, M., Marsh, A., Mühl, S., Nieuwenhuyse, O., Radner, K., Rasheed, K. and Saber, S. A. 2012. New Investigations in the Environment, History, and Archaeology of the Iraqi Hilly Flanks: Shahrizor Survey Project 2009–2011. *Iraq* 74: 1–35.

Altaweel, M., Marsh, A., Jotheri, J., Hritz, C., Fleitmann, D., Rost, S., Lintner, S. F., Gibson, M., Bosomworth, M., Jacobson, M., Garzanti, E., Limonta, M. and Radeff, G. 2019. New Insights on the Role of Environmental Dynamics Shaping Southern Mesopotamia: From the Pre-Ubaid to the Early Islamic Period. *Iraq* 81: 1–24.

Amoah, E., Gelaye, S., Guthrie, P. and Rexroad Jr, C. 1996. Breeding Season and Aspects of Reproduction of Female Goats. *Journal of Animal Science* 74 (4): 723–728.

Anastasiou, E. and Mitchell, P. 2013. Simplifying the Process for Extracting Parasitic Worm Eggs from Cesspool and Latrine Sediments: A Trial Comparing the Efficacy of Widely Used Techniques for Disaggregation. *International Journal of Paleopathology* 3: 204–207.

Anastasiou, E., Papathanasiou, A., Schepartz, L. A. and Mitchell, P. D. 2018. Infectious Disease in the Ancient Aegean: Intestinal Parasitic Worms in the Neolithic to Roman Period Inhabitants of Kea, Greece. *Journal of Archaeological Science: Reports* 17: 860–864.

Anderberg, A.-L. 1994. *Atlas of Seeds and Small Fruits of Northwest-European Plant Species. Part 4. Resedaceae-Umbelliferae*. Stockholm, Swedish Museum of Natural History

Anderson, D. G., Loovers, J. P. L., Schroer, S. A. and Wishart, R. P. 2017. Architectures of Domestication: On Emplacing Human–Animal Relations in the North. *Journal of the Royal Anthropological Institute* 23 (2): 398–416.

Anderson, E., Almond, M., Matthews, W., Cinque, G. C. and Frogley, M. D. 2014. Analysis of Red Pigments from the Neolithic Sites of Çatalhöyük in Turkey and Sheikh-e Abad in Iran. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 131: 373–383.

Anderson, P. C. 1994. Reflections on the Significance of Two PPN Typological Classes in Light of Experimentation and Microwear Analysis: Flint 'Sickles' and Obsidian 'Çayönü' Tools, in H. G. Gebel and S. K. Kozlowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente: 61–82.

Anderson, P. C. 1999. *Prehistory of Agriculture: New Experimental and Ethnographic Approaches*. Monograph 40. Los Angeles, Institute of Archaeology, University of California.

Anderson, S. and Ertuğ-Yaraş, F. 1998. Fuel Fodder and Faeces: An Ethnographic and Botanical Study of Dung Fuel Use in Central Anatolia. *Environmental Archaeology* 1 (1): 99–109.

Anderson-Whymark, H. 2011. Intentional Breakage in the British Neolithic: Some Comments and Examples. *Lithics* 32: 16–21.

Andrefsky, W. 2005. *Lithics: Macroscopic Approaches to Analysis*. Cambridge, Cambridge University Press.

Andrefsky, W. 2008. The Analysis of Stone Tool Procurement, Production, and Maintenance. *Journal of Archaeological Research* 17 (1): 65–103.

Andrews, P. and Cook, J. 1990. *Owls, Caves and Fossils: Predation, Preservation and Accumulation of Small Mammal Bones in Caves, with an Analysis of the Pleistocene Cave Faunas from Westbury-Sub-Mendip, Somerset, UK*. Chicago, University of Chicago Press.

Andrew, R. 2018. Global CO_2 Emissions from Cement Production. *Earth System Science Data* 10: 195–217.

Appleby, J. E. 2011. Bodies, Burials and Ageing: Accessing the Temporality of Old Age in Prehistoric Societies. *Oxford Journal of Archaeology* 30 (3): 231–246.

Aranda Jiménez, G., Montón-Subías, S. and Romero, M. S. (eds). 2011. *Guess Who's Coming to Dinner? Feasting Rituals in the Prehistoric Societies of Europe and the Near East*. Oxford, Oxbow Books.

Araus, J., Ferrio, J., Voltas, J., Aguilera, M. and Buxó, R. 2014. Agronomic Conditions and Crop Evolution in Ancient Near East Agriculture. *Nature Communications* 5: 3953.

Arbuckle, B. S. 2014. Pace and Process in the Emergence of Animal Husbandry in Neolithic Southwest Asia. *Bioarchaeology of the Near East* 8: 53–81.

Arbuckle, B. S. and Atici, L. 2013. Initial Diversity in Sheep and Goat Management in Neolithic South-Western Asia. *Levant* 45 (2): 219–235.

Arbuckle, B. S. and Özkaya, V. 2006. Animal Exploitation at Körtik Tepe: An Early Aceramic Neolithic Site in Southeastern Turkey. *Paléorient*: 113–136.

Arbuckle, B. S., Price, M. D., Hongo, H. and Öksüz, B. 2016. Documenting the Initial Appearance of Domestic Cattle in the Eastern Fertile Crescent (Northern Iraq and Western Iran). *Journal of Archaeological Science* 72: 1–9.

Arneth, A., Barbosa, H., Benton, T., Calvin, K., Calvo, E., Connors, S., Cowie, A., Davin, E., Denton, F., van Diemen, R., Driouech, F., Elbehri, A., Evans, J., Ferrat, M., Harold, J., Haughey, E., Herrero, M., House, J., Howden, M., Hurlbert, M., Gensuo Jia, Johansen, T. G., Krishnaswamy, J., Kurz, W., Lennard, C., Myeong, S., Mahmoud, N., Masson-Delmotte, V., Mbow, C., McElwee, P., Mirzabaev, A., Morelli, A., Moufouma-Okia, W., Nedjraoui, D., Neogi, S., Nkem, J., Noblet-Ducoudré, N. D., Olsson, L., Pathak, M., Petzold, J., Pichs-Madruga, R., Poloczanska, E., Popp, A., Pörtner, H.-O., Pereira, J. P., Pradhan, P., Reisinger, A., Roberts, D. C., Rosenzweig, C., Rounsevell, M., Shevliakova, E., Shukla, P., Skea, J., Slade, R., Smith, P., Sokona, Y., Sonwa, D. J., Soussana, J.-F., Tubiello, F., Verchot, L., Warner, K., Weyer, N., Wu, J., Yassaa, N., Zhai, P. and Zommers, Z. 2019. *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*. Geneva, Intergovernmental Panel on Climate Change.

Arranz-Otaegui, A. and Richter, T. 2016. Tubers, Grains, Dung and Wood: Studying Hearth Contents at the Early Natufian Shubayqa 1 (North-Eastern Jordan). *IWGP*. Abstract from *International Work Group for Palaeoethnobotany 03/07/2016–10/07/2016*.

Arranz-Otaegui, A., Colledge, S., Ibañez, J. J. and Zapata, L. 2016a. Crop Husbandry Activities and Wild Plant Gathering, Use and Consumption at the EPPNB Tell

Qarassa North (South Syria). *Vegetation History and Archaeobotany* 25 (6): 629–645.

Arranz-Otaegui, A., Colledge, S., Zapata, L., Teira-Mayolini, L. C. and Ibáñez, J. J. 2016b. Regional Diversity on the Timing for the Initial Appearance of Cereal Cultivation and Domestication in Southwest Asia. *Proceedings of the National Academy of Sciences* 113 (49): 14001–14006.

Arranz-Otaegui, A., Polo-Diaz, A. and Richter, T. 2017. Dung Use before Animal Domestication in Southwest Asia: Evidence from Early Natufian Shubayqa 1 (Northeastern Jordan). Abstract from *Annual Meeting of the Society for American Archaeology 2017*, Vancouver, Canada 2017.

Arranz-Otaegui, A., Carretero, L. G., Ramsey, M. N., Fuller, D. Q. and Richter, T. 2018a. Archaeobotanical Evidence Reveals the Origins of Bread 14,400 Years Ago in Northeastern Jordan. *Proceedings of the National Academy of Sciences* 115 (31): 7925–7930.

Arranz-Otaegui, A., Carretero, L. G., Roe, J. and Richter, T. 2018b. Founder Crops V. Wild Plants: Assessing the Plant-Based Diet of the Last Hunter-Gatherers in Southwest Asia. *Quaternary Science Reviews* 186: 263–283.

Ascough, P. L., Bird, M. I., Francis, S. and Lebl, T. 2011. Alkali Extraction of Archaeological and Geological Charcoal: Evidence for Diagenetic Degradation and Formation of Humic Acids. *Journal of Archaeological Science* 38 (1): 69–78.

Ashkenazy, H. 2013. Lithic Technology in the Late Natufian – Technological Differences between 'Core-Area' and 'Periphery', in O. Bar-Yosef and F. R. Valla (eds). *Natufian Foragers in the Levant: Terminal Pleistocene Social Changes in Western Asia*. Ann Arbor, International Monographs in Prehistory Archaeological Series 19: 649–70.

Aslıhan Yener, K., Edens, C., Casana, J., Diebold, B., Ekstrom, H., Loyet, M. and Özbal, R. 2000. Tell Kurdu Excavations 1999. *Anatolica* 26: 31–117.

Asouti, E. 2006. Beyond the Pre-Pottery Neolithic B Interaction Sphere. *Journal of World Prehistory* 20 (2–4): 87–126.

Asouti, E. 2017. Human Palaeoecology in Southwest Asia During the Early Pre-Pottery Neolithic (*c.* 9700–8500 Cal BC): The Plant Story, in M. Benz, H. G. K. Gebel and T. Watkins (eds). *Neolithic Corporate Identities*. Berlin, ex oriente,: 21–43.

Asouti, E. and Austin, P. 2005. Reconstructing Woodland Vegetation and Its Exploitation by Past Societies, Based on the Analysis and Interpretation of Archaeological Wood Charcoal Macro-Remains. *Environmental Archaeology* 10 (1): 1–18.

Asouti, E. and Baird, D. 2015. The Eastern Fertile Crescent Project: A Summary of the First Results of Archaeological Prospection, Survey and Excavation at Karim Shahir, Turkaka and Palegawra (KRG, Northern Iraq). *British Institute for the Study of Iraq Newsletter* (33): 17–20.

Asouti, E. and Fuller, D. 2012. From Foraging to Farming in the Southern Levant: The Development of Epipalaeolithic and Pre-Pottery Neolithic Plant Management Strategies. *Vegetation History and Archaeobotany* 21: 149–162.

Asouti, E. and Fuller, D. Q. 2013. A Contextual Approach to the Emergence of Agriculture in Southwest Asia. *Current Anthropology* 54 (3): 299–345.

Asouti, E. and Kabukcu, C. 2014. Holocene Semi-Arid Oak Woodlands in the Irano-Anatolian Region of Southwest Asia: Natural or Anthropogenic? *Quaternary Science Reviews* 90: 158–182.

Astruc, L., Vargiolu, R., Ben Tkaya, M., Balkan-Atlı, N., Özbaşaran, M. and Zahouani, H. 2011. Multi-Scale Tribological Analysis of the Technique of Manufacture of an Obsidian Bracelet from Aşıklı Höyük (Aceramic Neolithic, Central Anatolia). *Journal of Archaeological Science* 38 (12): 3415–3424.

Atalay, S. and Hastorf, C. A. 2006. Food, Meals and Daily Activities: Food Habitus at Neolithic Çatalhöyük. *American Antiquity* 71 (2): 283–319.

Audoin-Rouzeau, F. and Beyries, S. (eds). 2002. *Le Travail du Cuir de la Préhistoire à nos Jours: XXIIIe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*. Antibes, APDCA. Association pour la promotion et la Diffusion des Connaissances Archéologiques.

Aufderheide, A. C., Rodríguez-Martín, C. and Langsjoen, O. 1998. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge, Cambridge University Press

Aurenche, O. and Kozlowski, S. K. 2011. The Spatial Distribution of Arrow-Heads and Microliths in the Near East (10,200–8,000 Ca. BC), in E. Healey, S. Campbell and O. Maeda (eds). *The State of the Stone: Terminologies, Continuities and Contexts in Near Eastern Lithics. Proceedings of the Sixth PPN Conference on Chipped and Ground Stone Artefacts in the Near East, Manchester, 3rd–4th March 2008. Includes Papers of the Fourth PPN Workshop on Chipped Lithic Industries, Niğde/Cappadocia, 4th–8th June 2001*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 449–446.

Aurenche, O., Bazin, M. and Sadler, S. 1997. *Villages Engloutis. Enquête Ethnoarchéologique á Cafer Höyük (Vallée de l'Euphrate)*. Lyon: Maison de l'Orient et de la Méditerranée Jean Pouilloux'

Aurenche, O., Galet, P., Régagnon-Caroline, E. and Évin, J. 2001. Proto-Neolithic and Neolithic Cultures in the Middle East - the Birth of Agriculture, Livestock Raising, and Ceramics: A Calibrated ^{14}c Chronology 12,500–4,500 cal BC. *Radiocarbon* 43 (3): 1191–1202.

Avery, B. and Bascomb, C. 1974. *Soil Survey Laboratory Methods*. Harpenden Rothamsted Experimental Station Soil Survey Technical Monograph 6.

Azizi, H., Hadi, A., Asahara, Y. and Mohammad, Y. O. 2013. Geochemistry and Geodynamics of the Mawat Mafic Complex in the Zagros Suture Zone, Northeast Iraq. *Central European Journal of Geosciences* 5 (4): 523–537.

Bader, N. O. 1973. Tell Maghzaliyah: An Early Neolithic Site in Northern Iraq, in N. Yoffee and J. J. Clark (eds). *Early Stages in the Evolution of Mesopotamian Civilization: Soviet Excavations in Northern Iraq*. Tucson, University of Arizona Press: 7–40.

Bailey, D. W. 2007. The Anti-Rhetorical Power of Representational Absence: Incomplete Figurines from the Balkan Neolithic, in C. Renfrew and I. Morley (eds). *Image and Imagination*. Cambridge, McDonald Institute for Archaeological Research: 111–120.

Bailon, S. 1991. *Amphibiens et Reptiles du Pliocène et du Quaternaire de France et d'Espagne: Mise en Place et Évolution des Faunes*. Diplôme de Doctorat, Paris VII.

Bailon, S. 1999. Clés de Détermination Ostéologique des Amphibiens Anoures de France, in J. Desse and N. Desse Berset (eds). *Fiches d'Ostéologie Animale pour l'Archéologie, Varia.* Valbonne, Centre de Recherches Archéologiques: 1–38.

Bailon, S. 2011. La Taphonomie des Amphibiens et des Reptiles Squamates: État de la Question, in V. Laroulandie, J. B. Mallye and C. Denys (eds). *Taphonomie des Petits Vertébrés: Référentiels et Transferts aux Fossiles.* Oxford, British Archaeological Reports S2269: 33–41.

Bains, R. 2012. *The Social Significance of Neolithic Stone Bead Technologies at Çatalhöyük.* London, University College London.

Baird, D. 2005. The History of Settlement and Social Landscapes in the Early Holocene in the Çatalhöyük Area, in Hodder (ed.) 2005b: 55–74.

Baird, D. 2012. Pınarbaşı; from Epipalaeolithic Campsite to Sedentarising Village in Central Anatolia, in M. Özdoğan, N. Başgelen and P. Kunihom (eds). *Neolithic in Turkey: New Excavations, New Discoveries*. 3. Istanbul, Arkeoloji ve Sanat Yayınları: 181–218.

Baird, D., Fairbairn, A. and Martin, L. 2016. The Animate House, the Institutionalization of the Household in Neolithic Central Anatolia. *World Archaeology* 49: 753–776.

Baker, B. J., Dupras, T. L. and Tocheri, M. W. 2005. *The Osteology of Infants and Children*. 12. College Station, Texas A&M University Press.

Baker, C. M. 1975. Site Abandonment and the Archeological Record: An Empirical Case for Anticipated Return. *Arkansas Academy of Science Proceedings* 29: 10–11.

Baker, C. M. 1978. The Size Effect: An Explanation of Variability in Surface Artifact Assemblage Content. *American Antiquity* 43 (2): 288–293.

Balbo, A. L., Iriarte, E., Arranz, A., Zapata, L., Lancelotti, C., Madella, M., Teira, L., Jiménez, M., Braemer, F. and Ibáñez, J. J. 2012. Squaring the Circle. Social and Environmental Implications of Pre-Pottery Neolithic Building Technology at Tell Qarassa (South Syria). *PloS one* 7 (7): e42109. doi:10.1371/journal.pone.0042109.

Balkan, N. 1989. L'Industrie Lithique de Boytepe (Turquie). *Paléorient* 15: 87–90.

Balkan-Atlı, N. and Binder, D. 2000. L'Atelier Neolithique de Kömürcü-Kaletepe: Fouilles de 1999. *Anatolia Antiqua* 8: 199–214.

Ball, T., Gardner, J. and Anderson, N. 1999. Identifying Inflorescence Phytoliths from Selected Species of Wheat (*Triticum Monococcum, T. Dicoccon, T. Dicoccoides* and *T. Aestivum*) and Barley (*Hordeum Vulgare* and *H. Spontaneum*) (Gramineae). *American Journal of Botany* 86 (11): 1615–1623.

Ball, T. B., Gardner, J. S. and Brotherson, J. D. 1996. Identifying Phytoliths Produced by the Inflorescence Bracts of Three Species of Wheat (*Triticum Monococcum* L., *T. Dicoccon* Schrank., and *T. Aestivum* L.) Using Computer-Assisted Image and Statistical Analyses. *Journal of Archaeological Science* 23: 619–632.

Bangsgaard, P., Yeomans, L., Darabi, H., Gregersen, K. M., Olsen, J., Richter, T. and Mortensen, P. 2019. Feasting on Wild Boar in the Early Neolithic. Evidence from an 11,400-Year-Old Placed Deposit at Tappeh Asiab, Central Zagros. *Cambridge Archaeological Journal* 29: 443–463.

Bar-Gal, G. K. and Greenblatt, C. L. 2007. The Emergence of the Zoonotic Pathogens in the Southern Levant, in M. Faerman, L. K. Horwitz, T. Kahana and U. Zilberman (eds). *Faces from the Past: Diachronic Patterns of the Biology of Human Populations from the Eastern Mediterranean.* Oxford, British Archaeological Reports 1603: 228–232.

Bar-Matthews, M., Ayalon, A. and Kaufman, A. 1997. Late Quaternary Paleoclimate in the Eastern Mediterranean Region from Stable Isotope Analysis of Speleothems at Soreq Cave, Israel. *Quaternary Research* 168 (47): 155–168.

Bar-Yosef Mayer, D. E. (ed.) 2005a. *Archaeomalacology: Molluscs in Former Environments of Human Behaviour*. Oxford, Oxbow Books.

Bar-Yosef Mayer, D. E. 2005b. An Introduction to Archaeomalacology, in D. E. Bar-Yosef Mayer (ed). *Archaeomalacology: Molluscs in Former Environments of Human Behaviour*. Oxford, Oxbow Books: 1–4.

Bar-Yosef Mayer, D. E. 2005c. The Exploitation of Shells as Beads in the Palaeolithic and Neolithic of the Levant. *Paléorient* 31 (1): 176–185.

Bar-Yosef Mayer, D. E., Leng, M. J., Aldridge, D. C., Arrowsmith, C., Gümüş, B. A. and Sloane, H. J. 2012. Modern and Early–Middle Holocene Shells of the Freshwater Mollusc *Unio*, from Çatalhöyük in the Konya Basin, Turkey: Preliminary Palaeoclimatic Implications from Molluscan Isotope Data. *Journal of Archaeological Science* 39 (1): 76–83.

Bar-Yosef, O. 1995. Earliest Food Producers – Pre-Pottery Neolithic (8000–4500), in T. E. Levy (ed.) *The Archaeology of Society in the Holy Land*. Leicester, Leicester University Press: 190–204.

Bar-Yosef, O. 1998. On the Nature of Transitions: The Middle to Upper Palaeolithic and the Neolithic Revolution. *Cambridge Archaeological Journal* 8 (2): 141–163.

Bar-Yosef, O. 2001. From Sedentary Foragers to Village Hierarchies: The Emergence of Social Institutions, in W. G. Runciman (ed.) *The Origin of Human Social Institutions.* Oxford, Oxford University Press/*Proceedings of the British Academy* 110: 1–38.

Bar-Yosef, O. 2010. Warfare in Levantine Early Neolithic. A Hypothesis to Be Considered. *Neo-Lithics* 2010 (1): 6–10.

Bar-Yosef, O. 2014. Southeast Turkish Neolithic: A View from the Southern Levant, in M. Özdoğan, N. Başgelen and P. Kuniholm (eds). *The Neolithic in Turkey*. Istanbul, Archaeology and Art Publications: 293–320.

Barge, O., Azizi Kharanaghi, H., Biglari, F., Moradi, B., Mashkour, M., Tengberg, M. and Chataigner, C. 2018. Diffusion of Anatolian and Caucasian Obsidian in the Zagros Mountains and the Highlands of Iran: Elements of Explanation in 'Least Cost Path' Models. *Quaternary International* 467: 297–322.

Barker, G. 2006. *The Agricultural Revolution in Prehistory: Why Did Foragers Become Farmers?* Oxford, Oxford University Press.

Barrett, R., Kuzawa, C. W., McDade, T. and Armelagos, G. J. 1998. Emerging and Re-Emerging Infectious Diseases: The Third Epidemiologic Transition. *Annual Review of Anthropology* 27 (1): 247–271.

Barrett-Hamilton, G. E. H. 1910. *A History of British Mammals*. London, Gurney and Jackson.

Barthelmes, A., Prager, A. and Joosten, H. 2006. Palaeoecological Analysis of Alnus Wood Peats with Special Attention to Non-Pollen Palynomorphs. *Review of Palaeobotany and Palynology* 141 (1–2): 33–41.

Barton, R. N. E., Bouzouggar, A., Collcutt, S. and Humphrey, L. (eds). 2019. *Cemeteries and Sedentism in the Later Stone Age of North West Africa: Excavations at Grotte des Pigeons, Taforalt, Morocco*. Mainz, Romisch-Germanisches Zentralmuseum.

Bartu, A. 2005. Encounters/Entanglements/Engagements with Prehistory: Çatalhöyük and its Publics, in I. Hodder (ed.) 2005b. Çatalhöyük Perspectives: Reports from the

1995–99 Seasons. Cambridge McDonald Institute for Archaeological Research and British Institute at Ankara, 27–38.

Bashari, H. and Hemami, M.-R. 2013. A Predictive Diagnostic Model for Wild Sheep (Ovis Orientalis) Habitat Suitability in Iran. *Journal for Nature Conservation* 21 (5): 319–325.

Bate, D. M. A. 1930. Animal Remains from Zarzi Cave, in D. Garrod (ed.) *The Palaeolithic of Southern Kurdistan: Excavations in the Caves of Zarzi and Hazar Merd*. Bulletin of the American School of Prehistoric Research 6, 9–43.

Battarbee, R. W., Jones, V. J., Flower, R. J., Cameron, N. G., Bennion, H., Carvalho, L. and Juggins, S. 2002. Diatoms, in J. P. Smol, H. J. B. Birks and W. M. Last (eds). *Tracking Environmental Change Using Lake Sediments, Volume 3: Terrestrial, Algal, and Siliceous Indicators*. Dordrecht, Springer: 155–202.

Bayliss, A., Brock, F., Farid, S., Hodder, I., Southon, J. and Taylor, R. E. 2015. Getting to the Bottom of It All: A Bayesian Approach to Dating the Start of Çatalhöyük. *Journal of World Prehistory* 28 (1): 1–26.

Baysal, A. and Wright, K. 2006. Cooking, Crafts and Curation: Ground-Stone Artefacts from Çatalhöyük, in I. Hodder (ed.) *Changing Materialities at Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research, British Institute at Ankara, 307–324.

Baysal, E. 2013. Will the Real Specialist Please Stand Up? Characterising Early Craft Specialisation, a Comparative Approach for Neolithic Anatolia. *Documenta Praehistorica* 40: 233–246.

Beary, M. O. and Lyman, R. L. 2012. The Use of Taphonomy in Forensic Anthropology: Past Trends and Future Prospects, in D. C. Dirkmaat (ed.) *A Companion to Forensic Anthropology*, Chichester, John Wiley and Sons: 499–427.

Behrensmeyer, A. K. 1978. Taphonomic and Ecologic Information from Bone Weathering. *Paleobiology* 4 (2): 150–162.

Bello, S. and Andrews, P. 2006. The Intrinsic Pattern of Preservation of Human Skeletons and Its Influence on the Interpretation of Funerary Behaviours, in R. Gowland and C. Knüsel (eds). *Social Archaeology of Funerary Remains*. Oxford, Oxbow Books: 1–13.

Bellwood, P. 2005. *First Farmers. The Origins of Agricultural Societies*. Oxford, Blackwell.

Bendrey, R. 2011. Some Like It Hot: Environmental Determinism and the Pastoral Economies of the Later Prehistoric Eurasian Steppe. *Pastoralism: Research, Policy and Practice* 1 (1): 1–8.

Bendrey, R. 2013. Preliminary Assessment of the Zooarchaeological Assemblage, in R. Matthews, W. Matthews and K. Rasheed Raheem (eds). *Excavations at Bestansur, Sulaimaniyah Province, Kurdistan Regional Government, Republic of Iraq 21st March–24th April 2013*. CZAP Archive Report 3: 95–112. Available at czap.org/archive-reports.

Bendrey, R. 2014a. Care in the Community? Interpretations of a Fractured Goat Bone from Neolithic Jarmo, Iraq. *International Journal of Paleopathology* 7: 33–37.

Bendrey, R. 2014b. Animal Paleopathology, in C. Smith (ed.) *Encyclopedia of Global Archaeology*. New York, Springer Reference: 258–265.

Bendrey, R. 2014c. Preliminary Assessment of the Zooarchaeological Assemblage, in R. Matthews, W. Matthews and K. Rasheed Raheem (eds). *Excavations at Bestansur and Shimshara, Sulaimaniyah Province, Kurdistan Regional Government, Republic of Iraq 15th August–2nd October 2013*. CZAP Archive Report 4: 65–82. Available at czap.org/archive-reports.

Bendrey, R., Cole, G. and Lelek Tvetmarken, C. 2013. Zooarchaeology: Preliminary Assessment of the Animal Bones, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 147–158.

Bendrey, R., Whitlam, J., Elliott, S., Aziz, K. R., Matthews, R. and Matthews, W. 2016. 'Seasonal Rhythms' of a Rural Kurdish Village: Ethnozooarchaeological Research in Bestansur, Iraq, in L. Broderick (ed.) *People with Animals: Perspectives and Studies in Ethnozooarchaeology*. Oxford, Oxbow Books: 42–46.

Bendrey, R., Cassidy, J., Fournié, G., Merrett, D., Oakes, R. and Taylor, G. M. 2020. Approaching Ancient Disease from a One Health Perspective: Interdisciplinary Review for the Investigation of Zoonotic Brucellosis. *International Journal of Osteoarchaeology* 30 (1): 99–108.

Bengtsson, L. and Enell, M. 1986. Chemical Analysis, in B. E. Berglund (ed.) *Handbook of Holocene Paleoecology and Paleohydrology*. Chichester, Wiley: 423–441.

Bennison-Chapman, L. E. 2018. Reconsidering 'Tokens': The Neolithic Origins of Accounting or Multifunctional, Utilitarian Tools? *Cambridge Archaeological Journal* 29 (2): 233–249.

Benz, M. n.d. PPND - the Platform for Neolithic Radiocarbon Dates. from http://www.exoriente.org/associated_projects/ppnd.php.

Benz, M., Coşkun, A., Hajdas, I., Deckers, K., Riehl, S., Alt, K. W., Weninger, B. and Özkaya, V. 2012. Methodological Implications of New Radiocarbon Dates from the Early Holocene Site of Körtik Tepe, Southeast Anatolia. *Radiocarbon* 54 (3–4): 291–304.

Berggren, G. 1969. *Atlas of Seeds and Small Fruits of Northwest-European Plant Species. Part 2. Cyperaceae*. Stockholm, Swedish Museum of Natural History.

Berggren, G. 1981. *Atlas of Seeds and Small Fruits of Northwest-European Plant Species. Part 3. Salicaceae-Cruciferae*. Stockholm, Swedish Museum of Natural History.

Berna, F. 2017. Geo-Ethnoarchaeology Study of the Traditional Tswana Dung Floor from the Moffat Mission Church, Kuruman, North Cape Province, South Africa. *Archaeological and Anthropological Sciences* 9 (6): 1115–1123.

Bernbeck, R. 2004. Iran im Neolithikum, in T. Stöllner, R. Slotta and A. Vatandoust (eds). *Persiens Antike Pracht*. Bochum, Deutsches Bergbau Museum: 140–147.

Bernbeck, R. 2017. Merging Clay and Fire: Earliest Evidence from the Zagros Mountains, in A. Tsuneki, O. Nieuwenhuyse and S. Campbell (eds). *The Emergence of Pottery in West Asia*. Oxford, Oxbow Books: 97–118.

Bettison, C. A. 1985. An Experimental Approach to Sickle Sheen Deposition and Archaeological Interpretation. *Lithic Technology* 14: 26–32.

Bezić, A. 2007. Distribution of Flint in Turkey, from 10,000 to 6,000 cal BC. Case Study – Çatalhöyük, in C. Delage (ed.) *Chert Availability and Prehistoric Exploitation in the Near East*. Oxford, British Archaeological Reports IS 1615: 68–86.

Biggs, H. E. J. 1959. Some Land Mollusca from Northern Iraq. *Journal of Conchology* 24 (10): 342–347.

Biggs, H. E. J. 1960. Mollusca from Prehistoric Jericho. *Journal of Conchology* 24 (11): 379–387.

Biggs, H. E. J. 1962. Mollusca of the Iranian Plateau-II. *Journal of Conchology* 25 (2): 64–72.

Biggs, H. E. J. 1969. Molluscs from Human Habitation Sites, and the Problem of Ethnological Interpretation, in D. R. Brothwell and E. S. Higgs (eds). *Science in Archaeology: A Comprehensive Survey of Progress and Research*. London, Thames & Hudson: 415–422.

Biglari, F. and Shidrang, S. 2006. The Lower Paleolithic Occupation of Iran. *Near Eastern Archaeology* 69 (3–4): 160–168.

Biglari, F. and Shidrang, S. 2016. New Evidence of Paleolithic Occupation in the Western Zagros Foothills: Preliminary Report of Cave and Rockshelter Survey in the Sar Qaleh Plain, West of the Kermanshah Province, Iran, in K. Kopanias and J. MacGinnis (eds). *The Archaeology of the Kurdistan Region of Iraq and Adjacent Regions*. Oxford, Archaeopress: 29–47.

Binder, D. 2007. PPN Pressure Technology: Views from Anatolia, in L. Astruc, D. Binder and F. Briois (eds). *Systèmes Techniques Et Communautés du Néolithique Précéramique Au Proche-Orient: Actes du 5e Colloque International, Fréjus, du 29 Février Au 5 Mars 2004*. Antibes, Éditions APDCA: 235–243.

Binford, L. R. 1979. Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35 (3): 255–273.

Black, E., Brayshaw, D. J. and Rambeau, C. M. C. C. 2010. Past, Present and Future Precipitation in the Middle East: Insights from Models and Observations. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 368 (1931): 5173–5184.

Blackman, M. J. 1984. Provenance Studies of Middle Eastern Obsidian from Sites in Highland Iran, *Archaeological Chemistry – III. American Chemical Society Advances in Chemistry* 205: 19–40.

Bleed, P. 1986. The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51 (4): 737–747.

Bloch, M. 2010. Is There Religion at Çatalhöyük ... Or Are There Only Houses? in I. Hodder (ed.) *Religion in the Emergence of Civilization: Çatalhöyük as a Case Study*. Cambridge, Cambridge University Press: 146–162.

Blockley, S., Candy, I., Matthews, I., Langdon, P., Langdon, C., Palmer, A., Lincoln, P., Abrook, A., Taylor, B., Conneller, C., Bayliss, A., MacLeod, A., Deeprose, L., Darvill, C., Kearney, R., Beavan, N., Staff, R., Bamforth, M., Taylor, M. and Milner, N. 2018. The Resilience of Postglacial Hunter-Gatherers to Abrupt Climate Change. *Nature Ecology & Evolution* 2 (5): 810–818.

Blott, S. 2008. *Gradistat Version 6.0, a Grain Size Distribution and Statistics Package of Unconsolidated Sediments by Sieving or Laser Granulometer*, Egham.

Boardman, S. and Jones, G. 1990. Experiments on the Effects of Charring on Cereal Plant Components. *Journal of Archaeological Science* 17 (1): 1–11.

Bocquentin, F. and Bar-Yosef, O. 2004. Early Natufian Remains: Evidence for Physical Conflict from Mt. Carmel, Israel. *Journal of Human Evolution* 47 (1): 19–23.

Bocquet-Appel, J.-P. 2008. The Neolithic Demographic Transition, Population Pressure and Cultural Change. *Comparative Civilizations Review* 58 (58): 6.

Bocquet-Appel, J.-P. 2011a. When the World's Population Took Off: The Springboard of the Neolithic Demographic Transition. *Science* 333 (6042): 560–561.

Bocquet-Appel, J.-P. 2011b. The Agricultural Demographic Transition During and after the Agriculture Inventions. *Current Anthropology* 52 (S4): S497–S510.

Bocquet-Appel, J.-P. and Bar-Yosef, O. 2008a. Prehistoric Demography in a Time of Globalization, in J.-P. Bocquet-Appel and O. Bar-Yosef (eds). *The Neolithic Demographic Transition and its Consequences*. New York, Springer: 1–10.

Bocquet-Appel, J.-P. and Bar-Yosef, O. (eds). 2008b. *The Neolithic Demographic Transition and Its Consequences*. New York, Springer.

Boessneck, J. 1969. Osteological Differences between Sheep (*Ovis Aries* Linné) and Goat (*Capra Hircus* Linné), in D. Brothwell and E. Higgs (eds). *Science in Archaeology - a Survey of Progress and Research*. London, Thames & Hudson: 331–348.

Bofill, M., Procopiou, H., Vargiolu, R. and Zahouani, H. 2013. Use-Wear Analysis of Near Eastern Prehistoric Grinding Stones, in P. C. Anderson, C. Cheval and A. Durand (eds). *Regards Croisés sur les Outils Liés lu Travail des Végétaux. An Interdisciplinary Focus on Plant-Working Tools*. Antibes, Éditions APDCA: 219–236.

Bogaard, A. 2005. 'Garden Agriculture' and the Nature of Early Farming in Europe and the Near East. *World Archaeology* 37 (2): 177–196.

Bogaard, A. 2016. Middening and Manuring in Neolithic Europe: Issues of Plausibility, Intensity and Archaeological Method, in Jones (ed.) *Manure Matters: Historical, Archaeological and Ethnographic Perspectives*. Farnham, Ashgate Publishing: 25–40.

Bogaard, A., Charles, M., Twiss, K. C., Fairbairn, A., Yalman, N., Russell, N. and Henecke, J. 2009. Private Pantries and Celebrated Surplus: Storing and Sharing Food at Neolithic Çatalhöyük, Central Anatolia. *Antiquity* 83: 649–668.

Bogaard, A., Filipovic, D., Fairbairn, A., Green, L., Stroud, E., Fuller, D. and Charles, M. 2017. Agricultural Innovation and Resilience in a Long-Lived Early Farming Community: The 1,500-Year Sequence at Neolithic to Early Chalcolithic Çatalhöyük, Central Anatolia. *Anatolian Studies* 67: 1–28.

Böhme, G. 1977. Zur Bestimmung Quartärer Anuren Europas und Hand von Skelettelementen. *Wissenschaftliche Zeitschrift der Humboldt-Universität zu Berlin, Mathematisch-Naturwissenschaftliche Reiche* 26 (3): 283–300.

Boivin, N. 2000. Life Rhythms and Floor Sequences: Excavating Time in Rural Rajasthan and Neolithic Çatalhöyük. *World Archaeology* 31 (3): 367–388.

Boivin, N. and French, C. A. I. 1998. New Questions and Answers in the Micromorphology of the Occupation Deposits at the Souks Site, Beirut. *Berytus* 43: 181–210.

Boivin, N. and Owoc, M. A. (eds). 2004. *Soils, Stones and Symbols: Cultural Perceptions of the Mineral World*. London, UCL Press.

Boivin, N., Fuller, D. Q., Dennell, R., Allaby, R. and Petraglia, M. D. 2013. Human Dispersal across Diverse Environments of Asia During the Upper Pleistocene. *Quaternary International* 300: 32–47.

Boivin, N., Zeder, M. A., Fuller, D. Q., Crowther, A., Larson, G., Erlandson, J. M., Denham, T. and Petraglia, M. D. 2016. Ecological Consequences of Human Niche Construction: Examining Long-Term Anthropogenic Shaping of Global Species Distributions. *Proceedings of the National Academy of Sciences* 113 (23): 6388–6396.

Bökönyi, S. 1977. *The Animal Remains from Four Sites in the Kermanshah Valley, Iran: Asiab, Sarab, Dehsavar and Siahbid: The Faunal Evolution, Environmental Changes and Development of Animal Husbandry, VII–III Millennia BC*. Oxford, British Archaeological Reports S34.

Bolger, D. 2010. The Dynamics of Gender in Early Agricultural Societies of the Near East. *Signs: Journal of Women in Culture and Society* 35 (2): 503–531.

Bolger, D. and Wright, R. P. 2013. Gender in Southwest Asian Prehistory, in D. Bolger (ed.) *A Companion to Gender Prehistory*. New York, Wiley: 372–394.

Bollongino, R., Burger, J., Powell, A., Mashkour, M., Vigne, J.-D. and Thomas, M. G. 2012. Modern Taurine Cattle Descended from Small Number of Near-Eastern Founders. *Molecular Biology and Evolution* 29 (9): 2101–2104.

Bonogofsky, M. 2005. A Bioarchaeological Study of Plastered Skulls from Anatolia: New Discoveries and Interpretations. *International Journal of Osteoarchaeology* 15 (2): 124–135.

Booth, T. 2016. An Investigation into the Relationship between Funerary Treatment and Bacterial Bioerosion in European Archaeological Human Bone. *Archaeometry* 58 (3): 484–499.

Borrell, F. and Molist, M. 2007. Projectile Points, Sickle Blades and Glossed Points. Tools and Hafting Systems at Tell Halula (Syria) During the 8th Millennium cal. BC. *Paléorient*: 59–77.

Borrell, F. and Molist, M. 2014. Social Interaction at the End of the Pre-Pottery Neolithic B: An Inter-Site Analysis in the Euphrates Valley. *Cambridge Archaeological Journal* 24 (2): 215–231.

Borrell, F. and Štefanisko, D. 2016. Reconstructing Projectile Technology During the Pre-Pottery Neolithic B in the Levant: An Integrated Approach to Large Tanged Points from Halula. *Journal of Archaeological Science* 69: 130–142.

Borrell, F., Ibáñez Estévez, J. J. and Molist, M. (eds). 2013. *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East. Papers Presented to the 7th Conference on PPN Chipped and Ground Stone Industries of the Fertile Crescent*. Bellaterra, Universitat Autònoma de Barcelona, Servei de Publicacions.

Bottema, S. 2010. *Pollen Profile Zeribar, Lake Zeribar, Iran*. European Pollen Database (EPD), PANGAEA, http://www.europeanpollendatabase.net/index.php.

Bottema, S. and van Zeist, W. 1981. Palynological Evidence for the Climatic History of the Near East, 50,000–6,000 BP, *Préhistoire du Levant: Chronologie et Organisation de l'Espace Depuis les Origines Jusqu'au VIe Millénaire*. Lyon, Maison de l'Orient et de la Méditerranée Jean Pouilloux: 111–132.

Boulton, W. H. 1930. *The Romance of Archaeology*. London, Sampson Low, Marston & Co.

Bourdieu, P. 1977. *Outline of a Theory of Practice*. Cambridge, Cambridge University Press.

Bourguignat, J. R. 1852. *Testacea Novissima Quae Cl. De Saulcy in Itinere Per Orientem Annis 1850 Et 1851*. Paris, JB Baillière.

Bowman, S. 1990. *Radiocarbon Dating*. London, British Museum Publications.

Bowser, B. J. and Patton, J. Q. 2004. Domestic Spaces as Public Places: An Ethnoarchaeological Case Study of Houses, Gender, and Politics in the Ecuadorian Amazon. *Journal of Archaeological Method and Theory* 11 (2): 157–181.

Boz, B. and Hager, L. D. 2014. Making Sense of Social Behavior from Disturbed and Commingled Skeletons: A Case Study from Çatalhöyük, Turkey, in A. J. Osterholtz, K. M. Baustian and D. L. Martin. (eds). *Commingled and Disarticulated Human Remains*. New York, Springer: 17–33.

Braadbaart, F. and Poole, I. 2008. Morphological, Chemical and Physical Changes During Charcoalification of Wood and Its Relevance to Archaeological Contexts. *Journal of Archaeological Science* 35 (9): 2434–2445.

Braadbaart, F., Poole, I. and Van Brussel, A. 2009. Preservation Potential of Charcoal in Alkaline Environments: An Experimental Approach and Implications for the Archaeological Record. *Journal of Archaeological Science* 36 (8): 1672–1679.

Bradley, R. 2005. *Ritual and Domestic Life in Prehistoric Europe*. London, Routledge.

Braidwood, L. S. 1983. Appendix. Additional Remarks on the Jarmo Obsidian, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 285–288.

Braidwood, L. S., Braidwood, R. J., Howe, B., Reed, C. A. and Watson, P. J. (eds). 1983. *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105.

Braidwood, R. J. 1960. Seeking the World's First Farmers in Persian Kurdistan. *Illustrated London News* 237: 695–697.

Braidwood, R. J. and Howe, B. (eds). 1960. *Prehistoric Investigations in Iraqi Kurdistan*. Chicago, University of Chicago Press Studies in Oriental Civilization 31.

Braidwood, R. J., Braidwood, L., Smith, J. G. and Leslie, C. 1952. Matarrah: A Southern Variant of the Hassunan Assemblage, Excavated in 1948. *Journal of Near Eastern Studies* 11 (1): 1–75.

Braidwood, R. J., Howe, B. and Reed, C. A. 1961. The Iranian Prehistoric Project: New Problems Arise as More Is Learned of the First Attempts at Food Production and Settled Village Life. *Science* 133 (3469): 2008–2010.

Brami, M., Horejs, B. and Ostmann, F. 2016. The Ground beneath Their Feet: Building Continuity at Neolithic Çukuriçi Höyük. *Anatolian Studies* 66: 1–16.

Branch, N. P., Canti, M. G., Clark, P. and Turney, C. S. M. 2005. *Environmental Archaeology. Theoretical and Practical Approaches*. London, Hodder Arnold.

Brannen, P. 2017. *The Ends of the World: Volcanic Apocalypses, Lethal Oceans and Our Quest to Understand Earth's Past Mass Extinctions*. New York, Simon and Schuster.

Brayshaw, D. J., Rambeau, C. M. C. and Smith, S. J. 2011. Changes in Mediterranean Climate During the Holocene: Insights from Global and Regional Climate Modelling. *Holocene* 21 (1): 15–31.

Brisset, E., Djamali, M., Bard, E., Borschneck, D., Gandouin, E., Garcia, M., Stevens, L. and Tachikawa, K. 2019. Late Holocene Hydrology of Lake Maharlou, Southwest Iran, Inferred from High-Resolution Sedimentological and Geochemical Analyses. *Journal of Paleolimnology* 61 (1): 111–128.

Britten, M. 2015. *Science in a New Era of Communication: A Voice for Archaeology*. BA dissertation, University of Reading.

Brochier, J. E., Villa, P., Giacomarra, M. and Tagliacozzo, A. 1992. Shepherds and Sediments: Geo-Ethnoarchaeology of Pastoral Sites. *Journal of Anthropological Archaeology* 11 (1): 47–102.

Broman Morales, V. 1983. Jarmo Figurines and Other Clay Objects, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 369–426.

Broman Morales, V. 1990. *Figurines and Other Clay Objects from Sarab and Çayönü*. Chicago, Oriental Institute of the University of Chicago Communications 25.

Broman Morales, V. and Smith, P. E. L. 1990. Gashed Clay Cones at Ganj Dareh, Iran. *Paléorient* 16: 115–117.

Brönnimann, D., Ismail-Meyer, K., Rentzel, P., Pümpin, C. and Lisá, L. 2017a. Excrements of Herbivores, in C. Nicosia and G. Stoops (eds). *Archaeological Soil and Sediment Micromorphology*. Oxford, Wiley Blackwell: 55–65.

Brönnimann, D., Pümpin, C., Ismail-Meyer, K., Rentzel, P. and N. Égüez. 2017b. Excrements of Omnivores and Carnivores, in C. Nicosia and G. Stoops (eds). *Archaeological Soil and Sediment Micromorphology*. Oxford, Wiley Blackwell: 67–81.

Brönnimann, D., Portmann, C., Pichler, S. L., Booth, T. J., Röder, B., Vach, W., Schibler, J. and Rentzel, P. 2018. Contextualising the Dead – Combining Geoarchaeology and Osteo-Anthropology in a New Multi-Focus Approach in Bone Histotaphonomy. *Journal of Archaeological Science* 98: 45–48.

Broushaki, F., Thomas, M. G., Link, V., López, S., van Dorp, L., Kirsanow, K., Hofmanová, Z., Diekmann, Y., Cassidy, L. M., Díez-del-Molino, D., Kousathanas, A., Sell, C., Robson, H. K., Martiniano, R., Blöcher, J., Scheu, A., Kreutzer, S., Bollongino, R., Bobo, D., Davoudi, H., Munoz, O., Currat, M., Abdi, K., Biglari, F., Craig, O. E., Bradley, D. G., Shennan, S., Veeramah, K. R., Mashkour, M., Wegmann, D., Hellenthal, G. and Burger, J. 2016. Early Neolithic Genomes from the Eastern Fertile Crescent. *Science* 353 (6298): 499–503.

Brown, D. A. 1984. Prospects and Limits of a Phytolith Key for Grasses in the Central United States. *Journal of Archaeological Science* 11 (4): 345–368.

Brown, J. C. and Twigg, G. I. 1969. Studies on the Pelvis in British Muridae and Cricetidae (Rodentia). *Journal of Zoology* 158 (1): 81–132.

Bueno, C. G., Barrio, I. C., García González, R., Alados, C. L. and D, G. G. 2011. Assesment of Wild Boar Rooting on Ecological and Pastoral Values of Alpine Pyrenean Grasslands. *Pirineos* 166: 51–67.

Buikstra, J. E. 1994. *Standards for Data Collection from Human Skeletal Remains*. Arkansas, Arkansas Archaeological Society Archaeological Survey Research Series 44.

Bull, I. D., Simpson, I. A., Dockrill, S. J. and Evershed, R. P. 1999a. Organic Geochemical Evidence for the Origin of Ancient Anthropogenic Soil Deposits at Tofts Ness, Sanday, Orkney. *Organic Geochemistry* 30 (7): 535–546.

Bull, I. D., Simpson, I. A., Van Bergen, P. F. and Evershed, R. P. 1999b. Muck'n'molecules: Organic Geochemical Methods for Detecting Ancient Manuring. *Antiquity* 73: 86–96.

Bull, I. D., Lockheart, M. J., Elhmmali, M. M., Roberts, D. J. and Evershed, R. P. 2002. The Origin of Faeces by Means of Biomarker Detection. *Environment International* 27 (8): 647–654.

Bull, I. D., Elhmmali, M. M., Perret, V., Matthews, W., Roberts, D. J. and Evershed, R. P. 2005. Biomarker Evidence of Faecal Deposition in Archaeological Sediments, in Hodder, I. (ed.) 2005. Catalhöyük Perspectives: Reports from the 1995–99 Seasons. Cambridge, McDonald Institute for Archaeological Research and British Institute at Ankara Monograph 40: 415–420.

Bullock, P., Fedoroff, N., Jongerius, A., Stoops, G. and Tursina, T. 1985. *Handbook for Soil Thin Section Description*. Wolverhampton, Waine Research.

Buonasera, T. 2007. Investigating the Presence of Ancient Absorbed Organic Residues in Groundstone Using GC–MS and Other Analytical Techniques: A Residue Study of Several Prehistoric Milling Tools from Central California. *Journal of Archaeological Science* 34 (9): 1379–1390.

Buringh, P. 1960. *Soil and Soil Conditions in Iraq*. Baghdad, Ministry of Agriculture.

Burnett, S. E. 2016. Crown Wear: Identification and Categorisation, in J. D. Irish and G. R. Scott (eds). *A Companion to Dental Anthropology*. Oxford, Wiley Online Library: 415–432.

Burt, N. M., Semple, D., Waterhouse, K. and Lovell, N. C. 2013. *Identification and Interpretation of Joint Disease in Paleopathology and Forensic Anthropology*. Springfield IL, Charles C Thomas.

Butzer, K. W. 1982. *Archaeology as Human Ecology: Method and Theory for a Contextual Approach*. Cambridge, Cambridge University Press.

Byrd, B. F. 2000. Households in Transition – Neolithic Social Organization within Southwest Asia, in I. Kuijt (ed.) *Life in Neolithic Farming Communities*. New York, Plenum Press: 63-98.

Byrd, B. F. 2005. Reassessing the Emergence of Village Life in the Near East. *Journal of Archaeological Research* 13 (3): 231–290.

Byrd, B. F., Garrard, A. N. and Brandy, P. 2016. Modeling Foraging Ranges and Spatial Organization of Late Pleistocene Hunter–Gatherers in the Southern Levant – a Least-Cost GIS Approach. *Quaternary International* 396: 62–78.

Cahen, D., Keeley, L. H., Van Noten, F. L., Behm, J. A., Busby, C. I., Dunnell, R. C., Hayden, B., Johnson, L. L., Katz, P., Mohapatra, G. C., Movius, H. L., Narr, K. J., Newcomer, M., Newell, R. R., Odell, G. H., Ohel, M. Y., Paddayya, K., Pittioni, R., Roe, D. A., Tomenchuk, J. and Wynn, T. G. 1979. Stone Tools, Toolkits, and Human Behavior in Prehistory [and Comments and Reply]. *Current Anthropology* 20 (4): 661–683.

Cameron, C. M. 1991. Structure Abandonment in Villages. *Archaeological Method and Theory* 3: 155–194.

Cameron, C. M. 1993. Abandonment and Archaeological Interpretation, in C. M. Cameron and S. A. Tomka (eds). *Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. New Directions in Archaeology*. Cambridge, Cambridge University Press: 3–7.

Cameron, C. M. and Tomka, S. A. (eds). 1993. *Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches*. New Directions in Archaeology. Cambridge, Cambridge University Press.

Cammas, C. 2018. Micromorphology of Earth Building Materials: Toward the Reconstruction of Former Technological Processes (Protohistoric and Historic Periods). *Quaternary International* 483: 160–179.

Campbell, S. and Healey, E. 2018. Diversity in Obsidian

Use in the Prehistoric and Early Historic Middle East. *Quaternary International* 468: 141–144.

Caneva, I., Conti, A. M., Lemorini, C. and Zampetti, D. 1994. The Lithic Production at Çayönü: A Preliminary Overview of the Aceramic Sequence, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar Für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 253–266.

Cansdale, G. S. 1970. *Animals of Bible Lands*. Exeter, Paternoster Press.

Canti, M. 1997. An Investigation of Microscopic Calcareous Spherulites from Herbivore Dungs. *Journal of Archaeological Science* 24: 219–231.

Canti, M. 1998. The Micromorphological Identification of Faecal Spherulites from Archaeological and Modern Materials. *Journal of Archaeological Science* 25: 435–444.

Canti, M. 1999. The Production and Preservation of Faecal Spherulites: Animals, Environment and Taphonomy. *Journal of Archaeological Science* 26: 251–248.

Canti, M. 2003. Aspects of Chemical and Microscopic Characteristics of Plant Ashes Found in Archaeological Soils. *Catena* 54: 339–361.

Canti, M. and Nicosia, C. 2018. Formation, Morphology and Interpretation of Darkened Faecal Spherulites. *Journal of Archaeological Science* 89: 32–45.

Capasso, L., Kennedy, K. A. and Wilczak, C. A. 1999. *Atlas of Occupational Markers on Human Remains*. Teramo, Edigrafital.

Cappers, R. T. J., Bekker, R. M. and Jans, J. E. A. 2006. *Digitale Zadenatlas Van Nederland/Digital Seed Atlas of the Netherlands*. Groningen Archaeological Studies 4. Groningen, Barkhuis Publishing.

Cappers, R. T. J., Neef, R. and Bekker, R. M. 2012. *Digital Atlas of Economic Plants in Archaeology*. Groningen Archaeologiucal Studies 17. Groningen, Barkhuis Publishing.

Carbone, V. A. and Keel, B. C. 1985. Preservation of Plant and Animal Remains, in R. J. Gilbert and J. H. Mielke (eds). *The Analysis of Prehistoric Diets*. London, Academic Press: 2–19.

Cardoso, H. F. 2007. Environmental Effects on Skeletal Versus Dental Development: Using a Documented Subadult Skeletal Sample to Test a Basic Assumption in Human Osteological Research. *American Journal of Physical Anthropology* 132 (2): 223–233.

Carleton, W. C. and Collard, M. 2018. Recent Major Themes and Research Areas in the Study of Human-Environment Interaction in Prehistory. *Environmental Archaeology*: 1–17.

Carr, G. and Knüsel, C. 1997. The Ritual Framework of Excarnation by Exposure as the Mortuary Practice of the Early and Middle Iron Ages of Central Southern Britain, in A. Gwilt and C. Haselgrove (eds). *Reconstructing Iron Age Societies*. Oxford, Oxbow Books: 167–73.

Carretero, L. G., Wollstonecroft, M. and Fuller, D. Q. 2017. A Methodological Approach to the Study of Archaeological Cereal Meals: A Case Study at Çatalhöyük East (Turkey). *Vegetation History and Archaeobotany* 26 (4): 415–433.

Carsten, J. and Hugh-Jones, S. 1995. *About the House: Levi Strauss and Beyond*. Cambridge, Cambridge University Press.

Carter, T. 2011. A True Gift of Mother Earth: The Use and Significance of Obsidian at Çatalhöyük. *Anatolian Studies* 61: 1–19.

Carter, T. 2014. The Contribution of Obsidian Characterization Studies to Early Prehistoric Archaeology, in M. Yamada and A. Ono (eds). *Lithic Raw Material Exploitation and Circulation in Prehistory. A Comparative Perspective in Diverse Palaeoenvironments*. Liège, ERAUL: 23–33.

Carter, T., Poupeau, G., Bressy, C. and Pearce, N. J. G. 2006. A New Programme of Obsidian Characterization at Çatalhöyük, Turkey. *Journal of Archaeological Science* 33 (7): 893–909.

Carter, T., Grant, S., Kartal, M., Coşkun, A. and Özkaya, V. 2013a. Networks and Neolithisation: Sourcing Obsidian from Körtik Tepe (SE Anatolia). *Journal of Archaeological Science* 40 (1): 556–569.

Carter, T., Ford, R. and Grant, S. 2013b. A Preliminary Report on the Tell Nader Obsidian Characterisation. *Subartu* 6–7: 33–36.

Carvalho, C., Macario, K., De Oliveira, M. I., Oliveira, F., Chanca, I., Alves, E., Souza, R., Aguilera, O. and Douka, K. 2015. Potential Use of Archaeological Snail Shells for the Calculation of Local Marine Reservoir Effect. *Radiocarbon* 57 (3): 459–467.

Cattaneo, C., Gelsthorpe, K., Phillips, P. and Sokol, R. J. 1993. Blood Residues on Stone Tools: Indoor and Outdoor Experiments. *World Archaeology* 25 (1): 29–43.

Cauvin, J. 1977. Les Fouilles de Mureybet (1971–74) et Leur Signification pour les Origines de la Sedentarisation au Proche-Orient. *Annual of the American Schools for Oriental Research* 44: 19–41.

Cauvin, J. 1988. La Néolithisation de la Turquie du Sud-Est dans son Contexte Proche-Oriental. *Anatolica* 15: 69–80.

Cauvin, J., Aurenche, O., Cauvin, M.-C. and Balkan-Atlı, N. 2011. The Pre-Pottery Site of Cafer Höyük, in M. Ozdoğan, N. Başgelen and P. I. Kuniholm (eds). *The Neolithic in Turkey. New Excavations & New Research II: The Euphrates Basin*. Galatasaray, Archaeology & Art Publications: 1–40.

Cauvin, M.-C. 1991a. L'Obsidienne au Levant Préhistorique: Provenance et Fonction. *Cahiers de l'Euphrate* 5–6: 163–190.

Cauvin, M.-C. 1991b. Cafer Höyük (Turquie): L'Outillage Lithique des Niveaux Anciens et son Évolution dans le Secteur Est. *Cahiers de l'Euphrate* 5–6: 115–126.

Cauvin, M.-C. 1994. La Circulation de l'Obsidienne au Proche-Orient Néolithique, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar Für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment.: 15–22.

Cauvin, M.-C. and Balkan, N. 1985. Cafer Höyük: Analyse de l'Outillage Lithique (Campagnes 1982–1983). Problèmes Typologiques et Chronologiques. *Cahiers de l'Euphrate* 4: 53–85.

Cessford, C. 2003. Microartifactual Floor Patterning: The Case at Çatalhöyük. *Assemblage* 7: 31–41.

Cessford, C. 2005. Estimating the Neolithic Population of Çatalhöyük, in I. Hodder (ed.) *Changing Materialities at Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research, British Institute at Ankara: 65–100.

Cessford, C. and Carter, T. 2005. Quantifying the Consumption of Obsidian at Neolithic Çatalhöyük, Turkey. *Journal of Field Archaeology* 30 (3): 305–315.

Cessford, C. and Mitrovic, S. 2005a. Heavy Residue Analysis, in I. Hodder (ed.) *Changing Materialities at Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research, British Institute at Ankara: 45–63.

Cessford, C. and Mitrovic, S. 2005b. Heavy Residue Analysis (Supplementary Material), in I. Hodder (ed.) *Changing Materialities at Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research, British Institute at Ankara.: 411–447.

Challies, C. N. 1975. Feral Pigs (Sus Scrofa) on Auckland Island: Status, and Effects on Vegetation and Nesting Sea Birds. *New Zealand Journal of Zoology* 2 (4): 479–490.

Chamberlain, A. T. 2006. *Demography in Archaeology*. Cambridge, Cambridge University Press.

Chame, M. 2003. Terrestrial Mammal Feces: A Morphometric Summary and Description. *Memórias do Instituto Oswaldo Cruz* 98: 71–94.

Chamel, B. 2014. *Bioanthropologie et Pratiques Funéraires des Populations Néolithiques du Proche-Orient: l'Impact de la Néolithisation (Étude de Sept Sites Syriens–9820–6000 cal. BC)*. Ph.D thesis, Université Lumière Lyon.

Chapman, J. 1997. Places as Timemarks – the Social Construction of Prehistoric Landscapes in Eastern Hungary, in J. Chapman and P. M. Dolukhanov (eds). *Landscapes in Flux: Central and Eastern Europe in Antiquity*. Oxford, Oxbow Books: 137–161.

Chapman, J. C. 2000. *Fragmentation in Archaeology: People, Places and Broken Objects in the Prehistory of South Eastern Europe*. London, Routledge.

Chapman, J. C. and Gaydarska, B. 2006. *Parts and Wholes: Fragmentation in Prehistoric Context*. Oxford, Oxbow Books.

Chappell, J. and Strathern, M. 1966. Stone Axe Factories in the Highlands of East New Guinea. *Proceedings of the Prehistoric Society* 32: 96–121.

Charles, M. 1998. Fodder from Dung: The Recognition and Interpretation of Dung-Derived Plant Material from Archaeological Sites. *Environmental Archaeology* 1: 111–122.

Charles, M. 2007. East of Eden? A Consideration of Neolithic Crop Spectra in the Eastern Fertile Crescent and Beyond, in S. College and J. Conolly (eds). *The Origins and Spread of Domestic Plants in Southwest Asia and Europe*. Walnut Creek, Left Coast Press: 37–42.

Chataigner, C. 1998. Sources des Artefacts du Proche Orient d'Après leur Caractérisation Géochimique, in M.-C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner (eds). *L'Obsidienne au Proche et Moyen Orient: du Volcan à l'Outil*. Oxford, British Archaeological Reports S738: 273–324.

Chataigner, C. and Gratuze, B. 2014a. New Data on the Exploitation of Obsidian in the Southern Caucasus (Armenia, Georgia) and Eastern Turkey, Part 1: Source Characterization. *Archaeometry* 56 (1): 25–47.

Chataigner, C. and Gratuze, B. 2014b. New Data on the Exploitation of Obsidian in the Southern Caucasus (Armenia, Georgia) and Eastern Turkey, Part 2: Obsidian Procurement from the Upper Palaeolithic to the Late Bronze Age. *Archaeometry* 56 (1): 48–69.

Chech, M., Groves, C. P., Thorne, A. and Trinkaus, E. 1999. A New Reconstruction of the Shanidar 5 Cranium. *Paléorient* 25 (2): 143–146.

Chemineau, P., Pelletier, J., Guerin, Y., Colas, G., Ravault, J., Toure, G., Almeida, G., Thimonier, J., Ortavant, R. and Daveau, A. 1988. Photoperiodic and Melatonin Treatments for the Control of Seasonal Reproduction in Sheep and Goats. *Reproduction Nutrition Développement* 28 (2B): 409–422.

Cheng, H., Sinha, A., Verheyden, S., Nader, F. H., Li, X. L., Zhang, P. Z., Yin, J. J., Yi, L., Peng, Y. B., Rao, Z. G., Ning, Y. F. and Edwards, R. L. 2015. The Climate Variability in Northern Levant over the Past 20,000 Years. *Geophysical Research Letters* 42 (20): 8641–8640.

Cheronet, O., Finarelli, J. A. and Pinhasi, R. 2016. Morphological Change in Cranial Shape Following the Transition to Agriculture across Western Eurasia. *Scientific Reports* 6: 33316.

Childe, V. G. 1936. *Man Makes Himself*. London, Watts.

Chisholm, R. H., Trauer, J. M., Curnoe, D. and Tanaka, M. M. 2016. Controlled Fire Use in Early Humans Might Have Triggered the Evolutionary Emergence of Tuberculosis. *Proceedings of the National Academy of Sciences* 113 (32): 9051–9046.

Christensen, J. M. and Ryhl-Svendsen, M. 2015. Household Air Pollution from Wood Burning in Two Reconstructed Houses from the Danish Viking Age. *Indoor Air: International Journal of Indoor Environment and Health* 25 (3): 329–340.

Chu, V., Regev, L., Weiner, S. and Boaretto, E. 2008. Differentiating between Anthropogenic Calcite in Plaster, Ash and Natural Calcite Using Infrared Spectroscopy: Implications in Archaeology. *Journal of Archaeological Science* 35 (4): 905–911.

Chylénski, M., Ehler, E., Somel, M., Yaka, R., Krzewinska, M., Dabert, M., Juras, A. and Marciniak, A. 2019. Ancient Mitochondrial Genomes Reveal the Absence of Maternal Kinship in the Burials of Çatalhöyük People and Their Genetic Affinities. *Genes* 10 (3): 207.

Civáň, P., Ivaničová, Z. and Brown, T. A. 2013. Reticulated Origin of Domesticated Emmer Wheat Supports a Dynamic Model for the Emergence of Agriculture in the Fertile Crescent. *PloS one* 8 (11): e81955.

Clark, N. and Yusoff, K. 2014. Combustion and Society: A Fire-Centred History of Energy Use. *Theory, Culture and Society* 31 (5): 203–226.

Clark, P. U., Dyke, A. S., Shakun, J. D., Carlson, A. E., Clark, J., Wohlfarth, B., Mitrovica, J. X., Hostetler, S. W. and McCabe, A. M. 2009. The Last Glacial Maximum. *Science* 325 (5941): 710–714.

Clarke, J., Brooks, N., Banning, E. B., Bar-Matthews, M., Campbell, S., Clare, L., Cremaschi, M., di Lernia, S., Drake, N., Gallinaro, M., Manning, S., Nicoll, K., Philip, G., Rosen, S., Schoop, U.-D., Tafuri, M. A., Weninger, B. and Zerboni, A. 2016. Climatic Changes and Social Transformations in the Near East and North Africa During the 'Long' 4th Millennium BC: A Comparative Study of Environmental and Archaeological Evidence. *Quaternary Science Reviews* 136: 96–121.

Coad, B. W. 2010. *Freshwater Fishes of Iraq*. Sofia & Moscow, Pensoft.

Cohen, A. and Serjeantson, D. 1996. *A Manual for the Identification of Bird Bones from Archaeological Sites*. London, Archetype Press.

Cohen, M.N. 1989. Health and the Rise of Civilisation. New Haven and London: Yale University Press.

Cole, G. 2013. Human Burials, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 163–174.

Cole, G., Matthews, R. and Richardson, A. 2013. Material Networks of the Neolithic at Sheikh-e Abad: Objects of Bone, Stone and Clay, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 135–145.

Collar, A., Coward, F., Brughmans, T. and Mills, B. J. 2015. Networks in Archaeology: Phenomena, Abstraction, Representation. *Journal of Archaeological Method and Theory* 22 (1): 1–32.

Colledge, S. and Conolly, J. 2010. Reassessing the Evidence for the Cultivation of Wild Crops During the Younger Dryas at Tell Abu Hureyra, Syria. *Environmental Archaeology* 15 (2): 124–138.

Colledge, S. and Conolly, J. 2014. Wild Plant Use in European Neolithic Subsistence Economies: A Formal Assessment of Preservation Bias in Archaeobotanical Assemblages and the Implications for Understanding Changes in Plant Diet Breadth. *Quaternary Science Reviews* 101: 193–206.

Colledge, S., Conolly, J., Dobney, K., Manning, K. and Shennan, S. (eds). 2013. *The Origins and Spread of Domestic Animals in Southwest Asia and Europe*. Walnut Creek, Left Coast Press, UCL Institute of Archaeology Publications 59.

Collet, P. and Spoor, R. H. 1996. The Ground Stone Industry, in P. M. M. G. Akkermans (ed.) *Tell Sabi Abyad: The Late Neolithic Settlement. Vol II*. 2. Istanbul/Leiden, Nederlands Historisch-Archaeologisch Institut: 415–438.

Conard, N. J. and Zeidi, M. 2013. The Ground Stone Tools from the Aceramic Neolithic Site of Chogha Golan, Ilam Province, Western Iran, in F. Borrell, J. J. Ibáñez and M. Molist (eds). *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East*. Barcelona, Universitat Autònoma de Barcelona: 365–375.

Conard, N. J., Riehl, S. and Zeidi, M. 2013. Revisiting Neolithisation in the Zagros Foothills: Excavations at Chogha Golan, an Aceramic Neolithic Site in Ilam Province, Western Iran, in R. Matthews and H. Fazeli Nashli (eds). *The Neolithisation of Iran: The Formation of New Societies.* Oxford, BANEA/ Oxbow Books: 76–83.

Connan, J. 1999. Use and Trade of Bitumen in Antiquity and Prehistory: Molecular Archaeology Reveals Secrets of Past Civilizations. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 354 (1379): 33–40.

Conolly, J. and Lane, P. J. 2018. Vulnerability, Risk, Resilience: An Introduction. *World Archaeology* 50 (4): 547–543.

Conolly, J., Colledge, S., Dobney, K., Vigne, J.-D., Peters, J., Stopp, B., Manning, K. and Shennan, S. 2011. Meta-Analysis of Zooarchaeological Data from SW Asia and Se Europe Provides Insight into the Origins and Spread of Animal Husbandry. *Journal of Archaeological Science* 38 (3): 538–545.

Conrey, R., Goodman-Elgar, M., Bettencourt, N., Seyfarth, A., Van Hoose, A. and Wolff, J. 2014. Calibration of a Portable X-Ray Fluorescence Spectrometer in the Analysis of Archaeological Samples Using Influence Coefficients. *Geochemistry: Exploration, Environment, Analysis* 14 (3): 291–301.

Cooper, L., Welton, L. and Pak, S. 2018. Spring Excavations in Kurdistan: Bestansur 2017. *Journal of the Canadian Society for Mesopotamian Studies* 11–12: 57–59.

Copeland, L. and Verhoeven, M. 1996. Bitumen-Coated Sickle-Blade Elements at Tell Sabi Abyad II, Northern Syria, in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 327–30.

Coqueugniot, E. 2000. Dja'De (Syrie), Un Village Néolithique Á La Veille De La Domestication (Seconde Moitié du IXe Millénaire Av. J.-C., in J. Guilaine (ed.) *Premiers Paysans du Monde: Naissances Des Agricultures*. Paris, Errance: 63–79.

Coqueugniot, E. 2016. Dja'de El-Mughara, in Y. Kanjou and A. Tsuneki (eds). *A History of Syria in One Hundred Sites*. Oxford, Archaeopress: 51–53.

Coqueugniot, H., Dutour, O., Arensburg, B., Duday, H., Vandermeersch, B. and Tillier, A. M. 2014. Earliest Cranio-Encephalic Trauma from the Levantine Middle Palaeolithic: 3d Reappraisal of the Qafzeh 11 Skull, Consequences of Pediatric Brain Damage on Individual Life Condition and Social Care 9 (7): p.e102822.

Corbet, G. B. and Southern, H. N. 1977. *The Handbook of British Mammals*. Oxford, Blackwell Scientific.

Corbet, G. B. and Ovenden, D. 1980. *The Mammals of Britain and Europe*. London, HarperCollins.

Coşkun, A., Benz, M., Rössner, C., Deckers, K., Riehl, S., Alt, K. W. and Özkaya, V. 2012. New Results on the Younger Dryas Occupation at Körtik Tepe. *Neo-Lithics* 1(12): 25–32.

Coşkun, Y., Hamad, Z. A. and Kaya, A. 2016. Morphological Properties of Nannospalax (Rodentia: Spalacidae) Distributed in North-Iraq. *Hacettepe Journal Biology Chemistry* 44 (2): 173–179.

Costin, C. 1991. Craft Specialisation: Issues in Defining, Documenting and Explaining the Organisation of Production. *Archaeological Method and Theory* 3: 1–46.

Costin, C. 1996. *Craft Production and Mobilization Strategies in the Inka Empire*. Philadelphia, University of Pennsylvania Museum of Archaeology and Anthropology.

Courty, M.-A. and Coqueugniot, E. 2013. A Microfacies Toolkit for Revealing Linkages between Cultural Discontinuities and Exceptional Geogenic Events: The Tell Dja'de Case Study (NE Syria). *Journal of Archaeological Method and Theory* 20 (2): 331–362.

Courty, M. A., Goldberg, P. and Macphail, R. 1989. *Soils and Micromorphology in Archaeology*. Cambridge, Cambridge University Press.

Courty, M.-A., Macphail, R. I. and Wattez, J. 1991. Soil Micromorphological Indicators of Pastoralism; with Special Reference to Arene Candide, Finale Ligure, Italy. *Rivista di studi liguri* 57 (1–4): 127–140.

Coward, F. 2010. Small Worlds, Material Culture, and Ancient Near Eastern Social Networks, in R. I. M. Dunbar, C. Gamble and J. Gowlett (eds). *Social Brain, Distributed Mind*. Oxford, Oxford University Press, *Proceedings of the British Academy* 158: 149–180.

Coward, F. 2013. Grounding the Net: Social Networks, Material Culture and Geography in the Epipalaeolithic and Early Neolithic of the Near East, in C. Knappett (ed.) *Network Analysis in Archaeology: New Approaches to Regional Interaction*. Oxford, Oxford University Press: 247–280.

Cramp, S., Gillmor, R., Simmons, K. E. L., Hollom, P. A. D., Hudson, R., Nicholson, E. M., Ogilvie, M. A., Olney, P. J. S., Roselaar, C. S., Voous, K. H., Ferguson-Lees, I. J. and J, W. 1977. *Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic; Vol. I. Ostrich to Ducks*. Oxford, Oxford University Press.

Cramp, S., Gillmor, R., Simmons, K. E. L., Hollom, P. A. D., Hudson, R., Nicholson, E. M., Ogilvie, M. A., Olney, P. J. S., Roselaar, C. S., Voous, K. H., Wallace, D. I. M. and J, W. 1980. *Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic; Vol. 2. Hawks to Bustards*. Oxford, Oxford University Press.

Crépeau, R. and Smith, P. E. L. 1983. Fabrication Expérimentale De Répliques D'un Vase Néolithique du Site de Ganj Dareh, Iran: Recherche Technologique. *Paléorient* 9 (2): 55–62.

Crespo, F. A., Klaes, C. K., Switala, A. E. and DeWitte, S. N. 2017. Do Leprosy and Tuberculosis Generate a Systemic Inflammatory Shift? Setting the Ground for a New Dialogue between Experimental Immunology and Bioarchaeology. *American Journal of Physical Anthropology* 162 (1): 143–146.

Croucher, K. 2012. *Death and Dying in the Neolithic of the Near East*. Oxford, Oxford University Press.

Crutzen, P. J. and Stoermer, E. F. 2000. The Anthropocene. *Global Change Newsletter* 41: 17–18.

Cucchi, T., Vigne, J.-D. and Auffray, J.-C. 2005. First Occurrence of the House Mouse (*Mus Musculus Domesticus* Schwarz & Schwarz, 1943) in the Western Mediterranean: A Zooarchaeological Revision of Subfossil Occurrences. *Biological Journal of the Linnean Society* 84 (3): 429–445.

Cucchi, T., Vigne, J.-D. and Auffray, J.-C. 2012. On the Origin of the House Mouse Synanthropy and Dispersal in the Near East and Europe: Zooarchaeological Review and Perspectives, in M. Macholán, S. J. Baird, J. Piálek and P. Munclinger (eds). *Evolution of the House Mouse*. Cambridge, Cambridge University Press: 67–93.

Cunningham, C., Scheuer, L. and Black, S. 2016. *Developmental Juvenile Osteology*. London, Academic Press.

Daems, A. 2008. Evaluating Patterns of Gender through Mesopotamian and Iranian Human Figurines. A Reassessment of the Neolithic and Chalcolithic Period Industries, in D. Bolger (ed.) *Gender Through Time in the Ancient Near East*. Plymouth, AltaMira Press: 77–117.

Daems, A. 2017. From a Bird's Eye View: Figurines in Iran, in T. Insoll (ed.) *The Oxford Handbook of Prehistoric Figurines*. Oxford, Oxford University Press: 591–612.

Daems, A. and Croucher, K. 2007. Artificial Cranial Modification in Prehistoric Iran: Evidence from Crania and Figurines. *Iranica Antiqua* 42: 1–21.

Dahlberg, A. A. 1960. The Dentition of the First Agriculturists (Jarmo, Iraq). *American Journal of Physical Anthropology* 18 (4): 243–246.

Dalton, M. and Ryan, P. 2018. Variable Ovicaprid Diet and Faecal Spherulite Production at Amara West, Sudan. *Environmental Archaeology*: 1–20.

Daly, K. G., Delser, P. M., Mullin, V. E., Scheu, A., Mattiangeli, V., Teasdale, M. D., Hare, A. J., Burger, J., Verdugo, M. P., Collins, M. J., Kehati, R., Erek, C. M., Bar-Oz, G., Pompanon, F., Cumer, T., Cakirlar, C., Mohaseb, A. F., Decruyenaere, D., Davoudi, H., Cevik, O., Rollefson, G., Vigne, J.-D., Khazaeli, R., Fathi, H., Doost, S. B., Sorkhani, R. R., Vahdati, A. A., Sauer, E. W., Kharanaghi, H. A., Maziar, S., Gasparian, B., Pinhasi, R., Martin, L., Orton, D., Arbuckle, B. S., Benecke, N., Manica, A., Horwitz, L. K., Mashkour, M. and Bradley, D. G. 2018. Ancient Goat Genomes Reveal Mosaic Domestication in the Fertile Crescent. *Science* 361 (6397): 85–87.

Darabi, H. 2016. A Social Perspective on the Neolithic in Western Iran. *Documenta Praehistorica* 43: 283–300.

Darabi, H. and Glascock, M. D. 2013. The Source of Obsidian Artefacts Found at East Chia Sabz, Western Iran. *Journal of Archaeological Science* 40 (10): 3804–3809.

Darabi, H., Naseri, R., Young, R. and Fazeli Nashli, H. 2011. The Absolute Chronology of East Chia Sabz: A Pre-Pottery Neolithic Site in Western Iran. *Documenta Praehistorica* 38: 255–266.

Darabi, H., Fazeli Nashli, H., Naseri, R., Riehl, S. and Young, R. 2013. The Neolithisation Process in the Seimarreh Valley: Excavations at East Chia Sabz, Central Zagros, in R. Matthews and H. Fazeli Nashli (eds). *The Neolithisation of Iran: The Formation of New Societies*. Oxford, BANEA/Oxbow Books: 55–75.

Darabi, H., Richter, T. and Mortensen, P. 2018. New Excavations at Tappeh Asiab, Kermanshah Province, Iran. *Antiquity* 92 (361): 1–6.

Darabi, H., Richter, T. and Mortensen, P. 2019. Neolithisation Process in the Central Zagros: Asiab and Ganj Dareh revisited. *Documenta Praehistorica* 46: 44-57.

David, N. and Kramer, C. 2001. *Ethnoarchaeology in Action*. Cambridge, Cambridge University Press.

Davies, P. 2008. *Snails: Archaeology and Landscape Change*. Oxford, Oxbow Books.

Davis, M. 1982. The Çayönü Ground Stone, in L. S. Braidwood and R. J. Braidwood (eds). *Prehistoric Village Archaeology in South-Eastern Turkey: The Eighth Millennium B.C. Site at Çayönü, Its Chipped and Ground Stone Industries and Faunal Remains.* Oxford, British Archaeological Reports S138: 73–174.

Davis, S. J. 2000. The Effect of Castration and Age on the Development of the Shetland Sheep Skeleton and a Metric Comparison between Bones of Males, Females and Castrates. *Journal of Archaeological Science* 27 (5): 373–90.

Dawson, L., Levy, T. and Smith, P. 2003. Evidence of Interpersonal Violence at the Chalcolithic Village of Shiqmim (Israel). *International Journal of Osteoarchaeology* 13 (3): 115–119.

De Betta, E. and Martinati, P. 1855. *Catalogo Dei Molluschi Terrestri E Fluviatili Viventi Nelle Provincie Venete*. Verona, Antonelli.

de Castrillo, M. C., Philokyprou, M. and Ioannou, I. 2017. Comparison of Adobes from Pre-History to-Date. *Journal of Archaeological Science-Reports* 12: 437–448.

De Reu, J., Plets, G., Verhoeven, G., De Smedt, P., Bats, M., Cherretté, B., De Maeyer, W., Deconynck, J., Herremans, D. and Laloo, P. 2013. Towards a Three-Dimensional Cost-Effective Registration of the Archaeological Heritage. *Journal of Archaeological Science* 40 (2): 1108–1121.

De Reu, J., De Smedt, P., Herremans, D., Van Meirvenne, M., Laloo, P. and De Clercq, W. 2014. On Introducing an

Image-Based 3d Reconstruction Method in Archaeological Excavation Practice. *Journal of Archaeological Science* 41: 251–262.

Dean, J. R., Jones, M. D., Leng, M. J., Noble, S. R., Metcalfe, S. E., Sloane, H. J., Sahy, D., Eastwood, W. J. and Roberts, C. N. 2015. Eastern Mediterranean Hydroclimate over the Late Glacial and Holocene, Reconstructed from the Sediments of Nar Lake, Central Turkey, Using Stable Isotopes and Carbonate Mineralogy. *Quaternary Science Reviews* 124: 162–174.

Dean, J. R., Jones, M. D., Leng, M. J., Metcalfe, S. E., Sloane, H. J., Eastwood, W. J. and Roberts, C. N. 2018. Seasonality of Holocene Hydroclimate in the Eastern Mediterranean Reconstructed Using the Oxygen Isotope Composition of Carbonates and Diatoms from Lake Nar, Central Turkey. *Holocene* 28 (2): 267–276.

Delerue, S. 2007. *L'Obsidienne dans le Processus de Néolithisation du Proche-Orient (12000–6500 BC)*. PhD thesis, Université Michel de Montaigne, Bordeaux.

DeMarrais, E. 2016. Making Pacts and Cooperative Acts: The Archaeology of Coalition and Consensus. *World Archaeology* 48 (1): 1–13.

Devos, Y., Vrydaghs, L. and Hodson, M. J. Accepted. Autofluorescent Phytoliths: A new Proxy for Heating and Fire? *Environmental Archaeology: The Journal of Human Palaeoecology*.

Dieppe, P. 2008. Osteoarthritis: Clinical Features, in J. H. Klippel, J. H. Stone and P. H. White (eds). *Primer on the Rheumatic Diseases*. New York, Springer Science & Business Media: 224–228.

Dietrich, O., Heun, M., Notroff, J., Schmidt, K., Zarnkow, M. and Carver, M. 2012. The Role of Cult and Feasting in the Emergence of Neolithic Communities. New Evidence from Göbekli Tepe, South-Eastern Turkey. *Antiquity* 86 (333): 674–695.

Dimitrijević, V. 2014. The Provenance and Use of Fossil Scaphopod Shells at the Late Neolithic/Eneolithic Site Vinča - Belo Brdo, Serbia, in K. Szabó, C. Dupont, V. Dimitrijević, L. Gómez Gastélum and N. Serrrnad (eds). *Archaeomalacology: Shells in the Archaeological Record*. Oxford, British Archaeological Reports S2666: 33–41.

Dirks, P. H., Berger, L. R., Roberts, E. M., Kramers, J. D., Hawks, J., Randolph-Quinney, P. S., Elliott, M., Musiba, C. M., Churchill, S. E. and de Ruiter, D. J. 2015. Geological and Taphonomic Context for the New Hominin Species Homo Naledi from the Dinaledi Chamber, South Africa. *Elife* 4: e09561.

Dittemore, M. 1983. The Soundings at M'lefaat, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 671–692.

Djamali, M., de Beaulieu, J. L., Shah-hosseini, M., Andrieu-Ponel, V., Ponel, P., Amini, A., Akhani, H., Leroy, S. A. G., Stevens, L., Lahijani, H. and Brewer, S. 2008. A Late Pleistocene Long Pollen Record from Lake Urmia, NW Iran. *Quaternary Research* 69 (3): 413–420.

Djamali, M., de Beaulieu, J.-L., Andrieu-Ponel, V., Berberian, M., Miller, N. F., Gandouin, E., Lahijani, H., Shah-Hosseini, M., Ponel, P., Salimian, M. and Guiter, F. 2009a. A Late Holocene Pollen Record from Lake Almalou in NW Iran: Evidence for Changing Land-Use in Relation to Some Historical Events During the Last 3700 Years. *Journal of Archaeological Science* 36 (7): 1364–1375.

Djamali, M., de Beaulieu, J.-L., Miller, N. F., Andrieu-Ponel, V., Ponel, P., Lak, R., Sadeddin, N., Akhani, H. and Fazeli, H. 2009b. Vegetation History of the SE Section of the Zagros Mountains During the Last Five Millennia; a Pollen Record from the Maharlou Lake, Fars Province, Iran. *Vegetation History and Archaeobotany* 18 (2): 123–136.

Djamali, M., Akhani, H., Andrieu-Ponel, V., Braconnot, P., Brewer, S., de Beaulieu, J. L., Fleitmann, D., Fleury, J., Gasse, F., Guibal, F., Jackson, S. T., Lézine, A. M., Médail, F., Ponel, P., Roberts, N. and Stevens, L. 2010. Indian Summer Monsoon Variations Could Have Affected the Early-Holocene Woodland Expansion in the Near East. *Holocene* 20 (5): 813–820.

Djamali, M., Biglari, F., Abdi, K., Andrieu-Ponel, V., de Beaulieu, J. L., Mashkour, M. and Ponel, P. 2011. Pollen Analysis of Coprolites from a Late Pleistocene-Holocene Cave Deposit (Wezmeh Cave, West Iran): Insights into the Late Pleistocene and Late Holocene Vegetation and Flora of the Central Zagros Mountains. *Journal of Archaeological Science* 38 (12): 3394–3401.

Dobney, K., Beech, M., and Jaques, D. 1999.Hunting the 'Broad Spectrum Revolution' in northern Mesopotamia: the characterisation of proto/early Neolithic animal exploitation at Qermez Dere, in In J. C. Driver (ed). *Zooarchaeology at the Pleistocene/Holocene Boundary*. Oxford, British Archaeological Reports S800: 47–47,.

Donet, J. M., Gunn, R. G. and Horák, F. 1982. Reproduction, in I. E. Coop (ed.) *Sheep and Goat Production*. Amsterdam, Elsevier: 57–80.

Donoghue, H. D. 2017. Insights Gained from Ancient Biomolecules into Past and Present Tuberculosis – a Personal Perspective. *International Journal of Infectious Diseases* 56: 176–180.

Dorrell, P. G. 1983. Appendix A: Stone Vessels, Tools, and Objects, in K. M. Kenyon and T. A. Holland (eds). *Excavations at Jericho Volume 5. The Pottery Phases of the Tell and Other Finds*. 5. London, British School of Archaeology in Jerusalem: 485–475.

Doveri, F. 2007. *Fungi Fimicoli Italici: A Guide to the Recognition of Basidiomycetes and Ascomycetes Living on Faecal Material*. Trento, Associazione Micologica Bresadola.

Doyen, E. and Etienne, D. 2017. Ecological and Human Land-Use Indicator Value of Fungal Spore Morphotypes and Assemblages. *Vegetation History and Archaeobotany* 26 (4): 357–367.

Dreslerová, D., Kočár, P., Chuman, T., Šefrna, L. and Poništiak, Š. 2013. Variety in Cereal Cultivation in the Late Bronze and Early Iron Ages in Relation to Environmental Conditions. *Journal of Archaeological Science* 40 (4): 1988–2000.

Dubreuil, L. 2001a. Functional Studies of Prehistoric Grindingstones. A Methodological Research. *Bulletin du Centre de Recherche Français à Jérusalem* 9: 73–87.

Dubreuil, L. 2001b. Etudes Fonctionnelles du Matériel De Broyage En Préhistoire: Recherches Méthodologiques. Comment Faire Parler Les Pierres? *Bulletin du Centre de Recherche Français à Jérusalem* 9: 9–26.

Dubreuil, L. and Grosman, L. 2009. Ochre and Hide-Working at a Natufian Burial Place. *Antiquity* 83 (322): 935–944.

Dubreuil, L. and Savage, D. 2014. Ground Stones: A Synthesis of the Use-Wear Approach. *Journal of Archaeological Science* 48: 139–143.

Dubreuil, L., Savage, D., Delgado Raack, S., Plisson, H., Stephenson, B. and De la Torre, I. 2015. Current Analytical Frameworks for Studies of Use-Wear on Ground Stone Tools, in J. Marreiros, J. F. Gibaja and N. F. Bicho (eds). *Use-Wear and Residue Analysis in Archeology*. London, Springer: 105–148.

Dunnell, R. C. and Stein, J. K. 1989. Theoretical Issues in the Interpretation of Microartifacts. *Geoarchaeology* 4 (1): 31–41.

Düring, B. S. 2003. Burials in Context: The 1960s Inhumations of Çatalhöyük East. *Anatolian Studies* 53: 1–15.

Düring, B. S. 2006. *Constructing Communities: Clustered Neighbourhood Settlement of the Central Anatolian Neolithic Ca. 8500–4500 cal. BC*. Leiden, Nederlands Instituut Voor Het Nabije Oosten Te Leiden.

Düring, B. S. 2007. The Articulation of Houses at Neolithic Çatalhöyük, Turkey, in R. A. J. Beck (ed.) *The Durable House: House Society Models in Archaeology*. Carbondale, Southern Illinois University: 130–143.

Düring, B. S. 2008. Sub-Floor Burials at Çatalhöyük: Exploring Relations between the Dead, Houses, and the Living, in J. M. Cordoba, M. Molist, M. C. Perez, I. Rubio and S. Martinez (eds). *Proceedings of the 5th International Conference on the Archaeology of the Ancient Near East, Volume 3*. Madrid, Universidad Autonoma de Madrid.: 603–620.

Edwards, P. C. 2007. The Context and Production of Incised Neolithic Stones. *Levant* 39: 27–33.

Edwards, Y. H. and Martin, L. 2007. Fauna from the Natufian and PPNA Cave Site of Iraq Ed-Dubb in Highland Jordan. *Paléorient*: 143–174.

Eerkens, J. W. 1998. Reliable and Maintainable Technologies: Artifact Standardization and the Early to Later Mesolithic Transition in Northern England. *Lithic Technology* 23 (1): 42–43.

Eidem, J. 2013. Back to Rania, *Netherlands Institute for the Near East Annual Report 2012*. Leiden, NINO: 2–11.

Eidem, J. 2015. Dams and Damage. Heritage Loss and Second Phase Salvage on the Rania Plain (Kurdish Region of Iraq). *Netherlands Institute for the Near East Annual Report 2015*. Leiden, NINO: 2–13.

Eidem, J. and Læssøe, J. 2001. *The Shemshāra Archives 1: The Letters*. Copenhagen, Kongelige Danske Videnskabernes Selskab.

Elbaum, R., Weiner, S., Albert, R. M. and Elbaum, M. 2003. Detection of Burning of Plant Materials in the Archaeological Record by Changes in the Refractive Indices of Siliceous Phytoliths. *Journal of Archaeological Science* 30 (2): 217–226.

Elhmmali, M. M., Roberts, D. J. and Evershed, R. P. 1997. Bile Acids as a New Class of Sewage Pollution Indicator. *Environmental Science & Technology* 31 (12): 3663–3668.

Ellerman, J. R. 1941. *The Families and Genera of Living Rodents. Volume 2. Family Muridae*. London, British Museum of Natural History.

Elliott, S. 2015. *Investigating Early Animal Management in the Zagros Mountains of Iran and Iraq: Integrating Field and Laboratory Methods for the Identification and Analysis of Ancient Faecal Material.* Unpublished PhD Thesis, University of Reading.

Elliott, S., Bendrey, R., Whitlam, J., Aziz, K. and Evans, J. 2015. Preliminary Ethnoarchaeological Research on Modern Animal Husbandry in Bestansur, Iraqi Kurdistan: Integrating Animal, Plant and Environmental Data. *Environmental Archaeology* 20 (3): 283–303.

Elliott, S., Palmer, C., Allcock, S. L. and Jenkins, E. 2017. Examining Neolithic Building and Activity Areas through Historic Cultural Heritage in Jordan: A Combined Ethnographic, Phytolith and Geochemical Investigation. *Bulletin of the Council for British Research in the Levant* 12 (1): 21–28.

Epstein, H. and Herz, A. 1964. Fertility and Birth Weights of Goats in a Subtropical Environment. *Journal of Agricultural Science* 62 (2): 237–244.

Erasmus, U. 1986. *Fats and Oils: The Complete Guide to Fats and Oils in Health and Nutrition*. Vancouver, Alive Books.

Erdal, Y. S. 2008. Occlusal Grooves in Anterior Dentition among Kovuklukaya Inhabitants (Sinop, Northern Anatolia, 10th Century AD). *International Journal of Osteoarchaeology* 18 (2): 152–166.

Erdal, Y. S. 2015. Bone or Flesh: Defleshing and Post-Depositional Treatments at Körtik Tepe (Southeastern Anatolia, PPNA Period). *European Journal of Archaeology* 18 (1): 4–32.

Eren, M. I., Durant, A., Neudorf, C., Haslam, M., Shipton, C., Bora, J., Korisettar, R. and Petraglia, M. 2010. Experimental Examination of Animal Trampling Effects on Artifact Movement in Dry and Water Saturated Substrates: A Test Case from South India. *Journal of Archaeological Science* 37 (12): 3010–3021.

Esfandabad, B. S., Karami, M., Hemami, M.-R., Riazi, B. and Sadough, M.-B. 2010. Habitat Associations of Wild Goat in Central Iran: Implications for Conservation. *European Journal of Wildlife Research* 56 (6): 883–894.

Eshed, V., Gopher, A., Gage, T. and Hershkovitz, I. 2004a. Has the Transition to Agriculture Reshaped the Demographic Structure of Prehistoric Populations? New Evidence from the Levant. *American Journal of Physical Anthropology* 124: 315–329.

Eshed, V., Gopher, A., Galili, E. and Hershkovitz, I. 2004b. Musculoskeletal Stress Markers in Natufian Hunter-Gatherers and Neolithic Farmers in the Levant: The Upper Limb. *American Journal of Physical Anthropology* 123 (4): 303–315.

Eshed, V., Gopher, A. and Hershkovitz, I. 2006. Tooth Wear and Dental Pathology at the Advent of Agriculture: New Evidence from the Levant. *American Journal of Physical Anthropology* 130 (2): 145–149.

Eshed, V., Gopher, A., Pinhasi, R. and Hershkovitz, I. 2010. Paleopathology and the Origin of Agriculture in the Levant. *American Journal of Physical Anthropology* 143 (1): 121–133.

Esin, U. and Harmankaya, S. 1999. Asikli, in M. Ozdogan and N. Basgelen (eds). *Neolithic in Turkey: The Cradle of Civilization*. Istanbul, Arkeoloji ve Sanat Yayinlari: 115–132.

Evans, A. A. and Donahue, R. E. 2005. The Elemental Chemistry of Lithic Microwear: An Experiment. *Journal of Archaeological Science* 32 (12): 1733–1740.

Evans, J. G. 1969. Land and Freshwater Mollusca in Archaeology: Chronological Aspects. *World Archaeology* 1 (2): 170–183.

Fagan, A. 2017. Hungry Architecture: Spaces of Consumption and Predation at Göbekli Tepe. *World Archaeology* 49 (3): 318–337.

Farhadinia, M. S., Esfandabad, B. S., Karami, M., Hosseini-Zavarei, F., Absalan, H. and Nezami, B. 2009. Goitered Gazelle, *Gazella Subgutturosa*: Its Habitat Preference and Conservation Needs in Miandasht Wildlife Refuge, North-Eastern Iran (Mammalia: Artiodactyla). *Zoology in the Middle East* 46 (1): 9–18.

Farmelo, G. 2004. Introduction. Only Connect: Linking the Public with Current Scientific Research, in D. Chittenden, G. Farmelo and B. V. Lewenstein (eds). *Creating Connections: Museums and the Public Understanding of Current Research*. Oxford, Alta Mira Press: 1–26.

Fattah, O. 2013. *Learning in the Slemani Museum: Evaluating Learning Outcomes*. Unpublished MA dissertation, University of Leicester.

Fazekas, I. and Kosa, F. 1978. Determination of the Body Length and Age of Foetuses on the Basis of the Diaphyseal Size of the Extremity Bones, in I. G. Fazekas and F. Kósa (eds). *Forensic Foetal Osteology*. Budapest, Akademiai-Kiado: 232–277.

Fazeli Nashli, H., Coningham, R. A., Marghussian, A., Manuel, M., Azizi Kharanaghi, H. and Pollard, M. 2013. Mapping the Neolithic Occupation of the Kashan, Tehran and Qazvin Plains , in R. Matthews and H. Fazeli Nashli (eds). *The Neolithisation of Iran: The Formation of New Societies*. Oxford, BANEA/ Oxbow Books: 124–146.

Feldman, M., Fernández-Domínguez, E., Reynolds, L., Baird, D., Pearson, J., Hershkovitz, I., May, H., Goring-Morris, N., Benz, M. and Gresky, J. 2019. Late Pleistocene Human Genome Suggests a Local Origin for the First Farmers of Central Anatolia. *Nature communications* 10 (1): 1218.

Fernández-López de Pablo, J., Badal, E., Ferrer García, C., Martínez-Ortí, A. and Sanchis Serra, A. 2014 Land Snails as a Diet Diversification Proxy During the Early Upper Palaeolithic in Europe. *PloS one* 9 DOI: 10.1371/journal.pone.0104898.

Finlayson, B. 2013. Imposing the Neolithic on the Past. *Levant* 45 (2): 133–148.

Finlayson, B., Mithen, S., Najjar, M., Jenkins, E. and Smith, S. 2009. New Excavations at WF16, a Pre-Pottery Neolithic a Site in Southern Jordan. *Antiquity Project Gallery*: www.antiquity.ac.uk/projgall/finlayson319/.

Finlayson, B., Mithen, S. and Smith, S. 2011. On the Edge: Southern Levantine Epipalaeolithic–Neolithic Chronological Succession. *Levant* 43 (2): 127–138.

Firouz, E. 2005. *The Complete Fauna of Iran*. London, IB Tauris.

Fisher, K. D. 2009. Placing Social Interaction: An Integrative Approach to Analyzing Past Built Environments. *Journal of Anthropological Archaeology* 28 (4): 439–447.

Flannery, K. 1969. Origins and Ecological Effects of Early Domestication in Iran and the Near East, in P. J. Ucko and G. W. Dimbleby (eds). *The Domestication and Exploitation of Plants and Animals*. London, Duckworth: 73–100.

Flannery, K. 1983. Early Pig Domestication in the Fertile Crescant: A Retrospective Look, in T. C. Young, P. E. L. Smith and P. Mortensen (eds). *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia Presented to Robert J. Braidwood*. Chicago, Oriental Institute of the University of Chicago Studies in Ancient Oriental Civilization 36: 163-188.

Flannery, K. 2014. Hunting and Early Animal Domestication at Tepe Guran, in Mortensen (ed.) 2014: 89–105.

Fleitmann, D., Mudelsee, M., Burns, S. J., Bradley, R. S., Kramers, J. and Matter, A. 2008. Evidence for a Widespread Climatic Anomaly at around 9.2 Ka Before Present. *Paleoceanography and Paleoclimatology* 23 (1): PA1102.

Fletcher, A., Pearson, J. and Ambers, J. 2008. The Manipulation of Social and Physical Identity in the Pre-Pottery Neolithic: Radiographic Evidence for Cranial Modification at Jericho and Its Implications for the Plastering of Skulls. *Cambridge Archaeological Journal* 18 (3): 309–325.

Flohr, P., Fleitmann, D., Matthews, R., Matthews, W. and Black, S. 2016. Evidence of Resilience to Past Climate Change in Southwest Asia: Early Farming Communities and the 9.2 and 8.2 Ka Events. *Quaternary Science Reviews* 136: 23–39.

Flohr, P., Fleitmann, D., Zorita, E., Sadekov, A., Cheng, H., Bosomworth, M., Edwards, L., Matthews, W. and Matthews, R. 2017. Late Holocene Droughts in the Fertile Crescent Recorded in a Speleothem from Northern Iraq. *Geophysical Research Letters* 44 (3): 1528–1536.

Folke, C., Carpenter, S. and Walker, B. 2010. Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society* 15 (4): 20.

Fontijn, D. R. 2002. *Sacrificial Landscapes: Cultural Biographies of Persons, Objects and 'Natural' Places in the Bronze Age of the Southern Netherlands, C. 2300–600 BC*. Leiden, University of Leiden.

Forbes, R. J. 1936. *Bitumen and Petroleum in Antiquity*. Leiden, E.J. Brill.

Foster, C. P. 2009. *Household Archaeology and the Uruk Phenomenon: A Case Study from Kenan Tepe, Turkey*. Ph.D Thesis, University of California, Berkeley.

Fournié, G., Pfeiffer, D. U. and Bendrey, R. 2017. Early Animal Farming and Zoonotic Disease Dynamics: Modelling Brucellosis Transmission in Neolithic Goat Populations. *Royal Society open science* 4 (2): 160943.

Foxhall, L. 2000. The Running Sands of Time: Archaeology and the Short-Term. *World Archaeology* 31 (3): 484–498.

Frahm, E. 2012. Evaluation of Archaeological Sourcing Techniques: Reconsidering and Re-Deriving Hughes' Four-Fold Assessment Scheme. *Geoarchaeology* 27 (2): 166–174.

Frahm, E. 2014. Fifty Years of Obsidian Sourcing in the Near East: Considering the Archaeological Zeitgeist and Legacies of Renfrew, Dixon, and Cann, in C. D. Dillian (ed.) *Twenty-Five Years on the Cutting Edge of Obsidian Studies: Selected Readings from the IAOS Bulletin*. Ontario, International Association for Obsidian Studies: 169–188.

Frahm, E. and Tryon, C. A. 2018. Origins of Epipalaeolithic Obsidian Artifacts from Garrod's Excavations at Zarzi Cave in the Zagros Foothills of Iraq. *Journal of Archaeological Science: Reports* 21: 472–485.

Frangipane, M., Andersson Strand, E., Laurito, R., Möller-Wiering, S., Nosch, M.-L., Rast-Eicher, A. and Wisti Lassen, A. 2009. Arslantepe, Malatya (Turkey): Textiles, Tools and Imprints of Fabrics from the 4th to the 2nd Millennium BCE. *Paléorient* 35 (1): 5–29.

Frantz, L. A., Haile, J., Lin, A. T., Scheu, A., Geörg, C., Benecke, N., Alexander, M., Linderholm, A., Mullin, V. E. and Daly, K. G. 2019. Ancient Pigs Reveal a near-Complete Genomic Turnover Following Their Introduction to Europe. *Proceedings of the National Academy of Sciences* 116 (35): 17231–17238.

Fraser, F. C. 1953. Barda Balka Animal Bones. *Sumer* 9: 106–107.

Fraser, R. A., Bogaard, A., Schafer, M., Arbogast, R. and Heaton, T. H. E. 2013. Integrating Botanical, Faunal and Human Stable Carbon and Nitrogen Isotope Values to

Reconstruct Land Use and Palaeodiet at LBK Vaihingen an Der Enz, Baden-Wurttemberg. *World Archaeology* 45 (3): 492–417.

Freeman, J., Peeples, M. A. and Anderies, J. M. 2015. Toward a Theory of Non-Linear Transitions from Foraging to Farming. *Journal of Anthropological Archaeology* 40: 109–122.

French, D. H. 1971. An Experiment in Water-Sieving. *Anatolian Studies* 21: 59–64.

Frenken, K. 2009. *Irrigation in the Middle East Region in Figures Aquastat Survey – 2008*. Rome, Food and Agriculture Organization of the United Nations (FAO).

Friesem, D. E., Tsartsidou, G., Karkanas, P. and Shahack-Gross, R. 2014. Where Are the Roofs? A Geo-Ethnoarchaeological Study of Mud Brick Structures and Their Collapse Processes, Focusing on the Identification of Roofs. *Archaeological and Anthropological Sciences* 6 (1): 73–92.

Frodeman, R. 1995. Geological Reasonings: Geology as an Interpretative and Historical Science. *Geological Society of America Bulletin* 107: 960–968.

Frodeman, R. 2004. Reading the Earth: Philosophy in the Field, in N. Boivin and M. A. Owoc (eds). *Soils, Stones and Symbols: Cultural Perceptions of the Mineral World*. London, UCL Press: 203–216.

Frost, H. 1984. Khirokitia: Une Pierre d'Ancrage, in A. Le Brun (ed.) *Fouilles Récentes à Khirokitia (Chypre): 1977–1981*. Paris Editions Recherche sur les Civilisations. Mémoire 41: 125–126.

Fujii, S. 1988. Typological Reassessment and Some Discussions on Beaked Blade. *Bulletin of the Okayama Orient Museum* 7: 1–16.

Fuller, D., Q. 2007a. Archaeobotany: Phytolith Teaching and Research Images. Online: http://www.homepages.ucl.ac.uk/~tcrndfu/phytoliths.html.

Fuller, D. Q. 2007b. Contrasting Patterns in Crop Domestication and Domestication Rates: Recent Archaeobotanical Insights from the Old World. *Annals of Botany* 100 (5): 903–924.

Fuller, D. Q., Willcox, G. and Allaby, R. G. 2011. Cultivation and Domestication Had Multiple Origins: Arguments against the Core Area Hypothesis for the Origins of Agriculture in the Near East. *World Archaeology* 43 (4): 628–642.

Fuller, D. Q., Asouti, E. and Purugganan, M. D. 2012a. Cultivation as Slow Evolutionary Entanglement: Comparative Data on Rate and Sequence of Domestication. *Vegetation History and Archaeobotany* 21 (2): 131–145.

Fuller, D. Q., Willcox, G. and Allaby, R. G. 2012b. Early Agricultural Pathways: Moving Outside the 'Core Area' Hypothesis in Southwest Asia. *Journal of Experimental Botany* 63 (2): 617–633.

Fuller, D. Q., Denham, T., Arroyo-Kalin, M., Lucas, L., Stevens, C. J., Qin, L., Allaby, R. G. and Purugganan, M. D. 2014. Convergent Evolution and Parallelism in Plant Domestication Revealed by an Expanding Archaeological Record. *Proceedings of the National Academy of Sciences* 111 (17): 6147.

Galili, E., Gopher, A., Eshed, V. and Hershkovitz, I. 2005. Burial Practices at the Submerged Pre-Pottery Neolithic C Site of Atlit-Yam, Northern Coast of Israel. *Bulletin of the American Schools of Oriental Research* 339 (1): 1–19.

Gallego-Llorente, M., Connell, S., Jones, E. R., Merrett, D. C., Jeon, Y., Eriksson, A., Siska, V., Gamba, C., Meiklejohn, C., Beyer, R., Jeon, S., Cho, Y. S., Hofreiter, M., Bhak, J., Manica, A. and Pinhasi, R. 2016. The Genetics of an Early Neolithic Pastoralist from the Zagros, Iran. *Scientific Reports* 6 (1): 31326.

Galloway, A. 1997. The Process of Decomposition: A Model from the Arizona-Sonoran Desert, in M. H. Sorg and W. D. Haglund (eds). *Forensic Taphonomy: The Postmortem Fate of Human Remains*. Boca Raton, CRC Press: 139–140.

Gamble, C. 2004. Materiality and Symbolic Force: A Palaeolithic View of Sedentism, in E. De Marrais, C. Gosden and C. Renfrew (eds). *Rethinking Materiality: The Engagement of Mind with the Material World*. Cambridge, McDonald Institute for Archaeological Research: 85–95.

Gamble, L. H. 2017. Feasting, Ritual Practices, Social Memory, and Persistent Places: New Interpretations of Shell Mounds in Southern California. *American Antiquity* 82 (3): 427–441.

García-Suárez, A., Portillo, M. and Matthews, W. 2018. Early Animal Management Strategies During the Neolithic of the Konya Plain, Central Anatolia: Integrating Micromorphological and Microfossil Evidence. *Environmental Archaeology*: 1–19.

Garfinkel, Y. 1987. Burnt Lime Products and Social Implications in the Pre-Pottery Neolithic B Villages of the Near East. *Paléorient* 13 (1): 69–76.

Garrod, D. 1930. The Palaeolithic of Southern Kurdistan: Excavations in the Caves of Zarzi and Hazar Merd. *Bulletin of the American School of Prehistoric Research* 6: 8–43.

Gavrilova, O., Zavialova, N. Tekleva, M. and Karasev, E. 2018. Potential of CLSM in studying some modern and fossil palynological objects. *Journal of Microscopy* 269 (3): 291–309.

Gebel, H. G. 2002. Walls. Loci of Forces, in H. G. Gebel, B. D. Hermansen and C. H. Jensen (eds). *Magic Practices and Ritual in the Near Eastern Neolithic. Proceedings of a Workshop Held at the 2nd International Congress on the Archaeology of the Ancient Near East (ICAANE), Copenhagen University, May 2000*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence and Environment: 116–132.

Gebel, H. G., Hermansen, B. D. and Jensen, C. H. (eds). 2002. *Magic Practices and Ritual in the Near Eastern Neolithic. Proceedings of a Workshop Held at the 2nd International Congress on the Archaeology of the Ancient Near East (ICAANE), Copenhagen University, May 2000*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence and Environment.

Geber, J. and Murphy, E. 2012. Scurvy in the Great Irish Famine: Evidence of Vitamin C Deficiency from a Mid-19th Century Skeletal Population. *American Journal of Physical Anthropology* 148 (4): 512–524.

Ghasidian, E. and Heydari-Guran, S. 2018. Upper Palaeolithic Raw Material Economy in the Southern Zagros Mountains of Iran, *The Middle and Upper Paleolithic Archeology of the Levant and Beyond*. Singapore, Springer: 157–174.

Ghasidian, E., Azadi, A. and Pollock, S. 2010. Chipped Stone Artifacts, in S. Pollock, R. Bernbeck and K. Abdi (eds). *The 2003 Excavations at Tol-e Baši, Iran: Social Life in a Neolithic Village*. Mainz am Rhein, Von Zabern: 163–174.

Ghosh, R., Gupta, S., Bera, S., Jiang, H. E., Li, X. and Li, C. S. 2008. Ovi-Caprid Dung as an Indicator of Paleovegetation and Paleoclimate in Northwestern China. *Quaternary Research* 70 (2): 149–147.

Giddens, A. 1984. *The Constitution of Society: Outline of the Theory of Structuration*. Social and Political Theory from Polity Press, Cambridge: Polity.

Gillespie, R. 1984. *Radiocarbon User's Handbook*. Oxford, Oxford University Committee for Archaeology.

Giorgi, F. and Lionello, P. 2008. Climate Change Projections for the Mediterranean Region. *Global and Planetary Change* 63 (2–3): 90–104.

Giraud, J., Baldi, J., Bonilauri, S., Mashkour, M., Lemée, M., Pichon, F., Mura, M., Pot, M.-A., Biglari, F., Jamialahmadi, M., Ameen, A., Raeuf, K., Saber, S. A., Sofy, R., Jameel, J. and Rasheed, K. 2019. Human Occupation Along the Foothills of Northwestern Zagros During the Late Pleistocene and the Holocene in the Rani and Peshdar Plains. First Results of the French Archaeological Mission in the Governorate of Soulaimaniah (Iraqi Kurdistan). *Paléorient* 45 (2): 85–119.

Givens, M. D. and Marley, M. 2008. Infectious Causes of Embryonic and Fetal Mortality. *Theriogenology* 70 (3): 270–285.

Glasby, C. J. and Timm, T. 2008. Global Diversity of Polychaetes (Polychaeta; Annelida) in Freshwater. *Hydrobiologia* 595: 107–115.

Gleed-Owen, C. 2000. Subfossil Records of *Rana Cf. Lessonae*, *Rana Arvalis* and *Rana Cf. Dalmatina* from Middle Saxon (c. 600–950 AD) Deposits in Eastern England: Evidence for Native Status. *Amphibia-Reptilia* 21 (1): 57–65.

Glencross, B. 2013. Representing Violence in Anatolia and the Near East During the Transition to Agriculture: Readings from Contextualized Human Skeletal Remains, in C. Knüsel and M. Smith (eds). *The Routledge Handbook of the Bioarchaeology of Human Conflict*. Abingdon, Routledge: 136–144.

Godleman, J., Almond, M. A. and Matthews, W. 2016. An Infrared Microspectroscopic Study of Plasters and Pigments from the Neolithic Site of Bestansur, Iraq. *Journal of Archaeological Science: Reports* 7: 195–204.

Goldberg, P. and Berna, F. 2010. Micromorphology and Context. *Quaternary International* 214 (1–2): 56–62.

Goldberg, P. and Macphail, R. I. and with contributions by Matthews, W. 2006. *Practical and Theoretical Geoarchaeology*. Oxford, Blackwell Science.

Goldberg, P. and Rosen, A. M. 1987. Early Holocene Paleoenvironments of Israel, in T. E. Levy (ed.) *Shiqmim I: Studies Concerning Chalcolithic Societies in the Northern Negev Desert, Israel (1982–1984)*. Oxford, British Archaeological Reports S356: 23–34.

Golden, J., Levy, T. E. and Hauptmann, A. 2001. Recent Discoveries Concerning Chalcolithic Metallurgy at Shiqmim, Israel. *Journal of Archaeological Science* 28 (9): 951–963.

Golding, V. 2007. Learning at the Museum Frontiers: Democracy, Identity and Difference, in S. Knell, S. MacLeod and S. Watson (eds). *Museum Revolutions: How Museums Change and Are Changed*. Abingdon, Routledge: 315–329.

Golding, V. 2009. *Learning at the Museum Frontiers: Identity, Race and Power*. London, Ashgate.

Golding, V. 2013. Collaborative Museums: Curators, Communities, Collections, in V. Golding and E. Modest (eds). *Museums and Communities: Curators, Collections and Collaboration*. Oxford, Berg: 13–31.

González-Urquijo, J. E. and Ibáñez-Estévez, J. J. 2003. The Quantification of Use-Wear Polish Using Image Analysis. First Results. *Journal of Archaeological Science* 30 (4): 481–489.

González-Urquijo, J., Abbès, F., Alarashi, H., Ibáñez Estévez, J. J. and Lazuén, T. 2013. Microdrill Use at Khiamian Sites in Central and Northern Levant (Syria and Lebanon), in F. Borrell, J. J. Ibáñez Estévez and M. Molist (eds). *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East. Papers Presented to the 7th Conference on PPN Chipped and Ground Stone Industries of the Fertile Crescent*. Bellaterra, Universitat Autònoma de Barcelona, Servei de Publicacions: 177–190.

Goodale, N., Otis, H., Andrefsky, W., Kuijt, I., Finlayson, B. and Bart, K. 2010. Sickle Blade Life-History and the Transition to Agriculture: An Early Neolithic Case Study from Southwest Asia. *Journal of Archaeological Science* 37 (6): 1192–1201.

Goodale, N., Bailey, D. G., Jones, G. T., Prescott, C., Scholz, E., Stagliano, N. and Lewis, C. 2012. pXRF: A Study of Inter-Instrument Performance. *Journal of Archaeological Science* 39 (4): 875–883.

Goodfriend, G. A. 1987. Radiocarbon Age Anomalies in Shell Carbonate of Land Snails from Semi-Arid Areas. *Radiocarbon* 29 (2): 159–167.

Goodfriend, G. A. and Stipp, J. J. 1983. Limestone and the Problem of Radiocarbon Dating of Land-Snail Shell Carbonate. *Geology* 11 (10): 575–577.

Goodman, A. H. and Armelagos, G. J. 1989. Infant and Childhood Morbidity and Mortality Risks in Archaeological Populations. *World Archaeology* 21 (2): 225–243.

Gopher, A. and Orrelle, E. 1995. *The Ground Stone Assemblages of Munhata: A Neolithic Site in the Jordan Valley, Israel: A Report*. Les Cahiers Des Missions Archaeologiques Francaises En Israel Paris, Association Paléorient.

Goren, Y., Mommsen, H. and Klinger, J. 2011. Non-Destructive Provenance Study of Cuneiform Tablets Using Portable X-Ray Fluorescence (pXRF). *Journal of Archaeological Science* 38 (3): 684–696.

Goring-Morris, A. N. and Belfer-Cohen, A. 2011. Neolithization Processes in the Levant – the Outer Envelope. *Current Anthropology* 52 (Supplement 4): S195–S208.

Goring-Morris, A. N. and Horwitz, L. K. 2007. Funerals and Feasts During the Pre-Pottery Neolithic B of the Near East. *Antiquity* 81 (314): 902–919.

Goring-Morris, N. and Belfer-Cohen, A. 2010. Great Expectations, or the Inevitable Collapse of the Early Neolithic in the Near East, in M. S. Bandy and J. R. Fox (eds). *Becoming Villagers: Comparing Early Village Societies*. Tucson, University of Arizona Press: 62–77.

Gosden, C. 2001. Making Sense: Archaeology and Aesthetics. *World Archaeology* 33 (2): 163–167.

Gosden, C. and Marshall, Y. 1999. The Cultural Biography of Objects. *World Archaeology* 31 (2): 169–178.

Gould, R. A. 1978. Beyond Analogy in Ethnoarchaeology, in R. A. Gould (ed.) *Explorations in Ethnoarchaeology*. Albuquerque, University of New Mexico Press: 249–321.

Gould, R. A. 1987. The Ethnoarchaeology of Abandonment in a Northern Finnish Farming Community. *Nordia* 21: 133–142.

Greene, M. 2018. Socio-Technical Transitions and Dynamics in Everyday Consumption Practice. *Global Environmental Change* 52: 1–9.

Gregg, M. W., Brettell, R. and Stern, B. 2007. Bitumen in

Neolithic Iran: Biomolecular and Isotopic Evidence, in M. Glascock, R. J. Speakman and R. S. Popelka-Filcoff (eds). *Archaeological Chemistry: Analytical Techniques and Archaeological Interpretation*. Washington DC, American Chemical Society: 137–141.

Griffiths, H. I., Schwalb, A. and Stevens, L. R. 2001. Environmental Change in Southwestern Iran: The Holocene Ostracod Fauna of Lake Mirabad. *The Holocene* 11 (6): 757–764.

Grigson, C. 2007. Culture, Ecology, and Pigs from the 5th to the 3rd Millennium BC around the Fertile Crescent, in U. Albarella, K. Dobney, A. Ervynck and P. Rowley-Conwy (eds). *Pigs and Humans: 10,000 Years of Interaction*. Oxford, Oxford University Press: 83–108.

Gur-Arieh, S., Mintz, E., Boaretto, E. and Shahack-Gross, R. 2013. An Ethnoarchaeological Study of Cooking Installations in Rural Uzbekistan: Development of a New Method for Identification of Fuel Sources. *Journal of Archaeological Science* 40 (12): 4331–4347.

Haas, N. and Nathan, H. 1973. An Attempt at a Social Interpretation of the Chalcolithic Burials in the Nahal Mishmar Caves, in Y. Aharoni (ed.) *Excavations and Studies: Essays in Honour of Professor Shemuel Yeivin*. Tel Aviv, Tel Aviv University, Institute of Archaeology: xvii–xviii [English summary]; 143–143 [in Hebrew].

Habu, J., Fawcett, C. and Matsunaga, J. M. 2007. *Evaluating Multiple Narratives: Beyond Nationalist, Colonialist, Imperialist Archaeologies*. New York, Springer Science & Business Media.

Hadi, A., Kameran, D. and Ismael, S. 2013. Characteristics of the Amphibolite Rocks of Penjween Area, Kurdistan Region, Northeast Iraq: Genetic Implication and Association with Penjween Ophiolite Complexes. *Journal of Environment and Earth Science* 3 (14): 22–44.

Halcrow, S. E., Harris, N. J., Tayles, N., Ikehara-Quebral, R. and Pietrusewsky, M. 2013. From the Mouths of Babes: Dental Caries in Infants and Children and the Intensification of Agriculture in Mainland Southeast Asia. *American Journal of Physical Anthropology* 150 (3): 409–420.

Hall, E. T. 1966. *The Hidden Dimension*. Garden City NY, Doubleday.

Halperin, C. T. 2017. Anthropological Archaeology in 2016: Cooperation and Collaborations in Archaeological Research and Practice. *American Anthropologist* 119 (2): 284–297.

Halstead, P. and Tierney, J. 1998. Leafy Hay: An Ethnoarchaeological Study in NW Greece. *Environmental Archaeology* 1: 71–80.

Halstead, P., Hodder, I. and Jones, G. 1978. Behavioural Archaeology and Refuse Patterns: A Case Study. *Norwegian Archaeological Review* 11 (2): 118–131.

Halstead, P., Collins, P. and Isaakidou, V. 2002. Sorting the Sheep from the Goats: Morphological Distinctions between the Mandibles and Mandibular Teeth of Adult *Ovis* and *Capra*. *Journal of Archaeological Science* 29 (5): 545–43.

Hamilakis, Y. and Anagnostopoulos, A. 2009. What Is Archaeological Ethnography? *Public archaeology* 8 (2–3): 65–87.

Hammer, E. 2014. Local Landscape Organization of Mobile Pastoralists in Southeastern Turkey. *Journal of Anthropological Archaeology* 35: 269–288.

Hamon, C. 2008a. The Symbolic Value of Grindingstones Hoards: Technical Properties of Neolithic Examples, in C. Hamon and B. Quilliec (eds). *Hoards from the Neolithic to the Metal Ages.* Oxford, British Archaeological Reports S1758: 19–28.

Hamon, C. 2008b. Functional Analysis of Stone Grinding and Polishing Tools from the Earliest Neolithic of North-Western Europe. *Journal of Archaeological Science* 35 (6): 1502–1520.

Hardy, K., Blakeney, T., Copeland, L., Kirkham, J., Wrangham, R. and Collins, M. 2009. Starch Granules, Dental Calculus and New Perspectives on Ancient Diet. *Journal of Archaeological Science* 36 (2): 248–245.

Hardy-Smith, T. and Edwards, P. C. 2004. The Garbage Crisis in History: Artefact Discard Patterns at the Early Natufian Site of Wadi Hammeh 27 and the Origins of Household Refuse Disposal Strategies. *Journal of Anthropological Archaeology* 23: 253–289.

Harper, K. N. and Armelagos, G. J. 2013. Genomics, the Origins of Agriculture, and Our Changing Microbe-Scape: Time to Revisit Some Old Tales and Tell Some New Ones. *American Journal of Physical Anthropology* 57: 135–152.

Harrault, L., Milek, K., Jardé, E., Jeanneau, L., Derrien, M. and Anderson, D. G. 2019. Faecal Biomarkers Can Distinguish Specific Mammalian Species in Modern and Past Environments. *PloS one* 14 (2): e0211119.

Harris, D. R. (ed.) 1996. *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Washington DC, Smithsonian Institution Press.

Harris, O. and Cipolla, C. 2017. *Archaeological Theory in the New Millennium.* London, Routledge.

Harris, S. A. 1961. On the Land Snails of Iraq and Their Potential Use in Determining Past Climatic Conditions. *Sumer* 17: 107–113.

Harris, S. A. 1978. Vertical Zonation of Land Snails in the Iraqi Slopes of the Persian Mountains and in the Rocky Mountains of Alberta, Canada. *Arctic and Alpine Research* 10 (2): 457–463.

Harrison, D. L. and Bates, P. J. 1964. *The Mammals of Arabia*. London, Benn.

Hart, T. C. 2011. Evaluating the Usefulness of Phytoliths and Starch Grains Found on Survey Artifacts. *Journal of Archaeological Science* 38 (12): 3244–3243.

Harvey, E., L and Fuller, D. Q. 2005. Investigating Crop Processing Using Phytolith Analysis: The Example of Rice and Millets. *Journal of Archaeological Science* 32: 739–742.

Hashemi, N., Darvish, J., Mashkour, M. and Biglari, F. 2006. Rodents and Lagomorphs Remains from Late Pleistocene and Early Holocene Caves and Rockshelter Sites in the Zagros Region, Iran. *Iranian Journal of Animal Biosystematics* 2 (1): 253–289.

Hassett, B. R. 2012. Evaluating Sources of Variation in the Identification of Linear Hypoplastic Defects of Enamel: A New Quantified Method. *Journal of Archaeological Science* 39 (2): 560–565.

Hastorf, C. A. 1998. The Cultural Life of Early Domestic Plant Use. *Antiquity* 72: 773–782.

Hastorf, C. A. (ed.) 2001. *Past Ritual and the Everyday*. Berkeley, University of California Kroeber Anthropological Society Papers 85.

Hastorf, C. A. I. 2005. Macrobotanical Investigation: Field Methods and Laboratory Analysis Procedures, in I. Hodder (ed.) *Inhabiting Catalhoyuk: Reports from the*

1995–99 Seasons. Cambridge, McDonald Institute for Archaeological Research and Institute of Archaeology at Ankara: 129–136.

Hastorf, C. A. 2016. *The Social Archaeology of Food: Thinking About Eating from Prehistory to the Present*. Cambridge, Cambridge University Press.

Hatt, R. T. 1959. *The Mammals of Iraq*. Ann Arbor, University of Michigan Press.

Hayden, B. 1979. *Palaeolithic Reflections: Lithic Technology and Ethnographic Excavation among Australian Aborigines*. Canberra, Australian Institute of Aboriginal Studies Canberra.

Hayden, B. 1987a. Traditional Metate Manufacturing in Guatemala Using Chipped Stone Tools, in B. Hayden (ed.) *Lithic Studies Among the Contemporary Highland Maya*. Tucson, University of Arizona Press: 8–119.

Hayden, B. (ed.) 1987b. *Lithic Studies Among the Contemporary Highland Maya*. Tucson, University of Arizona Press.

Hayden, B. 1990. Nimrods, Piscators, Pluckers, and Planters: The Emergence of Food Production. *Journal of Anthropological Archaeology* 9: 31–69.

Hayden, B. 2009. The Proof Is in the Pudding: Feasting and the Origins of Domestication. *Current Anthropology* 50 (5): 597–601.

Hayden, B. 2011. Feasting and Social Dynamics in the Epipaleolithic of the Fertile Crescent, in G. Aranda Jiménez, S. Montón-Subías and M. Sánchez Romero (eds). *Guess Who's Coming to Dinner? Feasting Rituals in the Prehistoric Societies of Europe and the Near East*. Oxford, Oxbow Books: 30–63.

Hayden, B. 2017. Are Burials Socially Integrative? The Natufian Case. *Current Anthropology* 58 (3): 410–411.

Hayden, B. and Cannon, A. 1983. Where the Garbage Goes: Refuse Disposal in the Maya Highlands. *Journal of Anthropological Archaeology* 2: 117–163.

Healey, E. 1988. *Lustred Flint Blades in the Epipalaeolithic and Neolithic of the Near East*, University of Durham. M. Phil. thesis.

Healey, E. 2014. Interpreting Obsidian Use in the Near East: A Personal Perspective. *IAOS Bulletin* 51: 7–30.

Helbaek, H. 1969. Plant Collecting, Dry-Farming, and Irrigation Agriculture in Prehistoric Deh Luran, in F. Hole, K. V. Flannery and J. A. Neely (eds). *Prehistory and Human Ecology of the Deh Luran Plain: An Early Village Sequence from Khuzistan, Iran*. Ann Arbor, University of Michigan Press: 383–426.

Helbaek, H. 1972. Samarran Irrigation Agriculture at Choga Mami in Iraq. *Iraq* 34: 35–48.

Helwing, B. 2014. East of Eden? A Review of Turkey's Eastern Neighbors in the Neolithic, in M. Özdogan, P. I. Kuniholm and M. N. Basgelen (eds). *The Neolithic in Turkey Vol. 6. 10500–4200bc: Environment Settlement, Flora, Fauna, Dating, Symbols of Belief, with Views from North, South, East, and West*. Istanbul, Archaeology and Art Publications Istanbul: 321–377.

Hemami, M. R. and Groves, C. P. 2001. Iran, in D. P. Mallon and S. C. Kingswood (eds). *Antelopes. Part IV: North Africa, the Middle East, and Asia*. Gland & Cambridge, IUCN: 114–118.

Henry, A. G., Büdel, T. and Bazin, P.-L. 2018. Towards an Understanding of the Costs of Fire. *Quaternary International* 493: 96–105.

Heptner, V., Nasimovich, A., Bannikov, A. and Hoffman, R. 1961. *Mammals of the Soviet Union, Volume 1: Artiodactyla and Perissodactyla (English Translation)*. Smithsonian Institution, Washington DC, Smithsonian Institution

Hershkovitz, I., Donoghue, H. D., Minnikin, D. E., Besra, G. S., Lee, O. Y., Gernaey, A. M., Galili, E., Eshed, V., Greenblatt, C. L. and Lemma, E. 2008. Detection and Molecular Characterization of 9000-Year-Old Mycobacterium Tuberculosis from a Neolithic Settlement in the Eastern Mediterranean. *PloS one* 3 (10): e3426.

Hershkovitz, I., Greenwald, C. M., Latimer, B., Jellema, L. M., Wish-Baratz, S., Eshed, V., Dutour, O. and Rothschild, B. M. 2002. Serpens Endocrania Symmetrica (Ses): A New Term and a Possible Clue for Identifying Intrathoracic Disease in Skeletal Populations. *American Journal of Physical Anthropology* 118 (3): 201–216.

Hesse, B. 1978. *Evidence for Husbandry from the Early Neolithic Sites of Ganj Dareh in Western Iran*. PhD thesis, Columbia University.

Hesse, B. 1979. Rodent Remains and Sedentism in the Neolithic: Evidence from Tepe Ganj Dareh, Western Iran. *Journal of Mammalogy* 60 (4): 856–847.

Hesse, B. 1984. *These Are Our Goats: The Origins of Herding in West Central Iran*. Oxford, British Archaeological Reports S202

Heun, M., Abbo, S., Lev-Yadun, S. and Gopher, A. 2012. A Critical Review of the Protracted Domestication Model for Near-Eastern Founder Crops: Linear Regression, Long-Distance Gene Flow, Archaeological, and Archaeobotanical Evidence. *Journal of Experimental Botany* 63 (12): 4333–4341.

Heydari-Guran, S. 2014. *Paleolithic Landscapes of Iran.* Oxford, British Archaeological Reports S2586.

Heydari-Guran, S. 2015. Tracking Upper Pleistocene Human Dispersals into the Iranian Plateau: A Geoarchaeological Model, in N. Sanz (ed.) *Human Origin Sites and the World Heritage Convention in Eurasia*. Paris, UNESCO HEADS 4, Volume 1: 40–43.

Heydari-Guran, S. and Ghasidian, E. 2020. Late Pleistocene Hominin Settlement Patterns and Population Dynamics in the Zagros Mountains: Kermanshah Region. *Archaeological Research in Asia* 21: 100161

Hildebrand, E. 1996. Changes in Methods and Techniques of Blade Production During the Epipalaeolithic and Early Neolithic in the Eastern Fertile Crescent, in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 193–206.

Hillman, G. C. and Davies, M. S. 1990. Domestication Rates in Wild-Type Wheats and Barley under Primitive Cultivation. *Biological Journal of the Linnean Society* 39 (1): 39–78.

Hillman, G. C., Legge, A. and Rowley-Conwy, P. 1997. On the Charred Seeds from Epipalaeolithic Abu Hureyra: Food or Fuel?. *Current Anthropology* 38 (4): 651–645.

Hillman, G. C., Hedges, R., Moore, A., Colledge, S. and Pettitt, P. 2001. New Evidence of Lateglacial Cereal Cultivation at Abu Hureyra on the Euphrates. *The Holocene* 11 (4): 383–393.

Hillson, S. 1996. *Dental Anthropology*. Cambridge, Cambridge University Press.

Hillson, S. 2005. *Teeth*. Cambridge, Cambridge University Press.

Hillson, S. 2014. *Tooth Development in Human Evolution and Bioarchaeology*. Cambridge, Cambridge University Press.

Hillson, S. W., Larsen, C. S., Boz, B., Pilloud, M. A., Sadvari, J. W., Agarwal, S. C., Glencross, B., Beauchesne, P., Pearson, J. and Ruff, C. B. 2013. The Human Remains I: Interpreting Community Structure, Health and Diet in Neolithic Catalhöyük, in I. Hodder (ed.) *Humans and Landscapes of Çatalhöyük: Reports from the 2000–2008 Seasons*. London, British Institute at Ankara: 339–396.

Hinton, M. A. 1926. *Monograph of the Voles and Lemmings (Microtinae) Living and Extinct*. London, British Museum (Natural History).

Hodder, I. 1990. *The Domestication of Europe: Structure and Contingency in Neolithic Societies*. Oxford, Blackwell.

Hodder, I. 1999. *The Archaeological Process: An Introduction*. Oxford, Blackwell.

Hodder, I. (ed.) 2000. *Towards Reflexive Method in Archaeology: The Example at Çatalhöyük*. Cambridge, McDonald Institute for Archaeological Research.

Hodder, I. (ed.) 2005a. *Changing Materialities at Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research, British Institute at Ankara.

Hodder, I. (ed.) 2005b. *Catalhöyük Perspectives: Reports from the 1995–99 Seasons*. Cambridge McDonald Institute for Archaeological Research and British Institute at Ankara.

Hodder, I. 2011. Human-Thing Entanglement: Towards an Integrated Archaeological Perspective. *Journal of the Royal Anthropological Institute* 17 (1): 154–177.

Hodder, I. 2012. *Entangled: An Archaeology of the Relationships between Humans and Things*. New York, Wiley-Blackwell.

Hodder, I. 2013. Human-Thing Evolution: The Selection and Persistence of Traits at Çatalhöyük, in S. Bergerbrant and S. Sabatini (eds). *Counterpoint: Essays in Archaeology and Heritage Studies in Honour of Professor Kristian Kristiansen*. Oxford, British Archaeological Reports S2508: 583–591.

Hodder, I. 2018a. Things and the Slow Neolithic: The Middle Eastern Transformation. *Journal of Archaeological Method and Theory* 25 (1): 155–177.

Hodder, I. (ed.) 2018b. *Religion, History, and Place in the Origin of Settled Life*. Louisville, University Press of Colorado.

Hodder, I. 2019. *Violence and the Sacred in the Ancient Near East: Girardian Conversations at Çatalhöyük*. Cambridge, Cambridge University Press.

Hodder, I. and Cessford, C. 2004. Daily Practice and Social Memory at Çatalhöyük. *American Antiquity* 69: 17–40.

Hodder, I. and Pels, P. 2010. History Houses: A New Interpretation of Elaboration at Çatalhöyük, in I. Hodder (ed.) *Religion and the Emergence of Civilization: Çatalhöyük as a Case Study*. Cambridge, Cambridge University Press: 163–186.

Hodson, M.J., Vrydaghs, L. and Devos, Y. 2020. Do phytoliths become auto-fluorescent upon heating? In R. Banerjea, C. Barnett, P. Flintoft, L. Morandi, M. Portillo, K. Williams and D. Young (eds). *Integrated Microscopy Approaches in Archaeobotany 2020 Abstracts*. School of Archaeology Geography and Environmental Science, University of Reading. Online: https://blogs.reading.ac.uk/integrated-microscopy-approaches-in-archaeobotany/imaa-2020/imaa-2020-abstracts/.

Hodgson, J. 1974. *Soil Survey Field Handbook*. Harpenden, Bartholomew Press.

Hole, F. 1977. *Studies in the Archeological History of the Deh Luran Plain: The Excavation of Chagha Sefid*. Ann Arbor, Memoirs of the Museum of Anthropology, University of Michigan 9.

Hole, F. 1978. Pastoral Nomadism in Western Iran, in R. A. Gould (ed.) *Explorations in Ethnoarchaeology*. Albuquerque, University of New Mexico Press: 127–167.

Hole, F. 1983. The Jarmo Chipped Stone, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 233–284.

Hole, F. 1987. Archaeology of the Village Period, in F. Hole (ed.). *The Archaeology of Western Iran*. Washington DC, Smithsonian Institution Press: 29–78.

Hole, F. 1994. Interregional Aspects of the Khuzestan Aceramic – Early Pottery Neolithic Sequence, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 101–116.

Hole, F. 1996a. A Syrian Bridge between the Levant and the Zagros? in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 5–14.

Hole, F. 1996b. The Context of Caprine Domestication in the Zagros Region, in D. R. Harris (ed.) *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Washington DC, Smithsonian Institution Press: 263–281.

Hole, F. 2007. Agricultural Sustainability in the Semi-Arid Near East. *Climate of the Past* 3 (2): 193–203.

Hole, F., Flannery, K. V. and Neely, J. A. (eds). 1969. *Prehistory and Human Ecology of the Deh Luran Plain: An Early Village Sequence from Khuzistan, Iran*. Ann Arbor, University of Michigan Press.

Holliday, V. T. and Gartner, W. G. 2007. Methods of Soil P Analysis in Archaeology. *Journal of Archaeological Science* 34: 301–333.

Hongo, H., Pearson, J., Öksüz, B. and Ilgezdi, G. 2009. The Process of Ungulate Domestication at Cayönü, Southeastern Turkey: A Multidisciplinary Approach Focusing on *Bos* Sp. and *Cervus Elaphus*. *Anthropozoologica* 44 (1): 63–79.

Hosfield, R. 2016. Walking in a Winter Wonderland? Strategies for Early and Middle Pleistocene Survival in Midlatitude Europe. *Current Anthropology* 57 (5): 653–682.

Houben, H. and Guillaud, H. 1989. *Earth Construction: A Comprehensive Guide*. Chippenham, Intermediate Technology Development Group.

Howe, B. 1983. Karim Shahir, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 23–154.

Howe, B. 2014. *Barda Balka. Oriental Institute Communications*

31. Chicago, Oriental Institute of the University of Chicago.

Huang, L. K., Lin, C. M., Chen, C. J. and Hu, C. J. 2017. Diagnosis of Chronic Leptomeningitis by Using Meningeal Biopsy: A Case Report of Tuberculous Meningitis. *Acta Neurologica Taiwanica* 26 (3): 133–137.

Hubbard, A., Guatelli-Steinberg, D. and Sciulli, P. W. 2009. Under Restrictive Conditions, Can the Widths of Linear Enamel Hypoplasias Be Used as Relative Indicators of Stress Episode Duration? *American Journal of Physical Anthropology* 138 (2): 177–189.

Hubbard, R. N. L. B. 1990. The Carbonised Seeds from Tepe Abdul Hosein: Results of Preliminary Analyses, in J. Pullar (ed.) *Tepe Abdul Hosein: A Neolithic Site in Western Iran. Excavations 1978*. Oxford, British Archaeological Reports S563: 217–222.

Huigens, H. O., van Exel, V., Flohr, P., Kelder, J. M., Koek, E. and Rooijackers, T. 2014. The Ground Stone Industry, in P. M. M. G. Akkermans, O. Nieuwenhuyse, H. Huigens and M. Brüning (eds). *Excavations at Late Neolithic Tell Sabi Abyad, Syria*. Turnhout, Brepols: 135–163.

Huisman, D. J., Braadbaart, F., van Wijk, I. M. and van Os, B. J. H. 2012. Ashes to Ashes, Charcoal to Dust: Micromorphological Evidence for Ash-Induced Disintegration of Charcoal in Early Neolithic (LBK) Soil Features in Elsloo (the Netherlands). *Journal of Archaeological Science* 39 (4): 994–1004.

Huisman, H., Ismail-Meyer, K., Sageidet, B. M. and Joosten, I. 2017. Micromorphological Indicators for Degradation Processes in Archaeological Bone from Temperate European Wetland Sites. *Journal of Archaeological Science* 85: 13–29.

Humphrey, L. T., De Groote, I., Morales, J., Barton, N., Collcutt, S., Ramsey, C. B. and Bouzouggar, A. 2014. Earliest Evidence for Caries and Exploitation of Starchy Plant Foods in Pleistocene Hunter-Gatherers from Morocco. *Proceedings of the National Academy of Sciences* 111 (3): 954–949.

Hunt, C. O., Reynolds, T. G., El-Rishi, H. A., Buzaian, A., Hill, E. and Barker, G. W. 2011. Resource Pressure and Environmental Change on the North African Littoral: Epipalaeolithic to Roman Gastropods from Cyrenaica, Libya. *Quaternary International* 244 (1): 15–26.

Hutterer, R., Linstädter, J., Eiwanger, J. and Mikdad, A. 2014. Human Manipulation of Terrestrial Gastropods in Neolithic Culture Groups of NE Morocco. *Quaternary International* 320: 83–91.

Ibáñez, J. J., González-Urquijo, J., Teira-Mayolini, L. C. and Lazuén, T. 2018. The Emergence of the Neolithic in the Near East: A Protracted and Multi-Regional Model. *Quaternary International* 470: 226–242.

Ibáñez, J. J., Ortega, D., Campos, D., Khalidi, L. and Méndez, V. 2015. Testing Complex Networks of Interaction at the Onset of the Near Eastern Neolithic Using Modelling of Obsidian Exchange. *Journal of The Royal Society Interface* 12 (107): 2015.0210.

Ingold, T. 1993. The Temporality of the Landscape. *World Archaeology* 25 (2): 152–174.

Inizan, M.-L. 1985. Des Indices Acheuléens sur les Bords du Tigre dans le Nord de l'Iraq. *Paléorient* 11 (1): 101–102.

Inizan, M.-L. and Lechevallier, M. 1994. L'Adoption du Débitage Laminaire par Pression au Proche-Orient, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar Für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence and Environment: 23–32.

Inizan, M.-L. and Tixier, J. 2000. L'Émergence des Arts du Feu: le Traitement Thermique des Roches Siliceuses. *Paléorient* 26 (2): 23–36.

Inokuchi, S. and Usami, N. 1997. Stress Fractures of the Proximal Phalanx of the Great Toe. *The Foot* 7 (2): 101–104.

Iraq Directorate General of Antiquities 1970. *Archaeological Sites in Iraq*. Baghdad, Iraq Directorate General of Antiquities.

Isendahl, C. and Stump, D. (eds.) 2019. *The Oxford Handbook of Historical Ecology and Applied Archaeology*. Oxford, Oxford University Press.

Ismail-Meyer, K. 2017. Plant Remains, in C. Nicosia and G. Stoops (eds). *Archaeological Soil and Sediment Micromorphology*. Oxford: Wiley Blackwell, 121–135.

IUCN 2017. *The IUCN Red List of Threatened Species. Version 2017–3*. International Union for the Conservation of Nature and Natural Resources. Online https://www.iucnredlist.org/

Iversen, I. 2015a. *Living in an Early Neolithic Community. Investigation of Social Structure of Settlement by Microartefactual Analysis of Spatial Organisation of Activities at Bestansur, Central Zagros and Boncuklu, Central Anatolia*. Unpublished PhD thesis, University of Reading.

Iversen, I. 2015b. The Molluscs of Bestansur, Iraqi Kurdistan: A Case Study of Early Holocene Helix Salomonica Exploitation in the Zagros. *Environmental Archaeology* 20 (3): 239–240.

Jackson, R. C., Dugmore, A. J. and Riede, F. 2018. Rediscovering Lessons of Adaptation from the Past. *Global Environmental Change* 52: 58–65.

Jacomet, S. 2006. *Identification of Cereal Remains from Archaeological Sites. Second Edition*. Basel, Basel University.

Jacomet, S. 2016. Archaeobotany: Analyses of Plant Remains from Waterlogged Archaeological Sites, in F. Menotti and A. O. Sullivan (eds). *The Oxford Handbook of Wetland Archaeology*. Oxford, Oxford University Press: 497–514.

James, S. R. 1997. Methodological Issues Concerning Screen Size Recovery Rates and Their Effects on Archaeofaunal Interpretations. *Journal of Archaeological Science* 24 (5): 385–397.

Jameson, J. H. 1997. *Presenting Archaeology to the Public: Digging for Truths*. London Alta Mira Press.

Jameson, J. H. and Baugher, S. 2007. *Past Meets Present: Archaeologists Partnering with Museum Curators, Teachers, and Community Groups*. New York, Springer Science & Business Media.

Janaway, R. C. 1996. The Decay of Buried Human Remains and Their Associated Materials, in J. Hunter, C. N. Roberts and A. Martin (eds). *Studies in Crime: An Introduction to Forensic Archaeology*. Abingdon, Routledge: 58–87.

Janovic, A., Milovanovic, P., Sopta, J., Rakocevic, Z., Filipovic, V., Nenezic, D. and Djuric, M. 2015. Intracranial Arteriovenous Malformations as a Possible Cause of Endocranial Bone Lesions and Associated Neurological Disorder. *International Journal of Osteoarchaeology* 25 (1): 88–97.

Janssen, M. A. and Hill, K. 2016. An Agent-Based Model of Resource Distribution on Hunter-Gatherer Foraging

Strategies: Clumped Habitats Favor Lower Mobility, but Result in Higher Foraging Returns, in J. A. Barceló and F. del Castillo (eds). *Simulating Prehistoric and Ancient Worlds*. Dordrecht, Springer: 159–174.

Jassim, S. J. and Goff, J. C. (eds). 2006. *Geology of Iraq*. Prague & Brno, Dolin & Moravian Museum.

Jassim, S. Z., Buda, G., Neuzilova, M. and Suk, M. 1982. Metamorphic Development of the Iraqi Zagros Ophiolite Zone. *Krystalinikum* 16: 21.

Jassim, S. Z., Suk, M. and Walhausrova, J. 2006. Magmatism and Metamorphism in the Zagros Suture, in S. J. Jassim and J. C. Goff (eds). *Geology of Iraq*. Prague 668 Bibliography & Brno, Dolin & Moravian Museum: 212–231.

Jayez, M., Mirzai, K. M. and Niknami, K. A. 2019. Introduction of Late Pleistocene Cultural Material of an Intermediate Region: Paleolithic Sites of Pion and Izeh Plain between Central and Southern Zagros, Southwest Iran. *Quaternary International* 512: 52–66.

Jenkins, E. 2012. Mice, Scats and Burials: Unusual Concentrations of Microfauna Found in Human Burials at the Neolithic Site of Çatalhöyük, Central Anatolia. *Journal of Social Archaeology* 12 (3): 380–403.

Jenkins, E., Baker, A. and Elliott, S. 2011. Past Plant Use in Jordan as Revealed by Archaeological and Ethnoarchaeological Phytolith Signatures, in S. Mithen and E. Black (eds). *Water, Life and Civilisation: Climate, Environment and Society in the Jordan Valley*. Cambridge, Cambridge University Press: 381–400.

Jenkins, E. L. 2005. Çatalhöyük Microfauna: Preliminary Results and Interpretations, in I. Hodder (ed.) *Inhabiting Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research and British Institute at Ankara: 111–116.

Jenkins, E. L. 2009. *Unwanted Inhabitants? The Microfauna from Çatalhöyük and Pınarbası*. Saarbrücken, VDM-Verlag.

Jenkins, E. L., Allcock, S., Elliott, S., Palmer, C. and Grattan, J. 2017. Ethno-Geochemical and Phytolith Studies of Activity Related Patterns: A Case Study from Al Ma'tan, Jordan. *Archaeological and Anthropological Sciences* 22 (4): 412–433.

Jenkins, R. 2004. *Social Identity*. London, Routledge.

Jin, J. J. and Mills, E. W. 2011. Split Phalanges from Archaeological Sites: Evidence of Nutritional Stress? *Journal of Archaeological Science* 38 (8): 1798–1809.

Johnsen, S. J., Dahl-Jensen, D., Gundestrup, N., Steffensen, J. P., Clausen, H. B., Miller, H., Masson-Delmotte, V., Sveinbjörnsdottir, A. E. and White, J. 2001. Oxygen Isotope and Palaeotemperature Records from Six Greenland Ice-Core Stations: Camp Century, Dye-3, Grip, Gisp2, Renland and Northgrip. *Journal of Quaternary Science* 16 (4): 299–307.

Johnson, E. V., Timpson, A., Thomas, M. G. and Outram, A. K. 2018. Reduced Intensity of Bone Fat Exploitation Correlates with Increased Potential Access to Dairy Fats in Early Neolithic Europe. *Journal of Archaeological Science* 94: 60–69.

Johnson, J. S., Lione, B. M., Norris, D. H., Price, L. O., Salih, S., Shemdin, G. and Drayman-Weisser, T. 2014. Collaboration, Sustainability, and Reconciliation: Teaching Cultural Heritage Preservation and Management in Iraq, in J. Bridgeland (ed.) *Icom-Cc 17th Triennial Conference Preprints, Melbourne, 15–19 September 2014*. Paris, International Council of Museums: 1–8.

Johnson, K. M. and Paul, K. S. 2016. Bioarchaeology and Kinship: Integrating Theory, Social Relatedness, and Biology in Ancient Family Research. *Journal of Archaeological Research* 24 (1): 75–123.

Jones, G. 1991. Numerical Analysis in Archaeobotany, in K. Wasylikowa, K.-E. Behre, v. W. Zeist, K. Wasylikowa and K.-E. Behre (eds). *Progress in Old World Palaeoethnobotany*. Rotterdam: 63–80.

Jones, M. D. 2013. Key Questions Regarding the Paleoenvironment of Iran, in D. T. Potts (ed.) *The Oxford Handbook of Ancient Iran*. Oxford, Oxford University Press 1–17.

Jones, M. D. and Roberts, C. N. 2008. Interpreting Lake Isotope Records of Holocene Environmental Change in the Eastern Mediterranean. *Quaternary International* 181 (1): 32–38.

Jones, M. D., Maher, L. A., McDonald, D. A., Ryan, C., Rambeau, C., Black, S. and Richter, T. 2016a. The Environmental Setting of Epipalaeolithic Aggregation Site Kharaneh IV. *Quaternary International* 396: 95–104.

Jones, M. D., Maher, L. A., Richter, T., Macdonald, D. and Martin, L. 2016b. Human-Environment Interactions through the Epipalaeolithic of Eastern Jordan, in D. A. Contreras (ed.) *Archaeology of Human-Environment Interactions: Strategies for Investigating Anthropogenic Landscapes, Dynamic Environments, and Climate Change in the Human Past*. New York, Routledge: 121–40.

Jones, M. D., Abu-Jaber, N., AlShdaifat, A., Baird, D., Cook, B. I., Cuthbert, M. O., Dean, J. R., Djamali, M., Eastwood, W., Fleitmann, D., Haywood, A., Kwiecien, O., Larsen, J., Maher, L. A., Metcalfe, S. E., Parker, A., Petrie, C. A., Primmer, N., Richter, T., Roberts, N., Roe, J., Tindall, J. C., Ünal-İmer, E. and Weeks, L. 2019. 20,000 Years of Societal Vulnerability and Adaptation to Climate Change in Southwest Asia. *Wiley Interdisciplinary Reviews: Water* 6 (2): e1330-e30.

Jones, R. (ed.) 2012. *Manure Matters: Historical, Archaeological and Ethnographic Perspectives*. Farnham, Ashgate.

Jones, R., Challands, A., French, C., Card, N., Downes, J. and Richards, C. 2010. Exploring the Location and Function of a Late Neolithic House at Crossiecrown, Orkney by Geophysical, Geochemical and Soil Micromorphological Methods. *Archaeological Prospection* 17 (1): 29–47.

Joy, J. 2009. Reinvigorating Object Biography: Reproducing the Drama of Object Lives. *World Archaeology* 41 (4): 540–546.

Joyce, A. A. and Johannessen, S. 1993. Abandonment and the Production of Archaeological Variability at Domestic Sites, in C. M. Cameron and S. A. Tomka (eds). *Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. New Directions in Archaeology*. Cambridge, Cambridge University Press: 138–143.

Juel Jensen, H. 1994. *Flint Tools and Plant Working: Hidden Traces of Stone Age Technology. A Use Wear Study of Some Danish Mesolithic and Trb Implements*. Åarhus, Åarhus University Press.

Junod, C. A. and Pokines, J. T. 2014. Subaerial Weathering, in J. T. Pokines and S. A. Symes (eds). *Manual of Forensic Taphonomy*. Boca Raton, CRC Press: 302–329.

Jurmain, R. 2013. *Stories from the Skeleton: Behavioral Reconstruction in Human Osteology*. London, Routledge.

Kaiser, D., Durant, J., Levenson, T., Linett, P. and Wiehe, B. 2014. *The Evolving Culture of Science Engagement:*

An Exploratory Initiative of the Massachusetts Institute of Technology and Culture Kettle, Report Findings: September 2013 Workshop. Cambridge MA, Massachusetts Institute of Technology and Culture Kettle.

Kamińska-Szymczak, J. 2002. Cutting Graminae Tools and Sickle Gloss Formation. *Lithic Technology* 27 (2): 111–141.

Kanjou, Y., Kuijt, I., Erdal, Y. S. and Kondo, O. 2015. Early Human Decapitation, 11,700–10,700 Cal bp, within the Pre-Pottery Neolithic Village of Tell Qaramel, North Syria. *International Journal of Osteoarchaeology* 25 (5): 743–742.

Karamii, M., Hutterer, R., Benda, P., Siahsarvie, R. and Kryštufek, B. 2008. Annotated Check-List of the Mammals of Iran. *Lynx, Series Nova* 39 (1): 63–102.

Karim, K. H. 2004. Origin of Structures and Textures of Some Kurdistan Marbles as Inferred from Sedimentary Ancestor Structures, NE-Iraq. *Journal of Zankoy Sulaimani* 7 (1 PART A): 69–86.

Karim, K. H. 2011. *Geology of Kurdistan*. Sulaimani, University of Sulaimani.

Karim, K. H. and Surdashy, A. M. 2005. Tectonic and Depositional History of Upper Cretaceous Tanjero Formation in Sulaimaniya Area, NE-Iraq. *Journal of Zankoy Sulaimani* 8 (1): 47–61.

Karim, K. H. and Taha, Z. A. 2009. Tectonical History of Arabian Platform During Late Cretaceous: An Example from Kurdistan Region, NE Iraq. *Iranian Journal of Earth Sciences* 1: 1–14.

Karim, K. H., Aziz, N. R. H. and Al-Bidary, M. A. 2015. Paragenesis and Geochronological Studies of Asnawa Iron Ore by the Isotope and Mineral Chemistry in Penjween Area, Zagros Suture Zone Kurdistan Region, NE Iraq. *Iranian Journal of Earth Sciences* 7 (2): 164–178.

Karkanas, P. and Van de Moortel, A. 2014. Micromorphological Analysis of Sediments at the Bronze Age Site of Mitrou, Central Greece: Patterns of Floor Construction and Maintenance. *Journal of Archaeological Science* 43: 198–213.

Kartal, M., Kartal, G., Coşkun, A., Carter, T., Şahin, F. and Özkaya, V. 2018. Chipped Stone Assemblages of Körtik Tepe (Turkey). *Journal of Archaeological Science: Reports* 19: 92–99.

Kasraian, N. and Arshi, Z. 1993. *Kurds of Iran* Tehran, Seke Press.

Katz, O., Cabanes, D., Weiner, S., Maeir, A. M., Boaretto, E. and Shahack-Gross, R. 2010. Rapid Phytolith Extraction for Analysis of Phytolith Concentrations and Assemblages During an Excavation: An Application at Tell Es-Safi/Gath, Israel. *Journal of Archaeological Science* 37 (7): 1557–1563.

Kealhofer, L., Torrence, R. and Fullagar, R. 1999. Integrating Phytoliths within Use-Wear/Residue Studies of Stone Tools. *Journal of Archaeological Science* 26 (5): 527–546.

Keeley, L. H. 1982. Hafting and Retooling: Effects on the Archaeological Record. *American Antiquity* 47 (4): 798–809.

Keller, J., Djerbashian, R., Karapetian, S., Pernicka, E. and Nasedkin, V. 1996. Armenian and Caucasian Obsidian Occurrences as Sources for the Neolithic Trade: Volcanological Setting and Chemical Characteristics, in S. Demirci, A. M. Özer and G. D. Summers (eds). *Archaeometry 94: The Proceedings of the 29th Symposium on Archaeometry, Ankara 9–14 May 1994* Ankara, Tübitak: 69–86.

Kempisty, A. 1990. Relics of Architecture, in S. K. Kozłowski (ed.) *Nemrik 9: Pre-Pottery Neolithic Site in Iraq*. Warszawa, Wydawnictwa Uniwersytetu Warszawskiego: 45–54.

Kendall, C., Eriksen, A. M. H., Kontopoulos, I., Collins, M. J. and Turner-Walker, G. 2018. Diagenesis of Archaeological Bone and Tooth. *Palaeogeography, Palaeoclimatology, Palaeoecology* 491: 21–37.

Kenyon, K. 1957. *Digging up Jericho*. London, Ernest Benn.

Khalaily, H. and Valla, F. R. 2013. Obsidian in Natufian Context: The Case of Eynan (Ain Mallaha), Israel, in O. Bar-Yosef and F. R. Valla (eds). *Natufian Foragers in the Levant: Terminal Pleistocene Social Changes in Western Asia*. Ann Arbor, International Monographs in Prehistory, Archaeological Series 19: 193–202.

Khalaily, H., Milevski, I., Getzov, N., Hershkovitz, I., Barzilai, O., Yarosevich, A., Shlomi, V., Najjar, A., Zidan, O. and Smithline, H. 2008. Recent Excavations at the Neolithic Site of Yiftah'el (Khalet Khalladyiah), Lower Galilee. *Neo-Lithics* 2 (8): 3–11.

Khazaee, M., Glascock, M. D., Masjedi, P., Nadoshan, F. K., Farsani, R. S., Delfan, M., Mansori, A., Sodaie, B. and Dolatyari, A. 2014. Sourcing the Obsidian of Prehistoric Tools Found in Western Iran to Southeastern Turkey: A Case Study for the Sites of Eastern Chia Sabz and Chogha Ahovan. *Anatolian Studies* 64: 23–31.

Khorassani, A. and Abedini, M. 1976. A New Study of Turquoise from Iran. *Mineralogical Magazine* 40 (314): 640–642.

Kim, S., Lee, M. and Seok, S. 2017. Intra-Articular Fracture of Proximal Phalanx of Great Toe Accompanied by Valgus Deformity Associated with Sports Activities. *Journal of Orthopaedic Surgery* 25 (1): 2309499017690324.

Kinaston, R. L., Buckley, H. R., Halcrow, S. E., Spriggs, M. J., Bedford, S., Neal, K. and Gray, A. 2009. Investigating Foetal and Perinatal Mortality in Prehistoric Skeletal Samples: A Case Study from a 3000-Year-Old Pacific Island Cemetery Site. *Journal of Archaeological Science* 36 (12): 2780–2787.

King, T., Humphrey, L. T. and Hillson, S. 2005. Linear Enamel Hypoplasias as Indicators of Systemic Physiological Stress: Evidence from Two Known Age-at-Death and Sex Populations from Postmedieval London. *American Journal of Physical Anthropology* 128 (3): 547–549.

Kintigh, K. W., Altschul, J. H., Beaudry, M. C., Drennan, R. D., Kinzig, A. P., Kohler, T. A., Limp, W. F., Maschner, H. D., Michener, W. K. and Pauketat, T. R. 2014. Grand Challenges for Archaeology. *American Antiquity* 79 (1): 5–24.

Kirkbride, D. 1966. Five Seasons at the Pre-Pottery Neolithic Village of Beidha in Jordan. *Palestine Exploration Quarterly* 98: 8–72.

Klaus, H. D. 2017. Paleopathological Rigor and Differential Diagnosis: Case Studies Involving Terminology, Description, and Diagnostic Frameworks for Scurvy in Skeletal Remains. *International Journal of Paleopathology* 19: 96–110.

Knappett, C. 2006. *Thinking through Material Culture: An Interdisciplinary Perspective*. Philadelphia, University of Philadephia Press.

Knüsel, C. 2005. The Physical Evidence of Warfare – Subtle Stigmata? in M. Parker Pearson and I. Thorpe (eds). *Warfare, Violence and Slavery in Prehistory. Proceedings of a Prehistoric Society Conference at Sheffield University*. Oxford, British Archaeological Reports S1374: 49–66.

Knüsel, C. J. 2014. Crouching in Fear: Terms of Engagement for Funerary Remains. *Journal of Social Archaeology* 14 (1): 26–48.

Knüsel, C. J. and Robb, J. 2016. Funerary Taphonomy: An Overview of Goals and Methods. *Journal of Archaeological Science: Reports* 10: 655–673.

Knüsel, C., Glencross, B. and Milella, M. 2019. A Girardian Framework for Violent Injuries at Neolithic Çatalhöyük in Their Western Asian Context, in I. Hodder (ed.) *Violence and the Sacred in the Ancient Near East: Girardian Conversations at Çatalhöyük*. Cambridge, Cambridge University Press: 60–95.

Kohler, T. A. and Smith, M. E. (eds). 2018. *Ten Thousand Years of Inequality: The Archaeology of Wealth Differences*. Tucson, University of Arizona Press.

Kohn, A. and Dawdy, S. L. 2016. Archaeologies of an Informal City: Temporal Dimensions of Contemporary Andean Urbanism, in M. Bille and T. F. Sorensen (eds). *Elements of Architecture: Assembling Archaeology, Atmosphere and the Performance of Building Spaces*. London, Routledge: 121–140.

Kopanias, K. and MacGinnis, J. (eds). 2016. *The Archaeology of the Kurdistan Region of Iraq and Adjacent Regions*. Oxford, Archaeopress.

Korfmann, M. 1973. The Sling as a Weapon. *Scientific American* 229 (4): 34–42.

Korshunov, V. M. 1994. Ecology of the Bearded Goat (*Capra Aegagrus* Ersleben 1777) in Turkmenistan, in V. Fet and K. I. Atamuradov (eds). *Biogeography and Ecology of Turkmenistan*. Dordrecht, Springer Monographiae Biologicae 72: 231–46.

Kozlowski, K. 1989. Nemrik 9, a PPN Neolithic Site in Northern Iraq. *Paléorient* 15: 25–31.

Kozlowski, S. K. 1990. Molluscs, in S. K. Kozłowski (ed.) *Nemrik 9: Pre-Pottery Neolithic Site in Iraq*. Warszawa, Wydawnictwa Uniwersytetu Warszawskiego: 211–114.

Kozlowski, S. K. 1994. Chipped Neolithic Industries at the Eastern Wing of the Fertile Crescent, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar Für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 143–172.

Kozlowski, S. K. 1996. The Trialetian Mesolithic Industry of the Caucasus, Transcaspia, Eastern Anatolia, and the Iranian Plateau, in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 161–70.

Kozlowski, S. K. 1998. M'lefaat: Early Neolithic Site in Northern Iraq. *Cahiers de l'Euphrate* 8: 179–273.

Kozlowski, S. K. 1999. *The Eastern Wing of the Fertile Crescent: Late Prehistory of Greater Mesopotamian Lithic Industries*. Oxford, British Archaeological Reports S760.

Kozlowski, S. K. 2002. *Nemrik: An Aceramic Village in Northern Iraq*. Warsaw, Institute of Archaeology, Warsaw University.

Kozlowski, S. K. 2013. The Jeziran Neolithic Market, in Y. Nishiaki, K. Kashima and M. Verhoeven (eds). *Neolithic Archaeology in the Khabur Valley, Upper Mesopotamia and Beyond*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence and Environment: 218–36.

Kozlowski, S. K. and Aurenche, O. 2005. *Territories, Boundaries and Cultures in the Neolithic Near East*. Oxford, British Archaeological Reports S362.

Kozłowski, S. K. and Kempisty, A. 1990. Architecture of the Pre-Pottery Neolithic Settlement in Nemrik, Iraq. *World Archaeology* 21 (3): 348–362.

Kozlowski, S. K. and Mazurowski, R. 1990. Miscellanea, in S. K. Kozlowski (ed.) *Nemrik 9: Pre-Pottery Neolithic Site in Iraq*. Warszawa, Wydawnictwa Uniwersytetu Warszawskiego: 145–154.

Kramer, C. 1979a. *Ethnoarchaeology: Implications of Ethnography for Archaeology*. New York, Columbia University Press.

Kramer, C. 1979b. An Archaeological View of a Contemporary Kurdish Village: Domestic Architecture, Household Size, and Wealth, in Kramer (ed.) 1979a: 139–163.

Kramer, C. 1982. *Village Ethnoarchaeology: Rural Iran in Archaeological Perspective*. New York, Academic Press.

Kremer, C., Racette, S., Dionne, C. A. and Sauvageau, A. 2008. Discrimination of Falls and Blows in Blunt Head Trauma: Systematic Study of the Hat Brim Line Rule in Relation to Skull Fractures. *Journal of Forensic Sciences* 53 (3): 716–719.

Kroll, E. M. and Isaac, G. L. 1984. Configurations of Artifacts and Bones at Early Pleistocene Sites in East Africa, in H. J. Hietala (ed.) *Intrasite Spatial Analysis in Archaeology*. Cambridge, Cambridge University Press: 4–31.

Kuhn, S. L. 1994. A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59 (3): 426–442.

Kuijt, I. (ed.) 2000a. *Life in Neolithic Farming Communities*. New York, Plenum Press.

Kuijt, I. 2000b. Keeping the Peace: Ritual, Skull Caching, and Community Integration in the Levantine Neolithic, in Kuijt (ed.) 2000a: 137–164.

Kuijt, I. 2000c. People and Space in Early Agricultural Villages: Exploring Daily Lives, Community Size, and Architecture in the Late Pre-Pottery Neolithic. *Journal of Anthropological Archaeology* 19: 75–102.

Kuijt, I. 2018. Material Geographies of House Societies: Reconsidering Neolithic Çatalhöyük, Turkey. *Cambridge Archaeological Journal* 28 (4): 565–590.

Kuijt, I. and Chesson, M. S. 2005. Lumps of Clay and Pieces of Stone: Ambiguity, Bodies, and Identity as Portrayed in Neolithic Figurines, in S. Pollock and R. Bernbeck (eds). *Archaeologies of the Middle East: Critical Perspectives*. Oxford, Blackwell: 152–183.

Kuijt, I. and Chesson, M. S. 2007. Imagery and Social Relationships: Shifting Identity and Ambiguity in the Neolithic, in C. Renfrew and I. Morley (eds). *Image and Imagination*. Cambridge, McDonald Institute for Archaeological Research: 211–226.

Kuijt, I. and Goring-Morris, N. 2002. Foraging, Farming and Social Complexity in the Pre-Pottery Neolithic of the Southern Levant: A Review and Synthesis. *Journal of World Prehistory* 16 (4): 361–440.

Kulick, R. 2019. Urban Micromorphology: A Microecological Narrative of a Neopalatial Neighborhood at Bronze Age Palaikastro, Crete. *Geoarchaeology* 34 (4): 430–447.

Kurek, M., Żądzińska, E., Sitek, A., Borowska-Strugińska, B., Rosset, I. and Lorkiewicz, W. 2016. Neonatal Line Width in Deciduous Incisors from Neolithic, Mediaeval and Modern Skeletal Samples from North-Central Poland. *Annals of Anatomy-Anatomischer Anzeiger* 203: 12–18.

Kurth, G. and Röhrer-Ertl, O. 1981. On the Anthropology of the Mesolithic to Chalcolithic Human Remains from the Tell Es-Sultan in Jericho, Jordan, in K. Kenyon and T. A. Holland (eds) *Excavations at Jericho* 3 (1). Jerusalem, British School at Jersualem: 409–499.

Lajeunesse, S. D., Dilustro, J. J., Sharitz, R. R. and Collins, B. S. 2006. Ground Layer Carbon and Nitrogen Cycling and Legume Nitrogen Inputs Following Fire in Mixed Pine Forests. *American Journal of Botany* 93 (1): 84–93.

LaMotta, V. M. and Schiffer, M. B. 1999. Formation Processes of House Floor Assemblages, in P. M. Allison (ed.) *The Archaeology of Household Activities*. Abingdon, Routledge: 19–29.

Lancelotti, C. and Madella, M. 2012. The 'Invisible' Product: Developing Markers for Identifying Dung in Archaeological Contexts. *Journal of Archaeological Science* 38: 953–963.

Lancelotti, C., Pecci, A. and Zurro, D. 2017. Anthropic Activity Markers: Archaeology and Ethnoarchaeology. *Environmental Archaeology* 22 (4): 339–342.

Lane, P. 1994. The Temporal Structuring of Settlement Space among the Dogon of Mali: An Ethnoarchaeological Study, in M. Parker Pearson and C. Richards (eds). *Architecture and Order: Approaches to Social Space*. London, Routledge: 196–216.

Langejans, G. H. J. 2010. Remains of the Day – Preservation of Organic Micro-Residues on Stone Tools. *Journal of Archaeological Science* 37 (5): 971–985.

Larsen, C. 2015. *Bioarchaeology: Interpreting Behavior from the Human Skeleton*. Cambridge, Cambridge University Press.

Larsen, C. S. 1995. Biological Changes in Human Populations with Agriculture. *Annual Review of Anthropology* 24 (1): 185–213.

Larsen, C. S. 2006. The Agricultural Revolution as Environmental Catastrophe: Implications for Health and Lifestyle in the Holocene. *Quaternary International* 150 (1): 12–20.

Larsen, C. S. 2014. Life Conditions in Early Farmers: A Global Perspective on Costs and Consequences of a Fundamental Transition, in A. W. R. Whittle and P. Bickle (eds). *Early Farmers: The View from Archaeology and Science*. Oxford, Oxford University Press/Proceedings of the British Academy 98: 215–232.

Larsen, C. S., Hillson, S. W., Boz, B., Pilloud, M. A., Sadvari, J. W., Agarwal, S. C., Glencross, B., Beauchesne, P., Pearson, J. and Ruff, C. B. 2015. Bioarchaeology of Neolithic Çatalhöyük: Lives and Lifestyles of an Early Farming Society in Transition. *Journal of World Prehistory* 28 (1): 27–68.

Larsen, C. S., Knüsel, C. J., Haddow, S. D., Pilloud, M. A., Milella, M., Sadvari, J. W., Pearson, J., Ruff, C. B., Garofalo, E. M., Bocaege, E., Betz, B. J., Dori, I. and Glencross, B. 2019. Bioarchaeology of Neolithic Çatalhöyük Reveals Fundamental Transitions in Health, Mobility, and Lifestyle in Early Farmers. *Proceedings of the National Academy of Sciences* 116 (26): 12615–12623.

Larson, G. and Fuller, D. Q. 2014. The Evolution of Animal Domestication. *Annual Review of Ecology, Evolution, and Systematics* 45: 115–136.

Larson, G., Piperno, D. R., Allaby, R. G., Purugganan, M. D., Andersson, L., Arroyo-Kalin, M., Barton, L., Vigueira, C. C., Denham, T. and Dobney, K. 2014. Current Perspectives and the Future of Domestication Studies. *Proceedings of the National Academy of Sciences* 111 (17): 6139–6146.

Lasota-Moskalewska, A. 1999. Animal remains from Nemrik 9, a pre-pottery Neolithic site in Iraq, in S. K. Kozlowski (ed). *Nemrik 9: Pre-pottery Neolithic site in Iraq.* Warzsawa, Wydawnictwa Uniwersytetu Warszawskiego: 5–42.

Law, M. 2017. Numerical Approaches to Land Snail Palaeoecology, in M. J. Allen (ed.) *Molluscs in Archaeology: Methods, Approaches and Applications*. 3. Oxford, Oxbow Books Studying Scientific Archaeology 3: 48–64.

Lawson, R., Slowinski, J. B., Crother, B. I. and Burbrink, F. T. 2005. Phylogeny of the Colubroidea (Serpentes): New Evidence from Mitochondrial and Nuclear Genes. *Molecular Phylogenetics and Evolution* 37 (2): 581–601.

Lay, D. M. 1967. *A Study of the Mammals of Iran: Resulting from the Street Expedition of 1962–63*. Chicago, Field Museum of Natural History.

Lazaridis, I., Nadel, D., Rollefson, G., Merrett, D. C., Rohland, N., Mallick, S., Fernandes, D., Novak, M., Gamarra, B., Sirak, K., Connell, S., Stewardson, K., Harney, E., Fu, Q., Gonzalez-Fortes, G., Jones, E. R., Roodenberg, S. A., Lengyel, G., Bocquentin, F., Gasparian, B., Monge, J. M., Gregg, M., Eshed, V., Mizrahi, A.-S., Meiklejohn, C., Gerritsen, F., Bejenaru, L., Blüher, M., Campbell, A., Cavalleri, G., Comas, D., Froguel, P., Gilbert, E., Kerr, S. M., Kovacs, P., Krause, J., McGettigan, D., Merrigan, M., Merriwether, D. A., O'Reilly, S., Richards, M. B., Semino, O., Shamoon-Pour, M., Stefanescu, G., Stumvoll, M., Tönjes, A., Torroni, A., Wilson, J. F., Yengo, L., Hovhannisyan, N. A., Patterson, N., Pinhasi, R. and Reich, D. 2016. Genomic Insights into the Origin of Farming in the Ancient Near East. *Nature* 536: 419.

Leatherbarrow, D. and Mostafavi, M. 2002. *Surface Architecture*. London, MIT Press.

Lebreton, V., Bertini, A., Ermolli, E. R., Stirparo, C., Orain, R., Vivarelli, M., Combourieu-Nebout, N., Peretto, C. and Arzarello, M. 2019. Tracing Fire in Early European Prehistory: Microcharcoal Quantification in Geological and Archaeological Records from Molise (Southern Italy). *Journal of Archaeological Method and Theory* 26 (1): 247–275.

Lécuru, S. 1969. Étude Morphologique de l'Humérus des Lacertiliens. *Annales des Sciences Naturelles (série Zoologie)* 11 (4): 1–47.

Ledger, M. L., Anastasiou, E., Shillito, L.-M., Mackay, H., Bull, I. D., Haddow, S. D., Knüsel, C. J. and Mitchell, P. D. 2019. Parasite Infection at the Early Farming Community of Çatalhöyük. *Antiquity* 93 (369): 573–587.

Leng, M. J. and Lewis, J. P. 2016. Oxygen Isotopes in Molluscan Shell: Applications in Environmental Archaeology. *Environmental Archaeology* 21 (3): 295–306.

Leng, M. J. and Marshall, J. D. 2004. Palaeoclimate Interpretation of Stable Isotope Data from Lake Sediment Archives. *Quaternary Science Reviews* 23 (7–8): 811–831.

Leroi-Gourhan, A. 1969. Pollen Grains of Gramineae and Cerealia from Shanidar and Zawi Chemi, in P. J. Ucko and G. W. Dimbleby (eds). *The Domestication and Exploitation of Plants and Animals*. 143–148. London, Duckworth.

Levi-Strauss, C. 1979. Nobles Sauvages, in R. Aron (ed.) *Culture, Science et Développement: Contribution à une*

Histoire de l'Homme. Mélanges en l'Honneur de Charles Morazé. Toulouse, Edouard Privat: 421–445.

Levy, T. E. 1995. Cult, Metallurgy and Rank Societies – Chalcolithic Period (ca. 4500–3500 BCE), in T. E. Levy (ed.) *The Archaeology of Society in the Holy Land*. London, Leicester University Press: 226–244.

Lewarch, D. E. and O'Brien, M. J. 1981. The Expanding Role of Surface Assemblages in Archaeological Research. *Advances in Archaeological Method and Theory* 4: 297–342.

Lewis, M. 2017. *Paleopathology of Children: Identification of Pathological Conditions in the Human Skeletal Remains of Non-Adults*. London, Academic Press.

Lewis, M. E. 2004. Endocranial Lesions in Non-Adult Skeletons: Understanding Their Aetiology. *International Journal of Osteoarchaeology* 14 (2): 82–97.

Lewis, S. L. and Maslin, M. A. 2018. *The Human Planet: How We Created the Anthropocene*. London, Penguin Random House.

Lieberman, D. E. 1998. Natufian Sedentism and the Importance of Biological Data for Estimating Reduced Mobility, in T. R. Rocek and O. Bar-Yosef (eds). *Seasonality and Sedentism: Archaeological Perspectives from Old and New World Sites* Cambridge, MA, Peabody Museum of Archaeology and Ethnology: 75–92.

Limbrey, S. 1975. *Soil Science and Archaeology*. London, Academic.

Lingle, A. and Seifert, J. 2019. Conservation, in S. D. Haddow (ed.) *Catalhöyük 2017 Archive Report*: 265–272. Online: http://www.catalhoyuk.com/archive_reports/2017.

Lister, A. M. 1996. The Morphological Distinction between Bones and Teeth of Fallow Deer (*Dama dama*) and Red Deer (*Cervus elaphus*). *International Journal of Osteoarchaeology* 6 (2): 119–143.

Littlefield, D. and Lewis, S. L. 2007. *Architectural Voices: Listening to Old Buildings*. New York, Wiley.

Liu, L., Wang, J. and Levin, M. J. 2017. Usewear and Residue Analyses of Experimental Harvesting Stone Tools for Archaeological Research. *Journal of Archaeological Science: Reports* 14: 439–443.

Liverani, M. 2013. *The Ancient Near East: History, Society and Economy*. London, Routledge.

Liversidge, H. M., Smith, B. H. and Maber, M. 2010. Bias and Accuracy of Age Estimation Using Developing Teeth in 946 Children. *American Journal of Physical Anthropology* 143 (4): 545–544.

Lopez, P. R. 2012. *The Built Environment and Public Health*. San Francisco, Jossey-Bass.

Lorentz, K. 2010. Ubaid Headshaping: Negotiations of Identity through Physical Appearance? in R. A. Carter and G. Philip (eds). *Beyond the Ubaid: Transformation and Integration in the Late Prehistoric Societies of the Middle East*. Chicago, Oriental Institute of the University of Chicago: 125–148.

Lorentz, K. 2017. Marking Identity through Cultural Cranial Modification within the First Sedentary Communities (Ninth to Eighth Millennium BCE) in the Near East: Tepe Abdul Hosein, Iran. *International Journal of Osteoarchaeology* 27 (6): 973–983.

Love, S. 2013. The Performance of Building and Technological Choice Made Visible in Mudbrick Architecture. *Cambridge Archaeological Journal* 23 (2): 263–282.

Lovejoy, C. O. 1985. Dental Wear in the Libben Population: Its Functional Pattern and Role in the Determination of Adult Skeletal Age at Death. *American Journal of Physical Anthropology* 68 (1): 47–46.

Lowenhaupt Tsing, A., Mathews, A. S. and Bubandt, N. 2019. Patchy Anthropocene: Landscape Structure, Multispecies History, and the Retooling of Anthropology: An Introduction to Supplement 20. *Current Anthropology* 60 (S20): S186–S197.

Loy, T. H. 1994. Methods in the Analysis of Starch Residues on Prehistoric Stone Tools, in J. G. Hather (ed.). *Tropical Archaeobotany: Applications and New Developments*. London, Routledge: 86–114.

Loy, T. H. and Wood, A. R. 1989. Blood Residue Analysis at Çayönü Tepesi, Turkey. *Journal of Field Archaeology* 16 (4): 451–460.

Lubell, D. 2004a. Prehistoric Edible Land Snails in the Circum-Mediterranean: The Archaeological Evidence, in J.-P. Brugal and J. Desse (eds). *Petits Animaux et Sociétés Humaines, du Complément Alimentaire aux Resources Utilitaires. XXIVe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes,* Antibes, Éditions APDCA: 77–98.

Lubell, D. 2004b. Are Land Snails a Signature for the Mesolithic–Neolithic Transition?. *Documenta Praehistorica* 31: 1–24.

Lubell, D. and Barton, N. 2011. Gastropods and Humans in the Late Palaeolithic and Mesolithic of the Western Mediterranean Basin. *Quaternary International* 244 (1): 1–4.

Lubell, D., Hassan, F. A., Gautier, A. and Ballais, J.-L. 1976. The Capsian Escargotières. *Science* 191 (4230): 910–920.

Lucas, G. 2017. Variations on a Theme: Assemblage Archaeology. *Cambridge Archaeological Journal* 27 (1): 187–190.

Luedtke, B. E. 1992. *An Archaeologist's Guide to Chert and Flint*. Los Angeles, Institute of Archaeology, University of California.

Luikart, G., Gielly, L., Excoffier, L., Vigne, J. D., Bouvet, J. and Taberlet, P. 2001. Multiple Maternal Origins and Weak Phylogeographic Structure in Domestic Goats. *Proceedings of the National Academy of Sciences of the USA* 98 (10): 5927–5932.

Luterbacher, J. and Xoplaki, E. 2003. 500-Year Winter Temperature and Precipitation Variability over the Mediterranean Area and Its Connection to the Large-Scale Atmospheric Circulation, in H. J. Bolle (ed.). *Mediterranean Climate - Variability and Trends*. Dordrecht, Springer: 133–43.

Lyman, R. L. 2017. Paleoenvironmental Reconstruction from Faunal Remains: Ecological Basics and Analytical Assumptions. *Journal of Archaeological Research* 25 (4): 315–371.

Lyman, R. L. and Lyman, C. 1994. *Vertebrate Taphonomy*. Cambridge, Cambridge University Press.

Macintosh, A. A., Pinhasi, R. and Stock, J. T. 2016. Early Life Conditions and Physiological Stress Following the Transition to Farming in Central/Southeast Europe: Skeletal Growth Impairment and 6000 Years of Gradual Recovery. *PloS one* 11 (2): e0148468.

Macphail, R. I., Courty, M. A., Hather, J. and Wattez, J. 1997. The Soil Micromorphological Evidence of Domestic Occupation and Stabling Activities, in R. Maggi (ed.) *Arene Candide: A Functional and Environmental Assessment of the Holocene Sequences Excavated by Bernado Brea (1940–1950)*. Umana, Meomorie dell Instituto di Paleontologia 5: 53–88.

Macphail, R. I., Cruise, G. M., Allen, M. J., Linderholm, J. and Reynolds, P. 2004. Archaeological Soil and Pollen Analysis of Experimental Floor Deposits; with Special Reference to Butzer Ancient Farm, Hampshire, UK. *Journal of Archaeological Science* 31: 175–191.

Madden, O., Chan, D. M. W., Dundon, M. and France, C. A. M. 2018. Quantifying Collagen Quality in Archaeological Bone: Improving Data Accuracy with Benchtop and Handheld Raman Spectrometers. *Journal of Archaeological Science: Reports* 18: 596–605.

Madella, M., Alexandre, A. and Ball, T. 2005. International Code for Phytolith Nomenclature 1.0. *Annals of Botany* 96: 253–260.

Maeda, O. 2011. The Social Roles of the Use of Flint and Obsidian Artefacts at Salat Cami Yanı in the Upper Tigris Valley, in E. Healey, S. Campbell and O. Maeda (eds). *The State of the Stone: Terminologies, Continuities and Contexts in Near Eastern Lithics. Proceedings of the Sixth PPN Conference on Chipped and Ground Stone Artefacts in the Near East, Manchester 3rd–4th March 2008*. Berlin, ex oriente: 317–326.

Maeda, O. 2018. Lithic Analysis and the Transition to the Neolithic in the Upper Tigris Valley: Recent Excavations at Hasankeyf Höyük. *Antiquity* 92 (361): 56–73.

Maeda, O. and Pappi, C. 2019. Bladelet Production by Pressure-Flaking at the Proto-Neolithic Site of Satu Qala in Iraqi Kurdistan, in L. Astruc, C. McCartney, F. Briois and V. Kassianidou (eds). *Near Eastern Technologies on the Move. Interactions and Contexts in Neolithic Traditions*. Studies in Mediterranean Archaeology. Nicosia, Astrom Editions: 249–246.

Maeda, O., Lucas, L., Silva, F., Tanno, K.-I. and Fuller, D. Q. 2016. Narrowing the Harvest: Increasing Sickle Investment and the Rise of Domesticated Cereal Agriculture in the Fertile Crescent. *Quaternary Science Reviews* 145: 226–237.

Maher, L. A. and Conkey, M. 2019. Homes for Hunters?: Exploring the Concept of Home at Hunter-Gatherer Sites in Upper Paleolithic Europe and Epipaleolithic Southwest Asia. *Current Anthropology* 60 (1): 91–137.

Maher, L. A., Richter, T., Macdonald, D., Jones, M. D., Martin, L. and Stock, J. T. 2012a. Twenty Thousand-Year-Old Huts at a Hunter-Gatherer Settlement in Eastern Jordan. *PloS one* 7 (2).

Maher, L. A., Richter, T. and Stock, J. T. 2012b. The Pre-Natufian Epipaleolithic: Long-Term Behavioral Trends in the Levant. *Evolutionary Anthropology: Issues, News, and Reviews* 21 (2): 69–81.

Malafouris, L. 2013. *How Things Shape the Mind: A Theory of Material Engagement*. Cambridge MA, MIT Press.

Mallol, C. and Henry, A. 2018. Ethnoarchaeology of Fire and Combustion Residues: Current Approaches. Introduction. *Ethnoarchaeology* 10 (2): 73–75.

Mallol, C., Marlowe, F. W., Wood, B. M. and Porter, C. C. 2007. Earth, Wind, and Fire: Ethnoarchaeological Signals of Hadza Fires. *Journal of Archaeological Science* 34: 2035–2042.

Mallol, C., Hernández, C. M., Cabanes, D., Sistiaga, A., Machado, J., Rodríguez, Á., Pérez, L. and Galván, B. 2013. The Black Layer of Middle Palaeolithic Combustion Structures. Interpretation and Archaeostratigraphic Implications. *Journal of Archaeological Science* 40 (5): 2515–2537.

Mallon, D. P. 2008. *Gazella Subgutturosa*. The IUCN Red List of Threatened Species. Version 2008. IUCN. Gland, IUCN.

Mann, R. W. and Hunt, D. R. 2013. *Photographic Regional Atlas of Bone Disease: A Guide to Pathologic and Normal Variation in the Human Skeleton*. Springfield, Charles C. Thomas.

Mannino, M. A. and Thomas, K. D. 2002. Depletion of a Resource? The Impact of Prehistoric Human Foraging on Intertidal Mollusc Communities and Its Significance for Human Settlement, Mobility and Dispersal. *World Archaeology* 33 (3): 452–474.

Maran, A. and Stevanovic, Z. 2009. *The Iraqi Kurdistan Environment: An Invitation to Discover*. Belgrade, IK Consulting Engineers.

Marciani, G., Arrighi, S., Aureli, D., Spagnolo, V., Boscato, P. and Ronchitelli, A. 2018. Middle Palaeolithic Lithic Tools: Techno-Functional and Use-Wear Analysis of Target Objects from Su 13 at the Oscurusciuto Rock Shelter, Southern Italy. *Journal of Lithic Studies* 5 (2): 1–30.

Marder, O., Khalaily, H., Milevski, I., Eisenberg, E., Sklar-Parnes, D. and Le Dosseur, G. 2008. Two Hafted Tools from PPNB Sites of the Southern Levant. *Neo-Lithics* 2 (8): 26–27.

Maréchal, C. 1985. Les Bracelets Néolithiques en Pierre de Cafer Höyük (Turquie). *Cahiers de l'Euphrate* 4: 109–115.

Marquer, L., Lebreton, V., Otto, T., Valladas, H., Haesaerts, P., Messager, E., Nuzhnyi, D. and Péan, S. 2012. Charcoal Scarcity in Epigravettian Settlements with Mammoth Bone Dwellings: The Taphonomic Evidence from Mezhyrich (Ukraine). *Journal of Archaeological Science* 39 (1): 109–120.

Marsh, A., Fleitmann, D., Al-Manmi, D. A. M., Altaweel, M., Wengrow, D. and Carter, R. 2018. Mid- to Late-Holocene Archaeology, Environment and Climate in the Northeast Kurdistan Region of Iraq. *Holocene* 28 (6): 955–967.

Marshall, J. L. 2012. *Missing Links: Demic Diffusion and the Development of Agriculture on the Central Iranian Plateau*, PhD thesis, Durham University.

Marston, J. M. 2011. Archaeological Markers of Agricultural Risk Management. *Journal of Anthropological Archaeology* 30 (2): 190–205.

Martin, G. B., Walkden-Brown, S. W., Boukhliq, R., Tjondronegoro, S., Miller, D. W., Fisher, J. S., Hötzel, M. J., Restall, B. J. and Adams, N. R. 1994. Non-Photoperiodic Inputs into Seasonal Breeding in Male Ruminants, in K. G. Davey, R. E. Peter and S. S. Tobe (eds). *Perspectives in Comparative Endocrinology*. Ottawa, National Research Council of Canada: 574–585.

Martin, L. 2000. Gazelle (*Gazella* Spp.) Behavioural Ecology: Predicting Animal Behaviour for Prehistoric Environments in South-West Asia. *Journal of Zoology* 250 (1): 13–30.

Martin, L. and Russell, N. 2000. Trashing Rubbish, in Hodder (ed.) 2000: 57–69.

Maskell, D., Thomson, A. and Walker, P. 2018. Multi-Criteria Selection of Building Materials. *Proceedings of the Institution of Civil Engineers: Construction Materials* 171 (2): 49–58.

Matcuk, G. R., Mahanty, S. R., Skalski, M. R., Patel, D. B., White, E. A. and Gottsegen, C. J. 2016. Stress Fractures: Pathophysiology, Clinical Presentation, Imaging Features, and Treatment Options. *Emergency Radiology* 23 (4): 365–375.

Matschullat, J., Ottenstein, R. and Reimann, C. 2000.

Geochemical Background – Can We Calculate It? *Environmental Geology* 39 (9): 990–1000.

Matson, F. R. 1960. Specialized Ceramic Studies and Radiocarbon Techniques, in R. J. Braidwood and B. Howe (eds). *Prehistoric Investigations in Iraqi Kurdistan*. Chicago, University of Chicago Press Studies in Oriental Civilization 31: 63–70.

Matthews, R. 2000. *The Early Prehistory of Mesopotamia: 500,000 to 4,500 BC*. Turnhout, Brepols.

Matthews, R. 2003. *The Archaeology of Mesopotamia: Theories and Approaches*. London, Routledge.

Matthews, R. and Glatz, C. 2009. *At Empires' Edge: Project Paphlagonia Regional Survey in North-Central Anatolia*. London, British Institute at Ankara.

Matthews, R. and Matthews, W. 2010. *Sedentism and Resource Management in the Neolithic of Western Iran*. Unpublished AHRC Research Grants Standard Proposal AH/H034315/1.

Matthews, R. and Fazeli Nashli, H. (eds). 2013. *The Neolithisation of Iran: The Formation of New Societies*. Oxford, BANEA/ Oxbow Books.

Matthews, R. and Richardson, A. 2018. Cultic Resilience and Inter-City Engagement at the Dawn of Urban History: Protohistoric Mesopotamia and the 'City Seals', 3200–2750 BC. *World Archaeology* 50 (5): 723–47.

Matthews, R., Mohammadifar, Y., Matthews, W. and Motarjem, A. 2010. Investigating the Early Neolithic of Western Iran: The Central Zagros Archaeological Project (CZAP). *Antiquity Project Gallery* 84 (323): http://antiquity.ac.uk/projgall/matthews323/.

Matthews, R., Matthews, W. and Mohammadifar, Y. (eds). 2013a. *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani. CZAP Report 1*. Oxford, British Institute of Persian Studies and Oxbow Books.

Matthews, R., Matthews, W. and Aziz, K. R. 2013b. Excavations in Trench 7, in R. Matthews, W. Matthews and K. Rasheed Raheem (eds). *Excavations at Bestansur and Shimshara, Sulaimaniyah Province, Kurdistan Regional Government, Republic of Iraq 18th August–27th September 2012; Survey in Zarzi Region January 2013*. CZAP Archive Report 2: 7–17. Online: czap.org/archive-reports.

Matthews, R., Matthews, W. and Richardson, A. 2013c. Radiocarbon Dating of Sheikh-e Abad and Jani, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani. CZAP Report 1*. Oxford, British Institute of Persian Studies and Oxbow Books: 61–66.

Matthews, R., Mohammadifar, Y., Matthews, W., Astin, T., Cole, G., Darabi, H., Daryaie, H., Lelet Tvetmarken, C., Shillito, L.-M. and Taylor, H. 2013d. Excavations, Surface Collection and Geophysics at Sheikh-e Abad, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani. CZAP Report 1*. Oxford, British Institute of Persian Studies and Oxbow Books: 25–42.

Matthews, R., Mohammadifar, Y., Matthews, W. and Motarjem, A. 2013e. Investigating the Neolithisation of Society in the Central Zagros of Western Iran, in R. Matthews and H. Fazeli Nashli (eds). *The Neolithisation of Iran: The Formation of New Societies*. Oxford, BANEA/ Oxbow Books: 14–34.

Matthews, R., Matthews, W., Stone, A. and Moore, T. 2016a. Excavations in Trench 10, in R. Matthews, W. Matthews and K. R. Raheem (eds). *Excavations at Bestansur, Sulaimaniyah Province, Kurdistan Regional Government, Republic of Iraq 26th March–15th April 2016*. CZAP Archive Report 6: 3-8. Online: czap.org/archive-reports.

Matthews, R., Matthews, W., Raheem, K. R. and Aziz, K. R. 2016b. Current Investigations into the Early Neolithic of the Zagros Foothills of Iraqi Kurdistan, in K. Kopanias and J. MacGinnis (eds). *The Archaeology of the Kurdistan Region of Iraq and Adjacent Regions*. Oxford, Archaeopress: 219–228.

Matthews, R., Richardson, A. and Maeda, O. 2018. 'Behind All Those Stones': Activity and Society in the Pre-Pottery Neolithic of the Eastern Fertile Crescent, in B. Horejs, C. Schwall, V. Müller, M. Luciani, M. Ritter, M. Giudetti, R. B. Salisbury, F. Höflmayer and T. Bürge (eds). *Proceedings of the 10th International Congress on the Archaeology of the Ancient Near East Volume 2*. Wiesbaden, Harrassowitz: 377–390.

Matthews, R., Matthews, W., Richardson, A., Rasheed Raheem, K., Walsh, S., Raeuf Aziz, K., Bendrey, R., Whitlam, J., Charles, M., Bogaard, A., Iversen, I., Mudd, D. and Elliott, S. 2019a. The Early Neolithic of Iraqi Kurdistan: current research at Bestansur, Shahrizor Plain. *Paléorient* 45 (2): 13–32.

Matthews, R., Rasheed, Q. H., Palmero Fernández, M., Fobbe, S., Nováček, K., Mohammed-Amin, R., Mühl, S. and Richardson, A. 2020. Heritage and Cultural Healing: Iraq in a Post-Daesh Era. *International Journal of Heritage Studies* 26 (2): 120–141.

Matthews, W. 1995. Micromorphological Characterisation of Occupation Deposits and Microstratigraphic Sequences at Abu Salabikh, Southern Iraq, in A. J. Barham and R. I. Macphail (eds). *Archaeological Sediments and Soils: Analysis, Interpretation and Management*. London, Institute of Archaeology, University College: 41–76.

Matthews, W. 1998. Report on Sampling Strategies, Microstratigraphy and Micromorphology of Depositional Sequences, and Associated Ethnoarchaeology at Çatalhöyük, 1998, in I. Hodder (ed.) Çatalhöyük 1998 Archive Report. Online: http://www.catalhoyuk.com/archive_reports/1998/ar98_06.html.

Matthews, W. 1999. *Micromorphology Archive Report,* in I. Hodder (ed.) Çatalhöyük 1999 Archive Report. Online: http://www.catalhoyuk.com/archive_reports/1999.

Matthews, W. 2005. Micromorphological and Microstratigraphic Traces of Uses and Concepts of Space, in I. Hodder (ed.) *Inhabiting Çatalhöyük: Reports from the 1995–99 Seasons*. Cambridge, McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara: 355–398, 553–572.

Matthews, W. 2010. Geoarchaeology and Taphonomy of Plant Remains and Microarchaeological Residues in Early Urban Environments in the Ancient Near East. *Quaternary International* 214 (1–2): 98–113.

Matthews, W. 2012. Household Life-Histories and Boundaries: Microstratigraphy and Micromorphology of Architectural Surfaces in Building 3 of the BACH Area, in R. Tringham and M. Stevanovic (eds). *Last House on the Hill. BACH Area Reports from Çatalhöyük, Turkey*. *Çatalhöyük Volume 7*. Los Angeles, Cotsen Institute of Archaeology Press and the British Institute of Archaeology at Ankara: 205–222.

Matthews, W. 2013. Contexts of Neolithic Interaction: Geography, Palaeoclimate and Palaeoenvironment of the Central Zagros, in R. Matthews, W. Matthews and

Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani. CZAP Report 1*. Oxford, British Institute of Persian Studies and Oxbow Books: 13–20.

Matthews, W. 2016. Humans and Fire: Changing Relations in Early Agricultural and Built Environments in the Zagros, Iran, Iraq. *Anthropocene Review* 3 (2): 107–139.

Matthews, W. 2018. Creating Settled Life: Micro-Histories of Community, Ritual, and Place – the Central Zagros and Çatalhöyük, in I. Hodder (ed.) *Religion, History, and Place in the Origin of Settled Life*. Louisville, University Press of Colorado: 64–98.

Matthews, W. and Ahmed, S. 2012. Excavations in Sounding 4, in R. Matthews, W. Matthews and K. Rasheed Raheem (eds). *Excavations at Bestansur, Sulaimaniyah Province, Kurdistan Regional Government, Republic of Iraq 17th March–24th April 2012*. CZAP Archive Report 1: 22–29. Online: czap.org/archive-reports.

Matthews, W. and Hastorf, C. A. 2000. Integrating Archaeological Science, in I. Hodder (ed.) *Towards Reflexive Method in Archaeology: The Example at Çatalhöyük*. Cambridge, McDonald Institute for Archaeological Research: 37–40.

Matthews, W., Postgate, N. J. Payne, S., Charles, M. and Dobney, K. 1994. The imprint of living in a Mesopotamian city: questions and answers. In R. Luff and P. Rowley Conwy (eds). *Whither Environmental Archaeology?* Oxford, Oxbow Books.

Matthews, W., French, C. A. I., Lawrence, T. and Cutler, D. 1996. Multiple Surfaces: The Micromorphology, in I. Hodder (ed.) *On the Surface: Çatalhöyük 1993–95*. Cambridge, McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara: 301–342.

Matthews, W., French, C., Lawrence, T., Cutler, D. F. and Jones, M. K. 1997a. Microstratigraphic Traces of Site Formation Processes and Human Activities. *World Archaeology* 29 (2): 281–308.

Matthews, W., French, C. A. I., Lawrence, T., Cutler, D. F. and Jones, M. K. 1997b. Microstratigraphy and Micromorphology of Depositional Sequences, in D. Oates, J. Oates and H. McDonald (eds). *Excavations at Tell Brak: The Mitanni and Old Babylonian Periods*. 1. Cambridge, McDonald Institute for Archaeological Research and British School of Archaeology in Iraq: 135–140.

Matthews, W., Hastorf, C. A., Ergenekon, B., Erkal, A., Yalman, N., Agcabay, M., Aydinoglu, B., Bartu, A., Baysal, A., Boz, B., Middleton, W., Near, J., Rosen, A. and Stevanovic, M. 2000. Ethnoarchaeology: Studies in Local Villages Aimed at Understanding Aspects of the Neolithic Site, in I. Hodder (ed.) *Towards Reflexive Method in Archaeology: The Example at Çatalhöyük*. Cambridge, McDonald Institute for Archaeological Research: 177–189.

Matthews, W., Almond, M. J., Anderson, E., Wiles, J., Williams, H. and Rowe, J. 2013f. Biographies of Architectural Materials and Buildings: Integrating High-Resolution Micro-Analysis and Geochemistry, in I. Hodder (ed.) *Substantive Technologies at Çatalhöyük: Reports from the 2000–2008 Seasons*. Los Angeles, Cotsen Institute of Archaeology Press and British Institute of Archaeology at Ankara: 115–136.

Matthews, W., Bosomworth, M. and Garcia-Suarez, A. 2013g. Excavations in Trenches 12-13, in R. Matthews, W. Matthews and K. Rasheed Raheem (eds). *Excavations at Bestansur, Sulaimaniyah Province, Kurdistan Regional Government, Republic of Iraq 21st March–24th April 2013.* CZAP Archive Report 3: 15-34. Online: czap.org/archive-reports.

Matthews, W., Shillito, L. M. and Elliott, S. 2013h. Investigating Early Neolithic Materials, Ecology and Sedentism: Micromorphology and Microstratigraphy, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani. CZAP Report 1*. Oxford, British Institute of Persian Studies and Oxbow Books: 67–104.

Matthews, W., Shillito, L.-M. and Elliott, S. 2014. Neolithic Lifeways: Microstratigraphic Traces within Houses, Animal Pens and Settlements, in A. W. R. Whittle and P. Bickle (eds). *Early Farmers: The View from Archaeology and Science*. Oxford, Oxford University Press/Proceedings of the British Academy 98: 251–279.

Matthews, W., Y. Mohammadifar, R. Matthews and A. Motarjem 2019b. Microstratigraphic approaches to settlement history: integrating field and laboratory analyses at the Neolithic site of Jani, western Iran, in S. Aryamanesh (ed.) *Farr-e Firouz in Honor of Dr. Firouz Bagherzadeh*. Tehran: RICHT, 19–49.Mayer, J. J. and Brisbin, I. L. 1988. Sex Identification of Sus Scrofa Based on Canine Morphology. *Journal of Mammalogy* 69 (2): 408–412.

Mazurowski, R. 1987. Preliminary Report on Two Seasons' Investigations in the Raffan Microregion 1984–1985, *Researches on the Antiquities of Saddam Dam Basin Salvage and Other Researches*. Baghdad, State Board of Antiquities and Heritage: 20–23.

Mazurowski, R. 1997. *Nemrik 9, Pre-Pottery Neolithic Site in Iraq Vol 3: Ground and Pecked Stone Industry in the Pre-Pottery Neolithic of Northern Iraq*. Warszawa, Wydawnictwa Uniwersytetu Warszawskiego.

Mazurowski, R. F. and Jammous, B. 2000. Tell Qaramel: Excavations 2000. *Polish Archaeology in the Mediterranean* 12: 327–341.

McClure, S. B. 2015. The Pastoral Effect: Niche Construction, Domestic Animals, and the Spread of Farming in Europe. *Current Anthropology* 56 (6): 901–910.

McCorriston, J. and Field, J. 2020. *Anthropocene: A New Introduction to World Prehistory*. London, Thames & Hudson.

McFadden, C. and Oxenham, M. F. 2018. The D0-14/D Ratio: A New Paleodemographic Index and Equation for Estimating Total Fertility Rates. *American Journal of Physical Anthropology* 165 (3): 471–479.

McGimsey, C. R. 1972. *Public Archaeology*. London, Seminar Press.

McGown, G. and Prangnell, J. 2006. The Significance of Vivianite in Archaeological Settings. *Geoarchaeology: An International Journal* 21 (1): 93–111.

McGranaghan, M. and Challis, S. 2016. Reconfiguring Hunting Magic: Southern Bushman (San) Perspectives on Taming and Their Implications for Understanding Rock Art. *Cambridge Archaeological Journal* 26 (4): 579–599.

McGregor, F., Heath, A., Maskell, D., Fabbri, A. and Morel, J.-C. 2016. A Review on the Buffering Capacity of Earth Building Materials. *Proceedings of the Institution of Civil Engineers – Construction Materials* 169 (5): 241–251.

McHugh, M. 2019. To Reap a Rich Harvest: Experiencing Agricultural Labour in Ancient Greece. *World Archaeology* 51 (2): 208–225.

Meadow, R. H. 1980. Animal Bones: Problems for the Archaeologist Together with Some Possible Solutions. *Paléorient* 6: 65–77.

Meadow, R. H., Becker, C., Manhart, H., Peters, J. and Schibler, J. 1999. The Use of Size Index Scaling Techniques for Research on Archaeozoological Collections from the Middle East, in C. Becker, H. Manhart, J. Peters and J. Schibler (eds). *Historia Animalium Ex Ossibus. Festschrift für Angela Von Den Driesch*. Rahden, Marie Leidorf: 285–300.

Meerburg, B. and Kijlstra, A. 2007. Role of Rodents in Transmission of *Salmonella* and *Campylobacter*. *Journal of the Science of Food and Agriculture* 87: 2774–2781.

Meerburg, B. G., Singleton, G. R. and Kijlstra, A. 2009. Rodent-Borne Diseases and Their Risks for Public Health. *Critical Reviews in Microbiology* 35 (3): 221–270.

Mehterian, S., Pourmand, A., Sharifi, A., Lahijani, H., Naderi, M. and Swart, P. K. 2017. Speleothem Records of Glacial/Interglacial Climate from Iran Forewarn of Future Water Availability in the Interior of the Middle East. *Quaternary Science Reviews* 164: 187–198.

Meiklejohn, C., Agelarakis, A., Akkermans, P. A., Smith, P. E. and Solecki, R. 1992. Artificial Cranial Deformation in the Proto-Neolithic and Neolithic Near East and Its Possible Origin: Evidence from Four Sites. *Paléorient* 18 (2): 83–97.

Meindl, R. S. and Lovejoy, C. O. 1985. Ectocranial Suture Closure: A Revised Method for the Determination of Skeletal Age at Death Based on the Lateral-Anterior Sutures. *American Journal of Physical Anthropology* 68 (1): 57–66.

Mellor, D. and Stafford, K. 2004. Animal Welfare Implications of Neonatal Mortality and Morbidity in Farm Animals. V*eterinary Journal* 168 (2): 118–133.

Menzdorf, A. 1975. Zum Vorkommen von Doppelbruten bei Hühnern der Gattung. *Alectoris*. *Vogelwelt* 96: 135–139.

Merrett, D. C. 2004. *Bioarchaeology in Early Neolithic Iran: Assessment of Health Status and Subsistence Strategy*. Ph.D. thesis, University of Manitoba.

Merrett, D. C. 2005. Occupational Health: Bioarchaeology and Subsistence Transition at Ganj Dareh Tepe. *American Journal of Physical Anthropology* S40: 152.

Merrett, D. C. 2006. Infant Health: Assessing Adaptation and Stability of Transitional Early Neolithic Subsistence Economies in the Zagros Mountains. *American Journal of Physical Anthropology* S42: 130.

Merriman, N. (ed.) 2004. *Public Archaeology*. London, Routledge.

Meskell, L. 2007. Refiguring the Corpus at Çatalhöyük, in C. Renfrew and I. Morley (eds). *Image and Imagination*. Cambridge, McDonald Institute for Archaeological Research: 137–149.

Meskell, L. 2012. The Social Life of Heritage, in I. Hodder (ed.) *Archaeological Theory Today*. London, Polity: 229–240.

Metcalfe, C. R. 1960. *Anatomy of Monocotyledons. I. Gramineae*. Oxford, Clarendon Press.

Metcalfe, D. and Heath, K. M. 1990. Microrefuse and Site Structure: The Hearths and Floors of the Heartbreak Hotel. *American Antiquity* 55 (4): 781–796.

Meyer, C., Knipper, C., Nicklisch, N., Münster, A., Kürbis, O., Dresely, V., Meller, H. and Alt, K. W. 2018. Early Neolithic Executions Indicated by Clustered Cranial Trauma in the Mass Grave of Halberstadt. *Nature communications* 9 (1): 2472.

Middleton, W. D. and Price, D. T. 1996. Identification of Activity Areas by Multi-Element Characterization of Sediments from Modern and Archaeological House Floors Using Inductively Coupled Plasma-Atomic Emission Spectroscopy. *Journal of Archaeological Science* 23 (5): 673–687.

Miksicek, C. H. 1987. Formation Processes of the Archaeobotanical Record, in M. Schiffer and M. Schiffer (eds). *Advances in Archaeological Method and Theory*. New York, NY: 211–247.

Milek, K. 2001. Environmental Archaeology and the Interpretation of Social Space: A Comment on Reconstructing House Activity Areas., in U. Albarella (ed.) *Environmental Archaeology: Meaning and Purpose.* Dordrecht, Kluwer Academic: 271–281.

Milek, K. B. 2012. Floor Formation Processes and the Interpretation of Site Activity Areas: An Ethnoarchaeological Study of Turf Buildings at Thvera, Northeast Iceland. *Journal of Anthropological Archaeology* 31 (2): 119–137.

Milek, K. B. and Roberts, H. M. 2013. Integrated Geoarchaeological Methods for the Determination of Site Activity Areas: A Study of a Viking Age House in Reykjavik, Iceland. *Journal of Archaeological Science* 40 (4): 1845–1865.

Millard, A.R. 2014. Conventions for reporting radiocarbon determinations. *Radiocarbon* 56, 555–459.

Miller, D. H. and Getz, L. L. 1972. Factors Influencing the Local Distribution of the Redback Vole, *Clethrionomys Gapperi*, in New England. *University of Connecticut Biological Science Series Occasional Papers* 2: 159–180.

Miller, G. S. 1912. *Catalogue of the Mammals of Western Europe (Europe Exclusive of Russia) in the Collection of the British Museum*. London, British Museum.

Miller, N. F. 1996. Seed Eaters of the Ancient Near East: Human or Herbivore?. *Current Anthropology* 37 (3): 521–528.

Miller, N. F. 2003. Plant Remains from the 1996 Excavation, in Alizadeh (ed.). *Excavations at the Prehistoric Mound of Chogha Bonut, Khuzestan, Iran.* Chicago, Oriental Institute of the University of Chicago Publications 120: 123–128.

Miller, N. F. 2013. Agropastoralism and Archaeobiology: Connecting Plants, Animals and People in West and Central Asia. *Environmental Archaeology* 18 (3): 247–256.

Miller, N. F. and Smart, T. L. 1984. Intentional Burning of Dung as Fuel: A Mechanism for the Incorporation of Charred Seeds into the Archaeological Record. *Journal of Ethnobiology* 4 (1): 15–28.

Miller, N. F., Spengler, R. N. and Frachetti, M. 2016. Millet Cultivation across Eurasia: Origins, Spread, and the Influence of Seasonal Climate. *The Holocene* 26 (10): 1566–1675.

Milner, G. R. 1984. Dental-Caries in the Permanent Dentition of a Mississippian Period Population from the American Midwest. *Collegium Antropologicum* 8 (1): 77–91.

Ministry of Agriculture Fisheries & Food 1973. *The Analysis of Agricultural Materials: A Manual of the Analytical Methods Used by the Agricultural Development and Advisory Service*. London, HM Stationery Office.

Mitchell, P. D. and Brickley, M. 2017. *Updated Guidelines to the Standards for Recording Human Remains*. Reading, Chartered Institute for Archaeologists.

Mithen, S. 2004. *After the Ice: A Global Human History 20,000–4000 BC*. London, Phoenix.

Mithen, S. and Black, E. (eds). 2011. *Water, Life and Civilisation: Climate, Environment and Society in the Jordan Valley*. Cambridge, Cambridge University Press International Hydrology Series.

Mithen, S. and Finlayson, B. 2007. The Radiocarbon Dates, in B. Finlayson and S. Mithen (eds). *The Early Prehistory of Wadi Faynan, Southern Jordan. Archaeological Survey of Wadis Faynan, Ghuwayr and Al-Bustan and Evaluation of the Pre-Pottery Neolithic a Site of WF16*. Oxford, Council for British Research in the Levant and Oxbow Books: 460–469.

Mithen, S., Finlayson, B., Maricevic, D., Smith, S., Jenkins, E. and Najjar, M. 2018. *WF16: Excavations at an Early Neolithic Site in Southern Jordan. Stratigraphy, Chronology, Architecture, Burials*. London, Council for British Research in the Levant.

Miyake, Y., Maeda, O., Tanno, K., Hongo, H. and Günden, C. Y. 2012. New Excavations at Hasankeyf Höyük: A 10th Millennium Cal. BC Site on the Upper Tigris, Southeast Anatolia. *Neo-Lithics* 1 (12): 3–7.

Mizoguchi, K. 2015. A Future of Archaeology. *Antiquity* 89 (343): 12–22.

Mohammadi, S. and Parvizi, P. 2016. Simultaneous Morphological and Molecular Characterization of *Tatera Indica* in Southwestern Iran. *Journal of Arthropod-borne Diseases* 10 (1): 55–64.

Mohammadifar, Y. and Motarjem, A. 2008. Settlement Continuity in Kurdistan. *Antiquity Project Gallery* 82 (317).

Moholy-Nagy, H. 1983. Jarmo Artifacts of Pecked and Ground Stone and Shell, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 289–346.

Molist, M. (ed.) 2013. *Tell Halula: Un Poblado De Los Pirmeros Agricutores En El Valle Del Eufrates, Siria. Tomo 1.* Madrid, Ministero de Educacion, Cultura y Deporte.

Molist, M., Palomo, T. and Ferrer, A. 1996. The Evolution of the Tell Halula (Syria) Chipped Stone Industry During the 9–8th Millennia bp. *Neo-Lithics* 1 (96): 5–6.

Molleson, T. I. 2000. The People of Abu Hureyra, in A. M. T. Moore, G. C. Hillman and A. J. Legge. 2000. *Village on the Euphrates: From Foraging to Farming at Abu Hureyra*. Oxford, Oxford University Press: 301–324.

Molnar, S. 1971. Human Tooth Wear, Tooth Function and Cultural Variability. *American Journal of Physical Anthropology* 34 (2): 175–189.

Mook, W.G. 1986. Business meeting: recommendations/resolutions adopted by the twelfth International Radiocarbon Conference. *Radiocarbon* 28, 799.

Moore, A. M. T. and Molleson, T. I. 2000. Disposal of the Dead, in A. M. T. Moore, G. C. Hillman and A. J. Legge. *Village on the Euphrates: From Foraging to Farming at Abu Hureyra*. Oxford, Oxford University Press: 277–299.

Moore, A. M. T., Hillman, G. C. and Legge, A. J. 2000. *Village on the Euphrates: From Foraging to Farming at Abu Hureyra*. Oxford, Oxford University Press.

Moore, H. L. 1982. The Interpretation of Spatial Patterning in Settlement Residues, in I. Hodder (ed.) *Symbolic and Structural Archaeology*. Cambridge, Cambridge University Press.

Moore, J. and Koon, H. E. 2017. Basilar Portion Porosity: A Pathological Lesion Possibly Associated with Infantile Scurvy. *International Journal of Paleopathology* 18: 92–97.

Moore, P. D., Webb, J. A. and Collinson, M. E. 1991. *Pollen Analysis*. Oxford, Blackwell Scientific.

Moorey, P. R. S. 1999. *Ancient Mesopotamian Materials and Industries: The Archaeological Evidence*. Winona Lake, Eisenbrauns.

Morales, J., Mulazzani, S., Belhouchet, L., Zazzo, A., Berrio, L., Eddargach, W., Cervi, A., Hamdi, H., Saidi, M., Coppa, A. and Peña-Chocarro, L. 2015. First Preliminary Evidence for Basketry and Nut Consumption in the Capsian Culture (Ca. 10,000–7500bp): Archaeobotanical Data from New Excavations at El Mekta, Tunisia. *Journal of Anthropological Archaeology* 37: 128–139.

Morandi, L. F. 2018. An Ethnoarchaeological Case Study of Dung Fungal Spore and Faecal Spherulite Taphonomy in a Pastoral Cave Deposit. *Environmental Archaeology* 25 (2): 198–207.

Moreno, E. 2014. Retrospective and Prospective Perspectives on Zoonotic Brucellosis. *Frontiers in Microbiology* 5: 213.

Morin, E. 2007. Fat Composition and Nunamiut Decision-Making: A New Look at the Marrow and Bone Grease Indices. *Journal of Archaeological Science* 34 (1): 69–82.

Morlan, R. E. 1994. Dialogue: Rodent Bones in Archaeological Sites. *Canadian Journal of Archaeology/Journal Canadien d'Archéologie* 18: 135–42.

Morrell, P. L. and Clegg, M. T. 2007. Genetic Evidence for a Second Domestication of Barley (*Hordeum Vulgare*) East of the Fertile Crescent. *Proceedings of the National Academy of Sciences* 104 (9): 3289–3294.

Morris, B., Mullen, S., Schroeppel, P. and Vopat, B. 2017. Open Physeal Fracture of the Distal Phalanx of the Hallux. *The American Journal of Emergency Medicine* 35 (7): 1035. e1–35. e3.

Morrison, K. D. 2012. Great Transformations: On the Archaeology of Cooking, in S. B. Graff and E. Rodríguez-Alegría (eds). *Menial Art of Cooking: Archaeological Studies of Cooking and Food Preparation* Boulder, University of Colorado Press: 231–244.

Morrow, J.J. and Elowsky, C. 2019. Application of Autofluorescence for Confocal Microscopy to Aid in Archaeoparasitological Analyses. *Korean Journal of Parasitology* 57 (6): 581–585.

Mortensen, P. 1970. *Tell Shimshara: The Hassuna Period*. Copenhagen, Det Kongelige Danske Videnskabernes Selskab.

Mortensen, P. 1972. Seasonal Camps and Early Villages in the Zagros, in P. J. Ucko, R. Tringham and G. W. Dimbleby (eds). *Man, Settlement and Urbanism*. London, Duckworth: 293–298.

Mortensen, P. 1983. Patterns of Interaction between Seasonal Settlements and Early Villages, in T. C. Young, P. E. L. Smith and P. Mortensen (eds). *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia Presented to Robert J. Braidwood*. Chicago, Oriental Institute of the University of Chicago Studies in Ancient Oriental Civilization 36: 208–230.

Mortensen, P. 2014. *Excavations at Tepe Guran: The Neolithic Period*. Leeuven, Peeters Acta Iranica.

Moutsiou, T. and Kassianidou, V. 2019. Geochemical Characterisation of Carnelian Beads from Aceramic Neolithic Cyprus Using Portable X-Ray Fluorescence Spectrometry (pXRF). *Journal of Archaeological Science: Reports* 25: 257–265.

Mudd, D. 2011. *The Symbolic World of WF 16: Decorated Artefacts from the 2008–2010 Excavations at Wadi Faynan*

16, Southern Jordan. Unpublished, M. Res. Dissertation, University of Reading.

Mudd, D. 2016. *People and Ground Stone Tools in the Zagros Neolithic - Economic and Social Interpretations of the Assemblage from Bestansur, Iraqi Kurdistan*. Unpublished Ph.D thesis, University of Reading.

Mudd, D. 2019. The Archaeology of Discard and Abandonment: Presence and Absence in the Ground Stone Assemblage from Bestansur, Iraqi Kurdistan, in A. Squitieri and D. Eitam (eds). *Stone Tools in the Ancient Near East and Egypt*. Oxford, Archaeopress: 9–26.

Mühl, S., Rösch, M., Almanmi, D., Kadereit, A. and Aziz, B. 2018. Irrigation in the Shahrizor Plain: The Potential of Archaeological and Geoarchaeological Archives to Reconstruct Ancient Water Management, in H. Kühne and O. Harrassowitz (eds). *Water for Assyria*. Wiesbaden, Harrassowitz: 117–136.

Müldner, G. 2013. Isotope Analysis of Animal Bone, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 159–161.

Mulholland, S. 1992. A Morphological Classification of Grass Silica-Bodies, in G. Rapp Jr and S. C. Mulholland (eds). *Phytolith Systematics. Emerging Issues, Advances in Archaeological and Museum Science*. New York, Plenum Press: 65–89.

Muñiz, A. M. 2010. Inferences About Prehistoric Fishing Gear Based on Archaeological Fish Assemblages, in T. Bekker-Nielsen and D. Bernal Casasola (eds). *Ancient Nets and Fishing Gear: Proceedings of the International Workshop on Nets and Fishing Gear in Classical Antiquity: A First Approach. Cádiz, November 15–17, 2007*. Cádiz, Universidad de Cádiz: 25–43.

Munro, N. D. and Grosman, L. 2010. Early Evidence (ca. 12,000 B.P.) for Feasting at a Burial Cave in Israel. *Proceedings of the National Academy of Sciences* 107 (35): 15362–15366.

Muryy, A. and Glennerster, A. 2018. Pointing Errors in Non-Metric Virtual Environments. *Spatial Cognition* XI (1). Dordrecht, Springer: 43–57.

Myers, P., Espinosa, R., Parr, C., Jones, T., Hammond, G. and Dewey, T. 2017. *The Animal Diversity Web* (Online). from http://animaldiversity.org.

Nadel, D. 2011. Stones in Their Symbolic Context: Epipalaeolithic–Pre-Pottery Neolithic Continuity in the Jordan Valley, in E. Healey, S. Campbell and O. Maeda (eds). *The State of the Stone: Terminologies, Continuities, and Contexts in Near Eastern Lithics*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment 13: 481–448.

Nadel, D., Rosenberg, D. and Yeshurun, R. 2009. The Deep and the Shallow: The Role of Natufian Bedrock Features at Rosh Zin, Central Negev, Israel. *Bulletin of the American Schools of Oriental Research* 355 (1): 1–29.

Naderi, S., Rezaei, H. R., Pompanon, F., Blum, M. G., Negrini, R., Naghash, H. R., Balkiz, O., Mashkour, M., Gaggiotti, O. E., Ajmone-Marsan, P., Kence, A., Vigne, J. D. and Taberlet, P. 2008. The Goat Domestication Process Inferred from Large-Scale Mitochondrial DNA Analysis of Wild and Domestic Individuals. *Proceedings of the National Academy of Sciences* 105 (46): 17659–17664.

Naegele, G. 1899. Eine Neue Pomatia Aus Persien. *Nachrichtsblatt der Deutschen Malakozoologischen Gesellschaft* 31 (1/2): 28–29.

Nagorsen, D. W. 2002. *An Identification Manual to the Small Mammals of British Columbia*. Victoria, British Columbia Ministry of Sustainable Resource Management.

Naji, S., de Becdelievre, C., Djouad, S., Duday, H., André, A. and Rottier, S. 2014. Recovery Methods for Cremated Commingled Remains: Analysis and Interpretation of Small Fragments Using a Bioarchaeological Approach, *Commingled Human Remains: Methods in Recovery, Analysis, and Identification*. Oxford, Elsevier: 33–46.

Nazaroff, A. J., Tsoraki, C. and Vasic, M. 2016. Aesthetic, Social, and Material Networks: A Perspective from the Flint Daggers at Çatalhöyük, Turkey. *Cambridge Archaeological Journal* 26 (1): 65–92.

Nazaroff, A. J., Baysal, A., Çiftçi, Y. and Prufer, K. 2014. Resilience and Redundance: Resource Networks and the Neolithic Chert Economy at Çatalhöyük, Turkey. *European Journal of Archaeology* 18 (3): 402–428.

Nelson, G. C. 2016. A Host of Other Dental Diseases and Disorders, in J. D. Irish and G. R. Scott (eds). *A Companion to Dental Anthropology*. Oxford, Wiley Blackwell: 465–483.

Neri, R. and Lancellotti, L. 2004. Fractures of the Lower Limbs and Their Secondary Skeletal Adaptations: A 20th Century Example of Pre-Modern Healing. *International Journal of Osteoarchaeology* 14 (1): 60–66.

Nesbitt, M. 1992. A Preliminary Note on the Charred Plant Remains, in S. K. Kozlowski (ed.) *Nemrik 9: Pre-Pottery Neolithic Site in Iraq*. 2. Warszawa, Wydawnictwa Uniwersytetu Warszawskiego: 127.

Nesbitt, M. 1993. Archaeobotanical Evidence for Early Dilmun Diet at Saar, Bahrain. *Arabian Archaeology and Epigraphy* 3: 20–47.

Nesbitt, M. 2002. When and Where Did Domesticated Cereals First Occur in Southwest Asia? in R. T. J. Capper and S. Bottema (eds). *The Dawn of Farming in the Near East*. Berlin, ex oriente: 113–132.

Neumann, K., Strömberg, A. E. C., Ball, T., Albert, R. M., Vrydaghs, L., Scott-Cummings, L. and (International Committee for Phytolith Taxonomy) 2019. International Code for Phytolith Nomenclature (ICPN) 2.0. *Annals of Botany* 124 (2): 189–199.

Nicosia, C. and Stoops, G. (eds). 2017. *Archaeological Soil and Sediment Micromorphology*. Hoboken, Wiley.

Nielsen-Marsh, C., Gernaey, A., Turner-Walker, G., Hedges, R., Pike, A. and Collins, M. 2000. The Chemical Degradation of Bone, in M. Cox and S. Mays (eds). *Human Osteology in Archaeology and Forensic Science*. London, Greenwich Medical Media: 439–444.

Nieuwenhuyse, O. P., Berghuijs, K. and Mühl, S. 2012. A Late Neolithic Fishing Net from Kurdistan, Northern Iraq? *Paléorient* 38 (1–2): 141–147.

Nishiaki, Y. 1993. Anatolian Obsidian and the Neolithic Obsidian Industries of North Syria: A Preliminary Review, in H. I. H. Prince Takahito Mikasa (ed.) *Essays on Anatolian Archaeology*. Wiesbaden, Harrassowitz: 140–160.

Nishiaki, Y. 1996. Side-Blow Blade-Flakes from Tell Kashkashok II, Syria: A Technological Study, in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology,* *Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 311–326.

Nishiaki, Y. 2013a. PPNB Flint Blade Production at Tell Seker Al-Aheimar, Upper Khabur, Syria, in Y. Nishiaki, K. Kashima and M. Verhoeven (eds). *Neolithic Archaeology in the Khabur Valley, Upper Mesopotamia and Beyond*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 64–79.

Nishiaki, Y. 2013b. A Reappraisal of the Pottery Neolithic Flaked Stone Assemblages at Tall-I Jari B, Fars, Southwest Iran, in F. Borrell, J. J. Ibáñez Estévez and M. Molist (eds). *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East: Papers Presented to the 7th Conference on PPN Chipped and Ground Stone Industries of the Fertile Crescent*. Bellaterra, Universitat Autònoma de Barcelona, Servei de Publicacions: 349–364.

Nishiaki, Y. 2016. Techno-Typological Observations on the Flaked Stone Industry of the Early Neolithic Settlement of Ganj Dareh, West Iran (the Tehran Collection), in K. Roustaei and M. Mashkour (eds). *The Neolithic of the Iranian Plateau*. Berlin, ex oriente: 189–208.

Niton, T. S. 2010. *Thermo Fisher Scientific Niton Analysers. Xl3 Analyser, Version 7.0.1. User's Guide, Revision C*. www.thermofisher.com.

Norton, J. 1986. *Building with Earth. A Handbook*. Leamington Spa, Salvo Print.

Nowak, J. and Paradiso, J. L. 1983. *Walker's Mammals of the World. Vol. 2*. Baltimore, Johns Hopkins University Press.

O'Connor, T. P. 1991. *Bones from 46–54 Fishergate*. London, Council for British Archaeology/Archaeology of York, the Animal Bones Fascicule 15 (4).

O'Connor, T. P. 2013. *Animals as Neighbours: The Past and Present of Commensal Animals*. Michigan, MSU Press.

Oates, J. 1968. Excavations Near Mandali, Iraq. *Iraq* 30: 1–20.

Oates, J. 1973. The Background and Development of Early Farming Communities in Mesopotamia and the Zagros. *Proceedings of the Prehistoric Society* 39: 147–181.

Oddone, M., Yegingil, Z., Bigazzi, G., Ercan, T. and Özdogan, M. 1997. Chemical Characterisations of Anatolian Obsidians by Instrumental and Epithermal Neutron Activation Analysis. *Journal of Radioanalytical and Nuclear Chemistry* 224 (1): 27–38.

Odell, G. H. 2001. Stone Tool Research at the End of the Millennium: Classification, Function, and Behavior. *Journal of Archaeological Research* 9 (1): 45–100.

Odell, G. H. 2004. *Lithic Analysis*. New York, NY, Springer.

Ogden, A. 2007. Advances in the Palaeopathology of Teeth and Jaws, in S. Mays and R. Pinhasi (eds). *Advances in Human Palaeopathology*. Chichester, Wiley: 283–308.

Ohnuma, K. 1993. Experimental Studies in the Determination of Manners of Micro-Blade Detachment. *Al-Rafidan* 14: 153–181.

Olsen, B. 2010. *In Defense of Things. Archaeology and the Ontology of Objects*. Lanham, Altamira Press.

Olsen, S. L. 2006. Early Horse Domestication on the Eurasian Steppe, in M. A. Zeder, D. Bradley, E. Emshwiller and B. Smith (eds). *Documenting Domestication: New Genetic and Archaeological Paradigms*. Berkeley, University of California Press: 245–267.

Olszewski, D. 2012. The Zarzian in the Context of the Epipaleolithic Middle East. *International Journal of Humanities* 19 (3): 1–20.

Olszewski, D. I. 1994. The PPN Glossed Blades from 'Ain Ghazal, Jordan (1982–85 and 1988–89 Seasons), in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 467–478.

Olszewski, D. I. 1996. The Lithic Transition to the Early Neolithic in the Zagros Region: Zarzian and M'lefatian Industries, in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 183–192.

Oonk, S., Slomp, C. P. and Huisman, D. J. 2009. Geochemistry as an Aid in Archaeological Prospection and Site Interpretation: Current Issues and Research Directions. *Archaeological Prospection* 16 (1): 35–41.

Ortega, D., Ibáñez, J. J., Campos, D., Khalidi, L., Méndez, V. and Teira, L. 2016. Systems of Interaction between the First Sedentary Villages in the Near East Exposed Using Agent-Based Modelling of Obsidian Exchange. *Systems* 4 (2): 18.

Ortner, D. J. 2003. *Identification of Pathological Conditions in Human Skeletal Remains*. San Diego, Academic Press.

Ortner, D. J. and Ericksen, M. F. 1997. Bone Changes in the Human Skull Probably Resulting from Scurvy in Infancy and Childhood. *International Journal of Osteoarchaeology* 7 (3): 212–220.

Orton, C. 2000. *Sampling in Archaeology*. Cambridge, Cambridge University Press.

Outram, A. K. 2001. A New Approach to Identifying Bone Marrow and Grease Exploitation: Why the Indeterminate Fragments Should Not Be Ignored. *Journal of Archaeological Science* 28 (4): 401–410.

Outram, A. K. 2004. Identifying Dietary Stress in Marginal Environments: Bone Fats, Optimal Foraging Theory and the Seasonal Round, in M. Mondini, A. S. Munoz and S. Wickler (eds). *Colonisation, Migration and Marginal Areas: A Zooarchaeological Approach*. Oxford, Oxbow Books: 74–85.

Outram, A. K., Knüsel, C. J., Knight, S. and Harding, A. F. 2005. Understanding Complex Fragmented Assemblages of Human and Animal Remains: A Fully Integrated Approach. *Journal of Archaeological Science* 32 (12): 1699–1710.

Özbal, R. 2000. Microartifact Analysis, in Aslıhan Yener, K., Edens, C., Casana, J., Diebold, B., Ekstrom, H., Loyet M. and Özbal, R. Tell Kurdu Excavations 1999: 49–55. *Anatolica* 26: 31–117.

Özbal, R. 2006. *Households, Daily Practice and Cultural Appropriation at Sixth Millennium Tell Kurdu*. Ph.D. thesis, Northwestern University.

Özbal, R., Gerritsen, F., Diebold, B., Healey, E., Aydın, N., Loyet, M., Nardulli, F., Reese, D., Ekstrom, H. and Sholts, S. 2004. Tell Kurdu Excavations 2001. *Anatolica* 30: 37–108.

Özbek, M. 1988. Culte Des Crânes Humains À Çayönü. *Anatolica* 15: 127–137.

Özdoğan, M. 1999. Çayönü, in M. Özdoğan and N. Başgelen (eds). *Neolithic in Turkey. The Cradle of Civilization, New Discoveries*. Istanbul, Arkeoloji ve Sanat yayýnlarý: 35–63.

Özdoğan, M. and Balkan-Atlı, N. 1994. South-East Anatolian Chipped Stone Sequence, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 205–206.

Özdogan, M. and Başgelen, N. (eds). 1999. *Neolithic in Turkey: The Cradle of Civilization, New Discoveries*. Istanbul, Arkeoloji ve Sanat yayýnlarý.

Özdoğan, M. and Özdoğan, A. 1998. Buildings of Cult and the Cult of Buildings, in G. Arsebük, M. J. Mellink and W. Schirmer (eds). *Light on Top of the Black Hill: Studies Presented to Halet Çambel*. Istanbul, Ege Yayınları: 582–601.

Özkaya, V. 2009. Excavations at Körtik Tepe: A New Pre-Pottery Neolithic a Site in Southeastern Anatolia. *Neo-Lithics* 2 (9): 3–8.

Page, A. E., Viguier, S., Dyble, M., Smith, D., Chaudhary, N., Salali, G. D., Thompson, J., Vinicius, L., Mace, R. and Migliano, A. B. 2016. Reproductive Trade-Offs in Extant Hunter-Gatherers Suggest Adaptive Mechanism for the Neolithic Expansion. *Proceedings of the National Academy of Sciences* 113 (17): 4694–4699.

Panagiotakopulu, E., Buckland, P. C. and Day, P. M. 1995. Natural Insecticides and Insect Repellents in Antiquity: A Review of the Evidence. *Journal of Archaeological Science* 22: 705–710.

Parker, B. J., Foster, C. P., Nicoll, K., Kennedy, J. R., Graham, P., Smith, A., Hopwood, D. E., Hopwood, M., Butler, K., Healey, E., Uzel, M. and Butler, K. 2009. The Upper Tigris Archaeological Research Project (UTARP): A Preliminary Report from the 2007 and 2008 Field Seasons at Kenan Tepe. *Anatolica* 35: 85–152.

Parry, W. and Kelly, R. L. 1987. Expedient Core Technology and Sedentism, in J. K. Johnson and C. A. Morrow (eds). *The Organization of Core Technology*. Boulder, Westview Press: 285–304.

Patterson Jr, D. K. 1984. *A Diachronic Study of Dental Palaeopathology and Attritional Status of Prehistoric Ontario Pre-Iroquois Populations*. Ottawa: Archaeological Survey of Canada Paper 112.

Pawłowska, K. 2014. The Smells of Neolithic Çatalhöyük, Turkey: Time and Space of Human Activity. *Journal of Anthropological Archaeology* 36: 1–11.

Pawlowska, K. and Marciszak, A. 2018. Small carnivores from a Late Neolithic burial chamber at Çatalhöyük, Turkey: pelts, rituals, and rodents. *Archaeological and Anthropological Sciences* 10 (5): 1225–1243.

Payne, S. 1972. Partial Recovery and Sample Bias: The Results of Some Sieving Experiments, in E. S. Higgs (ed.) *Papers in Economic Prehistory*. Cambridge, Cambridge University Press: 49–64.

Payne, S. 1992. *Some Notes on Sampling and Sieving for Animal Bones*. London, Ancient Monuments Laboratory Report 55/92. London, Historic Buildings and Monuments Commission for England.

Payne, S. and Bull, G. 1988. Components of Variation in Measurements of Pig Bones and Teeth, and the Use of Measurements to Distinguish Wild from Domestic Pig Remains. *Archaeozoologia* 2 (1): 2.

Payton, R. 1992. On-Site Conservation Techniques: Lifting Techniques, in R. Rayton (ed.) *Retrieval of Objects from Archaeological Sites*. London, Archetype Publications: 1–26.

Peacock, D. 2013. *The Stone of Life: The Archaeology of Querns, Mills and Flour Production in Europe up to c AD 500*. Southampton, Highfield Press Southampton Monographs in Archaeology new series 1.

Peaker, M. 1978. Gestation Period and Litter Size in the Goat. *British Veterinary Journal* 134 (4): 379–383.

Pearce-Duvet, J. M. 2006. The Origin of Human Pathogens: Evaluating the Role of Agriculture and Domestic Animals in the Evolution of Human Disease. *Biological Reviews* 81 (3): 369–382.

Pearsall, D. M. 2000. *Paleoethnobotany: A Handbook of Procedures*. San Diego and London, Academic Press.

Pearsall, D. M., Chandler-Ezell, K. and Zeidler, J. A. 2004. Maize in Ancient Ecuador: Results of Residue Analysis of Stone Tools from the Real Alto Site. *Journal of Archaeological Science* 31: 423–442.

Peers, L. and Brown, A. K. (eds). 2003. *Museums and Source Communities*. London, Routledge.

Pelegrin, J., Karlin, C. and Bodu, P. 1988. Chaînes Opératoires: Un Outil Pour Le Préhistorien, in J. Tixier (ed.) *Technologie Préhistorique*. Paris, CNRS Notes et Monographies Techniques du Centre De Recherches Archéologiques: 55–62.

Pelling, R., Campbell, G., Carruthers, W., Hunter, K. and Marshall, P. 2015. Exploring Contamination (Intrusion and Residuality) in the Archaeobotanical Record: Case Studies from Central and Southern England. *Vegetation History and Archaeobotany* 24 (1): 85–99.

Pereira, F. and Amorim, A. 2001. Origin and Spread of Goat Pastoralism, *Encyclopedia of Life Sciences*. Chichester, Wiley.

Perry, S., Chrysanthi, A., Kirkpatrick, I., Emond, E., Henderson, A., Hoffman, K., Wheeler, L., Meşe, G., Can Uslu, O. and Can, G. 2015. Site Visualisation and Presentation, in S. D. Haddow (ed.) Çatalhöyük 2014 Archive Report: 173–85. Available at http://www.catalhoyuk.com/archive_reports/2014.

Peters, J., von den Dreisch, A. and Helmer, D. 2005a. The Upper Euphrates–Tigris Basin: Cradle of Agro-Pastoralism?, in J.-D. Vigne, J. Peters and D. Helmer (eds). *The First Steps of Animal Domestication: New Archaeozoological Approaches*. Oxford, Oxbow Books: 96–124.

Peters, J., von den Driesch, A., Pöllath, N. and Schmidt, K. 2005b. Birds in the Megalithic Art of Pre-Pottery Neolithic Göbekli Tepe, Southeast Turkey, in G. Gruppe and J. Peters (eds). *Feathers, Grit and Symbolism: Birds and Humans in the Ancient Old and New Worlds*. Rahden, Marie Leidorf: 223–234.

Peterson, J. 2002. *Sexual Revolutions: Gender and Labor at the Dawn of Agriculture*. Walnut Creek, Alta Mira Press.

Pétrequin, P. and Pétrequin, A.-M. 1993. *Écologie d'un Outil: La Hache de Pierre en Irian Jaya (Indonésie)*. Paris, CNRS.

Pétrequin, P. and Pétrequin, A.-M. 2000. *Ormu Wari – la Hache d'échange en Nouvelle-Guinée*, Paris, Service du Film de Recherche Scientifique.

Petrie, W. M. F. 1888. The Treatment of Small Antiquities. *Archaeological Journal* 45 (1): 85–89.

Peuramaki-Brown, M. M. 2013. Identifying Integrative Built Environments in the Archaeological Record: An Application of New Urban Design Theory to Ancient Urban Spaces. *Journal of Anthropological Archaeology* 32 (4): 577–594.

PhytCore. n.d. Phytcore DB. from www.phytcore.org/phytolith/index.php?rdm=6mxtSxtjCd&action=home.

Pichon, F. 2017. Exploitation of the Cereals During the Pre-Pottery Neolithic of Dja'de-El-Mughara: Preliminary Results of the Functional Study of the Glossy Blades. *Quaternary International* 427: 138–141.

Pigati, J. S., Rech, J. A. and Nekola, J. C. 2010. Radiocarbon Dating of Small Terrestrial Gastropod Shells in North America. *Quaternary Geochronology* 5 (5): 519–532.

Pilloud, M. A. and Larsen, C. S. 2007. Biological Distance Analysis of Households at Neolithic Çatalhöyük, Turkey. *American Journal of Physical Anthropology* 132 S44: 189.

Pilloud, M. A. and Larsen, C. S. 2011. Official and Practical Kin: Inferring Social and Community Structure from Dental Phenotype at Neolithic Çatalhöyük, Turkey. *American Journal of Physical Anthropology* 145 (4): 519–530.

Pilloud, M. A., Haddow, S. D., Knüsel, C. J. and Larsen, C. S. 2016. A Bioarchaeological and Forensic Re-Assessment of Vulture Defleshing and Mortuary Practices at Neolithic Çatalhöyük. *Journal of Archaeological Science: Reports* 10: 735–743.

Pinhasi, R. and Stock, J. T. 2011. *Human Bioarchaeology of the Transition to Agriculture*. Chichester, Wiley.

Piperno, D. R. 1988. *Phytolith Analysis: An Archaeological and Geological Perspective*. London, Academic Press.

Piperno, D. R. 2006. *Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists*. Lanham and Oxford, Alta Mira Press.

Piperno, D. R., Weiss, E., Holst, I. and Nadel, D. 2004. Processing of Wild Cereal Grains in the Upper Palaeolithic Revealed by Starch Grain Analysis. *Nature* 430: 670–673.

Poets, A. M., Fang, Z., Clegg, M. T. and Morrell, P. L. 2015. Barley Landraces Are Characterized by Geographically Heterogeneous Genomic Origins. *Genome Biology* 16 (1): 173.

Pohlman, D. 2004. Catching Science in the Act: Mysteries of Çatalhöyük, in D. Chittenden, G. Farmelo and B. V. Lewenstein (eds). *Creating Connections: Museums and the Public Understanding of Current Research*. Oxford, Alta Mira Press: 267–275.

Poidevin, J.-L. 1998. Gisement d'Obsidienne de Turquie et de Transcaucasie, in M.-C. Cauvin, A. Gourgaud, B. Gratuze, N. Arnaud, G. Poupeau, J.-L. Poidevin and C. Chataigner (eds). *L'Obsidienne au Proche et Moyen Orient: Du Volcan à l'Outil*. Oxford, British Archaeological Reports S738: 105–203.

Pokines, J. T. 2014. Faunal Dispersal, Reconcentration, and Gnawing Damage to Bone in Terrestrial Environments, in J. T. Pokines and S. A. Symes (eds). *Manual of Forensic Taphonomy*. Boca Raton, CRC Press: 201–248.

Pokines, J. T. and Baker, J. E. 2014. Effects of Burial Environment on Osseous Remains, in J. T. Pokines and S. A. Symes (eds). *Manual of Forensic Taphonomy*. Boca Raton, CRC Press: 73–114.

Pollock, S. 2012. Toward an Archaeology of Commensal Spaces. An Introduction. *eTopoi Journal for Ancient Studies* 2 (Special Issue: Between Feasts and Daily Meals: Toward an Archaeology of Commensal Spaces): 1–20.

Pollock, S. and Bernbeck, R. 2010. Neolithic Worlds at Tol-e Basi, in S. Pollock, R. Bernbeck and K. Abdi (eds). *The 2003 Excavations at Tol-e Baši, Iran. Social Life in a Neolithic Village*. Mainz am Rhein, Philipp von Zabern Archäologie in Iran und Turan: 274–287.

Pope, M. 2010. A Microwear Study of Chipped Stone Tools, in S. Pollock, R. Bernbeck and K. Abdi (eds). *The 2003 Excavations at Tol-e Baši, Iran: Social Life in a Neolithic Village*. Mainz am Rhein, Philipp Von Zabern Archäologie in Iran und Turan: 175–181.

Portillo, M. and Albert, R. 2014. Early Crop Cultivation and Caprine Herding: The Phytolith and Faecal Spherulite Evidence, in D. O. Henry (ed.) *The Sands of Time: The Desert Neolithic Settlement at Ayn Abū Nukhayla*. Cambridge, Cambridge University Press.

Portillo, M. and Matthews, W. 2020. Investigating the Use of Space and Human-Animal Interactions in Farming Built Environments: The Geo-Ethnoarchaeology of Livestock Dung, in A. Otto, M. Herles and K. Kaniuth (eds). *Proceedings of the 11th International Congress on the Archaeology of the Ancient NearEast (ICAANE), University of Munich 201, Volume 1*. Wiesbaden, Harrassowitz.

Portillo, M., Albert, R. and Henry, D. 2009. Domestic Activities and Spatial Distribution in Ain Abu Nukhayla (Wadi Rum, Southern Jordan): The Use of Phytoliths and Spherulites Studies. *Quaternary International* 193: 174–183.

Portillo, M., Valenzuela, S. and Albert, R. 2012. Domestic Patterns in the Numidian Site of Althiburos (Northern Tunisia): The Results from a Combined Study of Animal Bones, Dung and Plant Remains. *Quaternary International* 275: 84–96.

Portillo, M., Bofill, M., Molist, M. and Albert, R. M. 2013. Phytolith and Use-Wear Functional Evidence for Grinding Stones from the Near East, in P. A. Anderson, C. Cheval and A. Durand (eds). *Regards Croisés sur les Outils Liés au Travail des Végétaux. An Interdisciplinary Focus on Plant-Working Tools*. Antibes, Éditions APDCA: 205–218.

Portillo, M., Kadowaki, S., Nishiaki, Y. and Albert, R. M. 2014. Early Neolithic Household Behavior at Tell Seker Al-Aheimar (Upper Khabur, Syria): A Comparison to Ethnoarchaeological Study of Phytoliths and Dung Spherulites. *Journal of Archaeological Science* 42: 107–118.

Portillo, M., Belarte, M. C., Ramon, J., Kallala, N., Sanmartí, J. and Albert, R. M. 2017. An Ethnoarchaeological Study of Livestock Dung Fuels from Cooking Installations in Northern Tunisia. *Quaternary International* 431: 131–144.

Portillo, M., García-Suárez, A., Arkadiusz, K., Baranski, M. and Matthews, W. 2019. Animal Penning and Open Area Activity at Neolithic Çatalhöyük, Turkey. *Journal of Anthropological Archaeology* 56: 101–106.

Portillo, M., Garcia-Suarez, A. and Matthews, W. 2020. Livestock Faecal Indicators for Animal Management, Penning, Foddering and Dung Use in Early Agricultural Built Environments in the Konya Plain, Central Anatolia. *Journal of Anthropological and Archaeological Sciences* 12: 40 doi.org/10.1007/s12520-019-00988-0.

Postgate, J. N. 1984. The Historical Geography of the Hamrin Basin. *Sumer* 40: 149–149.

Postgate, N. 1997. Mesopotamian Petrology: Stages in the Classification of the Material World. *Cambridge Archaeological Journal* 7 (2): 205–224.

Potts, D. T. 1997. *Mesopotamian Civilization: The Material Foundations*. Ithaca, Cornell University Press.

Potts, D. T. 2014. *Nomadism in Iran: From Antiquity to the Modern Era*. Oxford, Oxford University Press.

Pournelle, J. R. 2007. Klm to Corona: A Bird's-Eye View of Cultural Ecology and Early Mesopotamian Urbanization, in E. C. Stone (ed.) *Settlement and Society*. Los Angeles, Cotsen Institute of Archaeology University of California: 29–62.

Price, E. O. 1998. Behavioral Genetics and the Process of Animal Domestication, in T. Grandin (ed.) *Genetics and the Behavior of Domestic Animals*. San Diego, Academic Press: 31–66.

Price, E. O. 2002. *Animal Domestication and Behaviour*. Wallingford, CABI Publishing.

Price, M. D. and Arbuckle, B. S. 2015. Early Pig Management in the Zagros Flanks: Reanalysis of the Fauna from Neolithic Jarmo, Northern Iraq. *International Journal of Osteoarchaeology* 25: 441–443.

Price, M. D. and Evin, A. 2017. Long-Term Morphological Changes and Evolving Human-Pig Relations in the Northern Fertile Crescent from 11,000 to 2000 cal. BC. *Archaeological and Anthropological Sciences* 11 (1): 237–241.

Pritchard Parker, M. A. and Torres, J. A. 1998. Analysis of Experimental Debitage from Hammerstone Use and Production: Implications for Ground Stone Use. *Lithic Technology* 23 (2): 139–146.

Proudfoot, B. 1976. The Analysis and Interpretation of Soil Phosphorus in Archaeological Contexts, in D. A. Davidson and M. L. Shackley (eds). *Geoarchaeology*. Boulder, Westview Press: 93–113.

Prummel, W. 1989. Appendix to Atlas for Identification of Foetal Skeletal Elements of Cattle, Horse, Sheep and Pig. *Archaeozoologia* 3 (1/2): 71–78.

Prummel, W. 2003. Animal Husbandry and Mollusc Gathering, in R. Reiders and W. Prummel (eds). *Housing in New Halos: A Hellenistic Town in Thessaly, Greece*. Lisse, Balkema: 175–223.

Prummel, W. and Frisch, H.-J. 1986. A Guide for the Distinction of Species, Sex and Body Side in Bones of Sheep and Goat. *Journal of Archaeological Science* 13 (6): 567–577.

Pullar, J. 1975. *The Neolithic of the Iranian Zagros*. Unpublished PhD thesis, University of London.

Pullar, J. 1977. Early Cultivation in the Zagros. *Iran* 15: 15–38.

Pullar, J. 1990. *Tepe Abdul Hosein: A Neolithic Site in Western Iran. Excavations 1978*. Oxford, British Archaeological Reports S563.

Pullar, J., Yellin, J. and Perlman, I. 1986. Sources of Obsidian from Tepe Abdul Hosein as Determined by Neutron Activation Analysis, in J. S. Olin and J. Blackman (eds). *Proceedings of the 24th International Archaeometry Symposium*. Washington DC, Smithsonian Institution: 389–402.

Quammen, D. 2012. *Spillover: Animal Infections and the Next Human Pandemic*. New York, W. W. Norton & Company.

Quarta, G., Romaniello, L., D'Elia, M., Mastronuzzi, G. and Calcagnile, L. 2007. Radiocarbon Age Anomalies in Pre-and Post-Bomb Land Snails from the Coastal Mediterranean Basin. *Radiocarbon* 49 (2): 817–826.

Querré, G., Herbault, F. and Calligaro, T. 2007. Long Distance Transport of Neolithic Variscite Ornaments Along the European Atlantic Arc Demonstrated by PIXE Analysis 1. *Proceedings of the XI International Conference on PIXE and its Analytical Applications. Peubla, Mexico, May 25–29 2007*. Mexico City, Universidad Nacional Autónoma de México: 381–384.

Querré, G., Calligaro, T., Domínguez-Bella, S. and Cassen, S. 2014. PIXE Analyses over a Long Period: The Case of Neolithic Variscite Jewels from Western Europe (5th–3th Millennium BC). *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms* 318: 149–146.

Quintana-Murci, L., Chaix, R., Wells, R. S., Behar, D. M., Sayar, H., Scozzari, R., Rengo, C., Al-Zahery, N., Semino, O., Santachiara-Benerecetti, A. S., Coppa, A., Ayub, Q., Mohyuddin, A., Tyler-Smith, C., Mehdi, S. Q., Torroni, A. and McElreavey, K. 2004. Where West Meets East: The Complex MtDNA Landscape of the Southwest and Central Asian Corridor. *American Journal of Human Genetics* 74 (5): 827–845.

Quintero, L. A., Wilke, P. J. and Waines, J. G. 1997. Pragmatic Studies of Near Eastern Neolithic Sickle Blades, in H. G. Gebel, Z. A.-K. Kafafi and G. O. Rollefson (eds). *The Prehistory of Jordan, II. Perspectives from 1997*. Berlin, ex oriente: Studies in Early Near Eastern Production, Subsistence, and Environment 4: 263–286.

Radini, A., Nikita, E., Buckley, S., Copeland, L. and Hardy, K. 2017. Beyond Food: The Multiple Pathways for Inclusion of Materials into Ancient Dental Calculus. *American Journal of Physical Anthropology* 162: 71–83.

Rafifar, J. 1996. Remarques sur l'Industrie Lithique Néolithique de l'Iran (10.000–6.000 av. J.-C), in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 405–420.

Rainville, L. 2000. Microdebris Analysis in Early Bronze Age Mesopotamian Households. *Antiquity* 74: 291–292.

Rainville, L. 2001. Micro-Debris Based Functional Analysis of Late Eba Houses: Building Unit IV, in G. Algaze, G. Dinckan, B. Hartenberger, T. Matney, J. Pournelle, L. Rainville, S. Rosen, E. Rupley, D. Schlee and R. Vallet, Research at Titris Höyük in Southeastern Turkey: The 1999 Season: 30–33. *Anatolica* 27: 23–106.

Rainville, L. 2003. Results from Micro-Archaeology in 2001–2002, in G. Emberling and H. Mcdonald, Excavations at Tell Brak 2001–2002: Preliminary Report: 63–72. *Iraq* 65: 1–75.

Rainville, L. 2005a. *Investigating Upper Mesopotamian Households Using Micro-Archaeological Techniques*. Oxford, British Archaeological Reports S1368.

Rainville, L. 2005b. Micro-Archaeology, in T. Matney and L. Rainsville, Archaeological Investigations at Ziyaret Tepe, 2003–2004: 37–39. *Anatolica* 31: 19–68.

Rajabi-Maham, H., Orth, A. and Bonhomme, F. 2008. Phylogeography and Postglacial Expansion of *Mus Musculus Domesticus* Inferred from Mitochondrial DNA Coalescent, from Iran to Europe. *Molecular Ecology* 17 (2): 627–641.

Rajshekar, M., Mithun, T., Idiculla, J. J. and Tennant, M. 2016. Developmental Anomalies of Teeth and Their Applications in Forensic Odontology. *European Journal of Forensic Science* 3 (2): 39–49.

Ramsey, C. B. 2009. Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51 (1): 337–360.

Ramsey, M. N. and Rosen, A. M. 2016. Wedded to Wetlands: Exploring Late Pleistocene Plant-Use in the Eastern Levant. *Quaternary International* 396: 5–19.

Ramsey, M. N., Jones, M., Richter, T. and Rosen, A. M. 2015. Modifying the Marsh: Evaluating Early Epipaleolithic Hunter-Gatherer Impacts in the Azraq Wetland, Jordan. *The Holocene* 25 (10): 1553–1564.

Ramsey, M. N., Maher, L. A., Macdonald, D. A. and Rosen, A. 2016. Risk, Reliability and Resilience: Phytolith Evidence for Alternative 'Neolithization' Pathways at Kharaneh IV in the Azraq Basin, Jordan. *PloS one* 11 (10).

Ramsey, M. N., Maher, L. A., Macdonald, D. A., Nadel, D. and Rosen, A. M. 2018. Sheltered by Reeds and Settled on Sedges: Construction and Use of a Twenty Thousand-Year-Old Hut According to Phytolith Analysis from Kharaneh IV, Jordan. *Journal of Anthropological Archaeology* 50: 85–97.

Rappoport, A. 1990. Systems of Activities and Systems of Settings, in S. Kent (ed.) *Domestic Architecture and the Use of Space*. Cambridge, Cambridge University Press.

Rasmussen, S. O., Andersen, K. K., Svensson, A., Steffensen, J. P., Vinther, B. M., Clausen, H. B., Siggaard-Andersen, M. L., Johnsen, S. J., Larsen, L. B., Dahl-Jensen, D., Bigler, M., Rothlisberger, R., Fischer, H., Goto-Azuma, K., Hansson, M. E. and Ruth, U. 2006. A New Greenland Ice Core Chronology for the Last Glacial Termination. *Journal of Geophysical Research: Atmospheres* 111 (D6).

Rathbun, T. A. 1984. Skeletal Pathology from the Paleolithic through the Metal Ages in Iran and Iraq, in M. N. Cohen and G. J. Armelagos (eds). *Paleopathology at the Origins of Agriculture*. London, Academic Press: 137–168.

Redding, R. W. 1981. *Decision Making in Subsistence Herding of Sheep and Goats in the Middle East*. Ph.D. thesis, University of Michigan.

Reddy, S. N. 1998. Fueling the Hearths in India: The Role of Dung in Paleoethnobotanical Interpretation. *Paléorient* 24 (2): 61–70.

Redfern, R. 2008. New Evidence for Iron Age Secondary Burial Practice and Bone Modification from Gussage All Saints and Maiden Castle (Dorset, England). *Oxford Journal of Archaeology* 27 (3): 281–301.

Redman, C. L. 1973. Early Village Technology: A View through the Microscope. *Paléorient* 1: 249–261.

Redman, C. L. 1982. The Çayönü Chipped Stone Industry: The 1968 and 1970 Excavation Seasons, in L. S. Braidwood and R. J. Braidwood (eds). *Prehistoric Village Archaeology in South-Eastern Turkey: The Eighth Millenium B.C. Site at Çayönü, Its Chipped and Ground Stone Industries and Faunal Remains*. Oxford, British Archaeological Reports S138: 17–71.

Reed, C. A. 1958. Observations on the Burrowing Rodent *Spalax* in Iraq. *Journal of Mammalogy* 39 (3): 386–389.

Reed, C. A. 1962. Snails on a Persian Hillside. *Postilla* 66: 1–20.

Reed, K. and Ryan, P. 2019. Lessons from the Past and the Future of Food. *World Archaeology* 51 (1): 1–16.

Reich, D. 2018. *Who We Are and How We Got Here: Ancient DNA and the New Science of the Human Past*. Oxford, Oxford University Press.

Reid, D. J. and Dean, M. C. 2000. Brief Communication: The Timing of Linear Hypoplasias on Human Anterior Teeth. *American Journal of Physical Anthropology* 113 (1): 135–139.

Reille, M. 1992. *Pollen et Spores d'Europe et d'Afrique du Nord*. Marseille, Laboratoire de botanique historique et palynologie, CNRS.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Ramsey, C. B., Buck, C. E., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatte, C., Heaton, T. J., Hoffmann, D. L., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Staff, R. A., Turney, C. S. M. and van der Plicht, J. 2013. Intcal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years Cal BP. *Radiocarbon* 55 (4): 1869–1887.

Reitz, E. J., Reitz, E. and Wing, E. S. 1999. *Zooarchaeology*. Cambridge, Cambridge University Press.

Renfrew, C. 1977. The Later Obsidian of Deh Luran – the Evidence of Chagha Sefid, in Hole (ed.) 1977: 289–311.

Renfrew, C. 2004. Towards a Theory of Material Engagement, in E. DeMarrais, C. Gosden and C. Renfrew (eds). *Rethinking Materiality: The Engagement of Mind with the Material World*. Cambridge, Cambridge University Press: 23–32.

Renfrew, C., Dixon, J. E. and Cann, J. R. 1966. Obsidian and Early Cultural Contact in the Near East. *Proceedings of the Prehistoric Society* 32: 30–72.

Renfrew, C., Dixon, J. E. and Cann, J. R. 1969. Further Analysis of Near Eastern Obsidians. *Proceedings of the Prehistoric Society* 34: 319–331.

Reuter, J., Buenning, N. and Yoshimura, K. 2018. Evaluating Hydrological Influences on Mid-Latitude δ18Op in the Middle East. *Climate Dynamics* 50 (9–10): 3153–3170.

Richardson, A. 2017. Neolithic Materials and Materiality in the Foothills of the Zagros Mountains, in T. Pereira, X. Terradas and N. Bicho (eds). *The Exploitation of Raw Materials in Prehistory: Sourcing, Processing and Distribution*. Newcastle upon Tyne, Cambridge Scholars Publishing: 506–519.

Richardson, A. 2019. Pre-Pottery Clay Innovation in the Zagros Foothills. *Oxford Journal of Archaeology* 38 (1): 2–17.

Richardson, L. 2014. *Public Archaeology in a Digital Age*. Unpublished Ph.D, thesis, University College London.

Richter, T., Garrard, A. N., Allock, S. and Maher, L. A. 2011. Interaction before Agriculture: Exchanging Material and Sharing Knowledge in the Final Pleistocene Levant. *Cambridge Archaeological Journal* 21: 95–114.

Ridout-Sharpe, J. 2015. Changing Lifestyles in the Northern Levant: Late Epipalaeolithic and Early Neolithic Shells from Tell Abu Hureyra. *Quaternary International* 390: 102–116.

Riehl, S. 2008. Climate and Agriculture in the Ancient Near East: A Synthesis of the Archaeobotanical and Stable Carbon Isotope Evidence. *Vegetation History and Archaeobotany* 17 (Suppl. 1): S43-S51.

Riehl, S. 2012. Variability in Ancient Near Eastern Environmental and Agricultural Development. *Journal of Arid Environments* 86: 113–21.

Riehl, S. 2016. The Role of the Local Environment in the Slow Pace of Emerging Agriculture in the Fertile Crescent. *Journal of Ethnobiology* 36 (3): 512–34.

Riehl, S., Benz, M., Conard, N., Darabi, H., Deckers, K., Nashli, H. and Zeidi-Kulehparcheh, M. 2012. Plant Use in Three Pre-Pottery Neolithic Sites of the Northern and Eastern Fertile Crescent: A Preliminary Report. *Vegetation History and Archaeobotany* 21 (2): 95–106.

Riehl, S., Zeidi, M. and Conard, N. J. 2013. Emergence of Agriculture in the Foothills of the Zagros Mountains of Iran. *Science* 341 (6141): 65–67.

Riehl, S., Pustovoytov, K. E., Weippert, H., Klett, S. and Hole, F. 2014. Drought Stress Variability in Ancient Near Eastern Agricultural Systems Evidenced by $\Delta^{13}C$ in Barley Grain. *Proceedings of the National Academy of Sciences of the United States of America* 111 (34): 12348–12353.

Riehl, S., Asouti, E., Karakaya, D., Starkovich, B. M., Zeidi, M. and Conard, N. J. 2015. Resilience at the Transition to Agriculture: The Long-Term Landscape and Resource Development at the Aceramic Neolithic Tell Site of Chogha Golan (Iran). *BioMed Research International* 2015. https://doi.org/10.1155/2015/532481

Rifkin, R. 2011. Assessing the Efficacy of Red Ochre as a Prehistoric Hide Tanning Ingredient. *Journal of African Archaeology* 9 (2): 131–148.

Rinaldo, N., Zedda, N., Bramanti, B., Rosa, I. and Gualdi-Russo, E. 2019. How Reliable Is the Assessment of Porotic Hyperostosis and Cribra Orbitalia in Skeletal Human Remains? A Methodological Approach for Quantitative Verification by Means of a New Evaluation Form. *Archaeological and Anthropological Sciences* 11: 3549–3559.

Rivera, F. and Mirazón Lahr, M. 2017. New Evidence Suggesting a Dissociated Etiology for Cribra Orbitalia and Porotic Hyperostosis. *American Journal of Physical Anthropology* 164 (1): 76–96.

Rizner, M., Vukosavljević, N. and Miracle, P. 2009. The Paleoecological and Paleodietary Significance of Edible Land Snails (*Helix* sp.) across the Pleistocene–Holocene Transition on the Eastern Adriatic Coast, in S. McCartan, R. Schulting, G. Warren and P. Woodman (eds). *Mesolithic Horizons. Papers Presented at the Seventh International Conference on the Mesolithic in Europe, Belfast*. Oxford, Oxbow Books: 527–532.

Robb, J. 2010. Beyond Agency. *World Archaeology* 42 (4): 493–520.

Robb, J. 2013. Material Culture, Landscapes of Action, and Emergent Causation: A New Model for the Origins of the European Neolithic. *Current Anthropology* 54 (6): 657–683.

Roberts, N. 1998. *The Holocene*. Oxford, Blackwell.

Roberts, N. 2002. Did Prehistoric Landscape Management Retard the Post-Glacial Spread of Woodland in southwest Asia? *Antiquity* 76: 1002–1010.

Roberts, N. 2013. *The Holocene: An Environmental History*. Chichester, Wiley.

Roberts, N. and Rosen, A. 2009. Diversity and Complexity in Early Farming Communities of Southwest Asia: New Insights into the Economic and Environmental Basis of Neolithic Çatalhöyük. *Current Anthropology* 50 (3): 393–402.

Roberts, N., Jones, M., Benkaddour, A., Eastwood, W., Filippi, M., Frogley, M., Lamb, H., Leng, M., Reed, J. and Stein, M. 2008. Stable Isotope Records of Late Quaternary Climate and Hydrology from Mediterranean Lakes: The Isomed Synthesis. *Quaternary Science Reviews* 27 (25–26): 2426–2441.

Roberts, N., Woodbridge, J., Bevan, A., Palmisano, A., Shennan, S. and Asouti, E. 2018. Human Responses and Non-Responses to Climatic Variations During the Last Glacial–Interglacial Transition in the Eastern Mediterranean. *Quaternary Science Reviews* 184: 47–67.

Robin, A. K., Mouralis, D., Akköprü, E., Gratuze, B., Kuzucuoğlu, C., Nomade, S., Pereira, A., Doğu, A. F., Erturaç, K. and Khalidi, L. 2016. Identification and Characterization of Two New Obsidian Sub-Sources in the Nemrut Volcano (Eastern Anatolia, Turkey): The Sıcaksu and Kayacık Obsidian. *Journal of Archaeological Science Reports* 9: 705–717.

Robinson, S. A., Black, S., Sellwood, B. W. and Valdes, P. J. 2006. A Review of Palaeoclimates and Palaeoenvironments in the Levant and Eastern Mediterranean from 25,000 to 5000 Years BP: Setting the Environmental Background for the Evolution of Human Civilisation. *Quaternary Science Reviews* 25 (13–14): 1517–1541.

Rogers, J. and Waldron, T. 1995. *A Field Guide to Joint Disease in Archaeology*. Chichester, Wiley.

Rohling, E. J., Grant, K. M., Roberts, A. P. and Larrasoaña, J.-C. 2013. Paleoclimate Variability in the Mediterranean and Red Sea Regions During the Last 500,000 Years. *Current Anthropology* 54 (S8): S183–S201.

Rokitta, D. 2006. Obsidian Tools of the Near Eastern Neolithic: The Çayönü Tools. *Neo-Lithics* 1 (6): 44.

Roksandič, M. 2002. Position of Skeletal Remains as a Key to Understanding Mortuary Behavior, in L. D. Hager and M. H. Sorg (eds). *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. Boca Raton, CRC Press: 99–117.

Rollefson, G. 1984. 'Ain Ghazal: An Early Neolithic Community in Highland Jordan, near Amman. *Bulletin of the American Schools of Oriental Research* 255: 3–14.

Rollefson, G. and Kafafi, Z. 1996. The 1995 Season at 'Ain Ghazal: Preliminary Report. *Annual of the Department of Antiquities of Jordan* 39: 11–28.

Rondelli, B., Lancelotti, C., Madella, M., Pecci, A., Balbo, A., Pérez, J. R., Inserra, F., Gadekar, C., Ontiveros, M. Á. C. and Ajithprasad, P. 2014. Anthropic Activity Markers and Spatial Variability: An Ethnoarchaeological Experiment in a Domestic Unit of Northern Gujarat (India). *Journal of Archaeological Science* 41: 482–492.

Rosen, A. M. 1986. *Cities of Clay. The Geoarchaeology of Tells*. Chicago, University Press of Chicago.

Rosen, A. M. 1992. Preliminary Identification of Silica Skeletons from Near Eastern Archaeological Sites: An Anatomical Approach, in G. Rapp and S. C. Mulholland (eds). *Phytolith Systematics: Emerging Issues*. New York, Plenum Press: 129–147.

Rosen, A. M. 1993. Microartifacts as a Reflection of Cultural Factors in Site Formation, in P. Goldberg, D. T. Nash and M. D. Petraglia (eds). *Formation Processes in Archaeological Context*. Madison, Prehistory Press: 141–148.

Rosen, A. M. 1999. Phytolith Analysis in Near Eastern Archaeology, in S. Pike and S. Gitin (eds). *The Practical Impact of Science on Aegean and Near Eastern Archaeology*. London, Archetype Press: 86–92.

Rosen, A. M. 2003. Preliminary Phytolith Analyses, in A. Alizadeh (ed.) *Excavations at the Prehistoric Mound of Chogha Bonut, Khuzestan, Iran*. Chicago, Oriental Institute of the University of Chicago Publications 120: 129–135.

Rosenberg, D. 2010. Early Maceheads in the Southern Levant: A Chalcolithic Hallmark in Neolithic Context. *Journal of Field Archaeology* 35 (2): 204–216.

Rosenberg, D. 2013. Not 'Just Another Brick in the Wall?' the Symbolism of Groundstone Tools in Natufian and Early Neolithic Southern Levantine Constructions. *Cambridge Archaeological Journal* 23 (2): 185–201.

Rosenberg, D. and Garfinkel, Y. 2014. *Sha'ar Hagolan 4. The Ground Stone Industry at the Dawn of Pottery Production in the Southern Levant*. Jerusalem, Israel Exploration Society and The Hebrew University of Jerusalem.

Rosenberg, D. and Gopher, A. 2010. Food Processing Tools and Other Groundstone Implements from Gilgal I and Gilgal III, in O. Bar-Yosef, A. N. Goring-Morris and A. Gopher (eds). *Gilgal. Early Neolithic Occupations in the Lower Jordan Valley: The Excavations of Tamar Noy*. Oxford, Oxbow Books: 139–175.

Rosenberg, D. and Nadel, D. 2014. The Sounds of Pounding: Boulder Mortars and Their Significance to Natufian Burial Customs. *Current Anthropology* 55 (6): 784–812.

Rosenberg, D., Shimmelmitz, R. and Nativ, A. 2008. Basalt Bifacial Tool Production in the Southern Levant: A Glance at the Quarry and Workshop Site of Giv'at Kipod, Israel. *Antiquity* 82: 367–376.

Rosenberg, M. 1994. A Preliminary Description of Lithic Industry from Hallan Çemi, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 223–238.

Rosenberg, M. and Erim-Özdoğan, A. 2011. The Neolithic in Southeastern Anatolia, in S. R. Steadman and J. G. McMahon (eds). *The Oxford Handbook of Ancient Anatolia: 10,000–323 B.C.E*. Oxford, Oxford University Press: 125–149.

Rosenberg, M. and Rocek, T. R. 2019. Socio-Political Organization in the Aceramic Neolithic of Southwestern Asia: The Complex Evolution of Socio-Political Complexity. *Journal of Anthropological Archaeology* 54: 17–30.

Rosenzweig, M. S. 2016. Ordering the Chaotic Periphery: The Environmental Impact of the Neo-Assyrian Empire on Its Provinces, in J. MacGinnis, D. Wicke and T. Greenfield (eds). *The Provincial Archaeology of the Assyrian Empire*. Cambridge, McDonald Institute for Archaeological Research: 49–58.

Rossignol-Strick, M. 1995. Sea-Land Correlation of Pollen Records in the Eastern Mediterranean for the Glacial-Interglacial Transition: Biostratigraphy Versus Radiometric Time-Scale. *Quaternary Science Reviews* 14 (9): 893–915.

Rössner, C., Deckers, K., Benz, M., Özkaya, V. and Riehl, S. 2018. Subsistence Strategies and Vegetation Development at Aceramic Neolithic Körtik Tepe, Southeastern Anatolia, Turkey. *Vegetation History and Archaeobotany* 27 (1): 15–29.

Roth, K. and Tsu, M. 2002. Conservation of Unfired Earth Artifacts on Archaeological Sites, *Field Notes: Practical Guides for Archaeological Conservation and Site Preservation* 14 Tokyo, Japanese Institute of Anatolian Archaeology: 1–6.

Rountree, K. 2006. Performing the Divine: Neo-Pagan Pilgrimages and Embodiment at Sacred Sites. *Body & Society* 12 (4): 95–115.

Rountree, K. 2007. Archaeologists and Goddess Feminists at Çatalhöyük: An Experiment in Multivocality. *Journal of Feminist Studies in Religion* 23 (2): 7–26.

Roustaei, K. and Mashkour, M. (eds). 2016. *The Neolithic of the Iranian Plateau*. Berlin, ex oriente.

Roustaei, K., Alamdari, K. and Petrie, C. A. 2006. Landscape and Environment in Mamasani, in D. T. Potts and K. Roustaei (eds). *The Mamasani Archaeological Project Stage One: A Report on the First Two Seasons of the ICAR - University of Sydney Expedition to the Mamasani District, Fars Province, Iran*. Tehran, Iranian Center for Archaeological Research, Deputy of Research: 17–30.

Rowan, Y. and Levy, T. 2011. Transitions in Macehead Manufacture in the Ancient Levant: A Case Study from Nahal Tillah (Tel Halif Terrace) Israel, in M. S. Chesson (ed.). *Daily Life, Materiality, and Complexity in Early Urban Communities of the Southern Levant: Papers in Honor of Walter E. Rast and R. Thomas Schaub*. Winona Lake, Eisenbrauns: 199–218.

Rowan, Y. M. 2014. Foreword, in B. Howe (ed.). *Barda Balka.* Chicago, Oriental Institute Communications 31: ix–xii.

Rowan, Y. M. and Golden, J. 2009. The Chalcolithic Period of the Southern Levant: A Synthetic Review. *Journal of World Prehistory* 22 (1): 1–92.

Rowley-Conwy, P. 2018. Zooarchaeology and the Elusive Feast: From Performance to Aftermath. *World Archaeology* 50 (6): 1–21.

Rubin, M., Likins, R. C. and Berry, E. G. 1963. On the Validity of Radiocarbon Dates from Snail Shells. *Journal of Geology* 71 (1): 84–89.

Ruddiman, W. F. 2003. Orbital Insolation, Ice Volume, and Greenhouse Gases. *Quaternary Science Reviews* 22 (15–17): 1597–1629.

Ruddiman, W. F., Ellis, E. C., Kaplan, J. O. and Fuller, D. Q. 2015. Defining the Epoch We Live In: Is a Formally Designated Anthropocene a Good Idea? *Science* 348 (6230): 38–39.

Ruiz-Calderon, J. F., Cavallin, H., Song, S. J., Novoselac, A., Pericchi, L. R., Hernandez, J. N., Rios, R., Branch, O. H., Pereira, H., Paulino, L. C., Blaser, M. J., Knight, R. and Dominguez-Bello, M. G. 2016. Walls Talk: Microbial Biogeography of Homes Spanning Urbanization. *Science Advances* 2 (2), e1501061.

Rule, A. C. 2006. Editorial: The Components of Authentic Learning. *Journal of Authentic Learning* 3 (1): 1–10.

Russell, N. 1995. The Bone Tool Industry at Mehrgarh and Sibri, in C. Jarrige, J.-F. Jarrige, R. H. Meadow and G. Quivron (eds). *Mehrgarh: Field Reports 1974–1985 from Neolithic Times to the Indus Civilization*. Karachi, Department of Culture and Tourism.

Russell, N. 2005. Çatalhöyük Worked Bone, in Hodder (ed.) 2005a: 339–367.

Russell, N. 2019. Spirit Birds at Neolithic Çatalhöyük. *Environmental Archaeology* 24 (4): 377–386.

Russell, N. and Martin, L. 2005. The Çatalhöyük Mammal Remains, in I. Hodder (ed.). *Inhabiting Çatalhöyük*. Cambridge, McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara: 33–98.

Russell, N. and Martin, L. 2012. Cooking Meat and Bones at Neolithic Çatalhöyük, in S. B. Graff and E. Rodríguez-Alegría (eds). *The Menial Art of Cooking: Archaeological Studies of Cooking and Food Production.* Boulder, University Press of Colorado: 87–97.

Russell, N. and McGowan, K. J. 2003. Dance of the Cranes: Crane Symbolism at Çatalhöyük and Beyond. *Antiquity* 77 (297): 445–445.

Russell, N. and McGowan, K. J. 2012. Bird Remains from the BACH Area, in R. Tringham and M. Stevanović (eds). *Last House on the Hill: BACH Area Reports from Çatalhöyük, Turkey*. Los Angeles, Cotsen Institute of Archaeology Press: 243–242.

Rutherford, D. 2019. Patchy Anthropocene: Frenzies and

Afterlives of Violent Simplifications: Wenner-Gren Symposium Supplement 20. *Current Anthropology* 60 (S20): S183–S85.

Saeed Ali, S. 2007. *Geology and Hydrogeology of Sharazoor - Pirmagroon Basin in Sulaimani Area, Northeastern Iraq*. Ph.D. thesis, University of Belgrade.

Saeed Ali, S., Aziz, B. Q. and Al-Manmi, D. A. M. 2012. Hydrogeology and Geophysical Investigation of Ganau Lake, Ranya Area, Iraqi Kurdistan Region. *Iraqi Bulletin of Geology and Mining* 8 (1): 31–46.

Saeedi, S. 2010. Microdebris Analysis, in S. Pollock, R. Bernbeck and K. Abdi (eds). *The 2003 Excavations at Tol-e Baši, Iran. Social Life in a Neolithic Village*. Archäologie in Iran Und Turan. Mainz am Rhein, Philipp von Zabern: 246–255.

Saisho, D. and Purugganan, M. D. 2007. Molecular Phylogeography of Domesticated Barley Traces Expansion of Agriculture in the Old World. *Genetics* 177 (3): 1765–1776.

Samuel, D. 1996. Approaches to the Archaeology of Food. *Petits Propos Culinaires* 54: 12–21.

Santana, J., Velasco, J., Balbo, A., Iriarte, E., Zapata, L., Teira, L., Nicolle, C., Braemer, F. and Ibáñez, J. J. 2015. Interpreting a Ritual Funerary Area at the Early Neolithic Site of Tell Qarassa North (South Syria, Late 9th Millennium BC). *Journal of Anthropological Archaeology* 37: 112–127.

Satterthwait, L. D. 1986. Aboriginal Australian Net Hunting. *Mankind* 16 (1): 31–48.

Saunders, N. J. 2004. The Cosmic Earth: Materiality and Mineralogy in the Americas, in N. Boivin and M. A. Owoc (eds). *Soils, Stones and Symbols. Cultural Perceptions of the Mineral World*. London, UCL Press: 123–142.

Savard, M., Nesbitt, M. and Jones, M. K. 2006. The Role of Wild Grasses in Subsistence and Sedentism: New Evidence from the Northern Fertile Crescent. *World Archaeology* 38 (2): 179–196.

Schadla-Hall, T. 1999. Editorial: Public Archaeology. *European Journal of Archaeology* 2 (2): 147–148.

Scheu, A., Powell, A., Bollongino, R., Vigne, J.-D., Tresset, A., Çakırlar, C., Benecke, N. and Burger, J. 2015. The Genetic Prehistory of Domesticated Cattle from Their Origin to the Spread across Europe. *BMC Genetics* 16: 1–11.

Scheuer, J. L., Musgrave, J. H. and Evans, S. P. 1980. The Estimation of Late Fetal and Perinatal Age from Limb Bone Length by Linear and Logarithmic Regression. *Annals of Human Biology* 7 (3): 257–265.

Schiffer, M. B. 1972. Archaeological Context and Systemic Context. *American Antiquity* 37 (2): 156–165.

Schiffer, M. B. 1976. *Behavioral Archeology*. New York, Academic Press.

Schiffer, M. B. 1978. Methodological Issues in Ethnoarchaeology, in R. A. Gould (ed.) *Explorations in Ethnoarchaeology*. Albuquerque, University of New Mexico Press: 229–247.

Schiffer, M. B. 1983. Towards the Identification of Formation Processes. *American Antiquity* 48 (4): 675–706.

Schiffer, M. B. 1987. *Formation Processes of the Archaeological Record*. Albuquerque, University of New Mexico Press.

Schlanger, N. 1994. Mindful Technology: Unleashing the Chaîne Opératoire for an Archaeology of Mind, in C. Renfrew and E. B. W. Zubrow (eds). *The Ancient Mind: Elements of Cognitive Archaeology*. Cambridge, Cambridge University Press: 143–141.

Schmaltz, R. F. 1960. Flint and the Patination of Flint Artefacts. *Proceedings of the Prehistoric Society* 26: 44–49.

Schmandt-Besserat, D. 1979. Reckoning before Writing. *Archaeology* 32: 22–31.

Schmandt-Besserat, D. 1992a. *Before Writing, Volume 1: From Counting to Cuneiform*. Austin, University of Texas Press.

Schmandt-Besserat, D. 1992b. *Before Writing, Volume 2: A Catalogue of Near Eastern Tokens*. Austin, University of Texas Press.

Schmandt-Besserat, D. 2013. The Human Clay Figurines and Ancient Near Eastern Magic, in D. Schmandt-Besserat (ed.) *Symbols at 'Ain Ghazal*. Berlin, ex oriente 'Ain Ghazal Excavation Report 3: 113–167.

Schmid-Holmes, S., Drickamer, L. C., Robinson, A. S. and Gillie, L. L. 2001. Burrows and Burrow-Cleaning Behavior of House Mice (*Mus Musculus Domesticus*). *American Midland Naturalist* 146 (1): 53–63.

Schmidt, A. 2007. Archaeology, Magnetic Methods, in D. Gubbins and E. Herrero-Bervera (eds). *Encyclopedia of Geomagnetism and Paleomagnetism*. Dordrecht, Springer Science & Business Media: 23–31.

Schmidt, A., Quigley, M., Fattahi, M., Azizi, G., Maghsoudi, M. and Fazeli, H. 2011. Holocene Settlement Shifts and Palaeoenvironments on the Central Iranian Plateau: Investigating Linked Systems. *The Holocene* 21 (4): 583–595.

Schmidt, E. 1972. *Atlas of Animal Bones for Prehistorians, Archaeologists and Quaternary Geologists*. Amsterdam, Elsevier.

Schmidt, K. 1994. The Nevali Çori Industry. Status of Research, in H. G. Gebel and S. K. Kozłowski (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent: Proceedings of the First Workshop on PPN Chipped Lithic Industries, Seminar für Vorderasiatrische Altertumskunde, Free University of Berlin, 29th March–2nd April, 1993*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 239–242.

Schmidt, K. 2000. Göbekli Tepe, Southeastern Turkey. A Preliminary Report on the 1995–1999 Excavations. *Paléorient* 26 (1): 45–54.

Schneider, J. 1996. Quarrying and Production of Milling Implements at Antelope Hill, Arizona. *Journal of Field Archaeology* 23 (3): 299–311.

Schneider, J. 2010. *Texture and Selection of Stone for Milling Tools: Testing the Hypothesis*. Sacramento, California State Parks.

Schotsmans, E. M. J., Fletcher, J. N., Denton, J., Janaway, R. C. and Wilson, A. S. 2014. Long-Term Effects of Hydrated Lime and Quicklime on the Decay of Human Remains Using Pig Cadavers as Human Body Analogues: Field Experiments. *Forensic Science International* 238: 141. e1–141.e13.

Schotsmans, E. M. J., Van de Vijver, K., Wilson, A. S. and Castex, D. 2015. Interpreting Lime Burials. A Discussion in Light of Lime Burials at St. Rombout's Cemetery in Mechelen, Belgium (10th–18th centuries). *Journal of Archaeological Science: Reports* 3: 464–479.

Schulting, R. J. and Wysocki, M. 2005. 'In This Chambered Tumulus Were Found Cleft Skulls …': An Assessment of the Evidence for Cranial Trauma in the British Neolithic. *Proceedings of the Prehistoric Society* 71: 107–138.

Schweingruber, F. H. 1990. *Anatomy of European Woods*. Stuttgart, Haupt.

Sciuto, C., Geladi, P., La Rosa, L., Linderholm, J. and Thyrel, M. 2019. Hyperspectral Imaging for Characterization of

Lithic Raw Materials: The Case of a Mesolithic Dwelling in Northern Sweden. *Lithic Technology* 44 (1): 22–35.

Scott, A. C. and Damblon, F. D. 2010. Charcoal: Taphonomy and Significance in Geology, Botany and Archaeology. *Palaeogeography, Palaeoclimatology, Palaeoecology* 291: 1–10.

Scott, J. C. 2017. *Against the Grain: A Deep History of the Earliest States*. Yale, Yale University Press.

Scott, R. M. and Halcrow, S. E. 2017. Investigating Weaning Using Dental Microwear Analysis: A Review. *Journal of Archaeological Science: Reports* 11: 1–11.

Scott-Cummings, L. 2011. Pollen/Starch Washes from Groundstone and Vessels. Retrieved 10 February, 2013, from http://www.paleoresearch.com/mainsite/services/2012%20New%20Site/Pollen%20Starch.html.

Sease, C. 1992. *A Conservation Manual for the Field Archaeologist*. Los Angeles, Cotsen Institute of Archaeology, UCLA.

Sebbane, M. 1998. *The Macehead in Canaan in the Fifth Millennium and the Beginning of the Fourth Millennium B.C.E.: Typology, Technology, Use and Foreign Relations. Unpublished M.A. thesis [in Hebrew]*, The Hebrew University of Jerusalem.

Sebbane, M. 2009. *The Mace in Israel and the Ancient Near East from the Ninth Millennium to the First. Unpublished Ph.D. thesis [in Hebrew]*, Tel Aviv University.

Semenov, S. A. 1964. *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artifacts from Traces of Manufacture and Wear*. London, Cory Adams & MacKay.

Semple, S. 2018. Editorial. *World Archaeology* 50 (1): 1–6.

Serjeantson, D. 2009. *Birds*. Cambridge, Cambridge University Press Cambridge Manuals in Archaeology.

Shah, S., Rodina, L., Burt, J. M., Gregr, E. J., Chapman, M., Williams, S., Wilson, N. J. and McDowell, G. 2018. Unpacking Social-Ecological Transformations: Conceptual, Ethical and Methodological Insights. *Anthropocene Review*: 250–246.

Shahack-Gross, R. 2011. Herbivorous Livestock Dung: Formation, Taphonomy, Methods for Identification, and Archaeological Significance. *Journal of Archaeological Science* 38 (2): 205–218.

Shahack-Gross, R. 2017. Archaeological Formation Theory and Geoarchaeology: State-of-the-Art in 2016. *Journal of Archaeological Science* 79: 36–43.

Shahack-Gross, R., Marshall, F. and Weiner, S. 2003. Geo-Ethnoarchaeology of Pastoral Sites: The Identification of Livestock Enclosures in Abandoned Maasai Settlements. *Journal of Archaeological Science* 30: 439–449.

Shahack-Gross, R., Albert, R., Gilboa, A., Nagar-Hilman, O., Sharon, I. and Weiner, S. 2005. Geoarchaeology in an Urban Context: The Uses of Space in a Phoenician Monumental Building at Tell Dor (Israel). *Journal of Archaeological Science* 32: 1417–1431.

Shankland, D. 1999. Integrating the Past: Folklore, Mounds and People at Çatalhöyük, in A. Gazin-Schwartz and C. Holtorf (eds). *Archaeology and Folklore*. London, Routledge: 139–147.

Shankland, D. 2000. Villagers and the Distant Past: Three Seasons of Work at Küçükköy, Çatalhöyük, in I. Hodder (ed.) 2000. *Towards Reflexive Method in Archaeology: The Example at Çatalhöyük*. Cambridge, McDonald Institute for Archaeological Research.

Sharifi, A., Pourmand, A., Canuel, E. A., Ferer-Tyler, E., Peterson, L. C., Aichner, B., Feakins, S. J., Daryaee, T., Djamali, M. and Beni, A. N. 2015. Abrupt Climate Variability since the Last Deglaciation Based on a High-Resolution, Multi-Proxy Peat Record from NW Iran: The Hand That Rocked the Cradle of Civilization? *Quaternary Science Reviews* 123: 215–230.

Shepperson, M. 2009. Planning for the Sun: Urban Forms as a Mesopotamian Response to the Sun. *World Archaeology* 41 (3): 363–378.

Sherratt, A. 1981. Plough and Pastoralism: Aspects of the Secondary Products Revolution, in I. Hodder, G. Isaac and N. Hammond (eds). *Pattern of the Past*. Cambridge, Cambridge University Press: 261–306.

Sherratt, A. 1983. The Secondary Exploitation of Animals in the Old World. *World Archaeology* 15 (1): 90–104.

Sherwood, S. C., Simek, J. F. and Polhemus, R. R. 1995. Artifact Size and Spatial Process: Macro-and Microartifacts in a Mississippian House. *Geoarchaeology* 10 (6): 429–445.

Shillito, L.-M. 2013. Grains of Truth or Transparent Blindfolds? A Review of Current Debates in Archaeological Phytolith Analysis. *Vegetation History and Archaeobotany* 22: 71–82.

Shillito, L.-M. 2017. Multivocality and Multiproxy Approaches to the Use of Space: Lessons from 25 Years of Research at Çatalhöyük. *World Archaeology* 49 (2): 237–249.

Shillito, L. M. and Elliott, S. 2013. Phytolith Indicators of Plant Resource Use at Sheikh-e Abad and Jani, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 185–200.

Shillito, L.-M., Matthews, W. and Almond, M. 2008. Investigating Midden Formation Processes and Cultural Activities at Neolithic Çatalhöyük, Turkey. *Antiquity* 82 (317). Online: http://antiquity.ac.uk/projgall/shillito317/.

Shillito, L.-M., Bull, I. D., Matthews, W., Almond, M. J., Williams, J. M. and Evershed, R. P. 2011. Biomolecular and Micromorphological Analysis of Suspected Faecal Deposits at Neolithic Çatalhöyük, Turkey. *Journal of Archaeological Science* 38 (8): 1869–1877.

Shillito, L-M, Bull, I. D., Matthews, W., Almond, M. J. and Evershed, R. J. 2013a. Integrated geochemical and microscopic analysis of human coprolites, animal dung and organic remains in burials, in I. Hodder (ed.) *Humans and Landscapes of Çatalhöyük: reports from the 2000–2008 excavations*. Los Angeles, Cotsen Institute/British Institute at Ankara: 75–79.

Shillito, L.-M., Matthews, W. and Almond, M. J. 2013b. Ecology, Diet and Discard Practices: New Interdisciplinary Approaches to the Study of Middens through Integrating Micromorphological, Phytolith and Geochemical Analyses, in I. Hodder (ed.). *Humans and Landscapes of Çatalhöyük: Reports from the 2000–2008 Seasons*. Los Angeles, British Institute of Archaeology at Ankara and Cotsen Intstitute of Archaeology UCLA: 63–74.

Shillito, L.-M., Matthews, W. and Bull, I. D. 2013c. Biomolecular Investigations of Faecal Biomarkers at Sheikh-e Abad and Jani, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 105–115.

Shillito, L.-M., Ridout-Sharpe, J. and Bell, M. 2013d. Molluscs from Sheikh-e Abad and Jani, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest*

Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 201–205.

Shimelmitz, R. and Rosenberg, D. 2013. Dull-Edged Weapons and Low-Level Fighting in the Late Prehistoric Southern Levant. *Cambridge Archaeological Journal* 23 (3): 433–442.

Shott, M. J. 2003. Chaîne Opératoire and Reduction Sequence. *Lithic Technology* 28 (2): 95–105.

Shove, E. and Walker, G. 2010. Governing Transitions in the Sustainability of Everyday Life. *Research Policy* 39 (4): 471–476.

Sillar, B. 1998. Dung by Preference: The Choice of Fuel as an Example of How Andean Pottery Production Is Embedded within Wider Technical, Social and Economic Practices. *Archaeometry* 42 (1): 43–60.

Simmons, T., Kolska-Horwitz, L. and Goring-Morris, N. 2007. What Ceremony Else? Taphonomy and the Ritual Treatment of the Dead in the Pre-Pottery Neolithic B Mortuary Complex at Kfar Hahoresh, Israel, in M. Faerman, L. Kolska Horwitz, T. Kahana and U. Zilberman (eds). *Faces from the Past: Diachronic Patterns in the Biology of Human Populations from the Eastern Mediterranean: Papers in Honour of Patricia Smith*. Oxford, British Archaeological Reports S1603: 100–126.

Simpson, I. R., Seager, R., Shaw, T. A. and Ting, M. 2015. Mediterranean Summer Climate and the Importance of Middle East Topography. *Journal of Climate* 28 (5): 1977–1996.

Sissakian, V. K. 2000. *Geological Map of Iraq. Sheets No.1 State Establishment of Geological Survey and Mining*. Baghdad, GEOSURV.

Skeates, R., McDavid, C. and Carman, J. 2012. *The Oxford Handbook of Public Archaeology*. Oxford, Oxford University Press.

Skibo, J. and Schiffer, M. B. 2008. *People and Things: A Behavioral Approach to Material Culture*. New York, Springer.

Slon, V., Sarig, R., Hershkovitz, I., Khalaily, H. and Milevski, I. 2014. The Plastered Skulls from the Pre-Pottery Neolithic B Site of Yiftahel (Israel) – a Computed Tomography-Based Analysis. *PloS one* 9 (2): e89242.

Smil, V. 2013. Harvesting the Biosphere: The Human Impact. *Population and Development Review* 37 (4): 613–636.

Smith, B. D. 2001. Low-Level Food Production. *Journal of Archaeological Research* 9 (1): 1–43.

Smith, B. D. and Zeder, M. A. 2013. The Onset of the Anthropocene. *Anthropocene* 4: 8–13.

Smith, M. 2006. Bones Chewed by Canids as Evidence for Human Excarnation: A British Case Study. *Antiquity* 80 (309): 671–685.

Smith, M. E. 2017. Social Science and Archaeological Enquiry. *Antiquity* 91 (356): 520–528.

Smith, P., Bar-Yosef, O. and Sillen, A. 1984. Archaeological and Skeletal Evidence for Dietary Change During the Late Pleistocene/Early Holocene in the Levant, in M.N. Cohen and G.J. Armelagos (eds). *Paleopathology at the Origins of Agriculture*. London, Academic Press: 101–136.

Smith, P. E. L. 1974. Ganj Dareh Tepe. *Paléorient* 2 (1): 207–209.

Smith, P. E. L. 1976. Reflections on Four Seasons of Excavations at Tappeh Ganj Dareh, in F. Bagherzadeh (ed.). *Proceedings of the IVth Annual Symposium on Archaeological Research in Iran: 3rd–8th November 1975*. Tehran, Iranian Centre for Archaeological Research: 11–22.

Smith, P. E. L. 1978. An Interim Report on Ganj Dareh Tepe. *American Journal of Archaeology* 82 (4): 537–540.

Smith, P. E. L. 1990. Architectural Innovation and Experimentation at Ganj Dareh, Iran. *World Archaeology* 21 (3): 323–335.

Smith, S. 2007. The Use Wear Analysis of Chipped Stone Points, in B. Finlayson and S. J. Mithen (eds). *The Early Prehistory of Wadi Faynan, Southern Jordan: Archaeological Survey of Wadis Faynan, Ghuwayr and Al-Bustan and Evaluation of the Pre-Pottery Neolithic a Site of WF16*. Oxford, Council for British Research in the Levant Supplementary Series and Oxbow Books: 284–319.

Snyder, J. A., Wasylik, K., Fritz, S. C. and Wright Jr, H. E. 2001. Diatom-Based Conductivity Reconstruction and Palaeoclimatic Interpretation of a 40-Ka Record from Lake Zeribar, Iran. *The Holocene* 11 (6): 737–745.

Solecki, R. L. 1981. *An Early Village Site at Zawi Chemi Shanidar*. Malibu, Undena Publications Bibliotheca Mesopotamica 13.

Solecki, R. L. and McGovern, T. H. 1980. Predatory Birds and Prehistoric Man, in S. Diamond (ed.) *Theory and Practice. Essays Presented to Gene Weltfish*. The Hague, Mouton: 79–96.

Solecki, R. L. and Solecki, R. S. 1970. Grooved Stones from Zawi Chemi Shanidar, a Protoneolithic Site in Northern Iraq. *American Anthropologist* 72 (4): 831–841.

Solecki, R. L. and Solecki, R. S. 1983. Late Pleistocene-Early Holocene Cultural Traditions in the Zagros and the Levant, in T. C. Young, P. E. L Smith and P. Mortensen (eds.) *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia Presented to Robert J. Braidwood*. Chicago, Oriental Institute of the University of Chicago Studies in Ancient Oriental Civilization 36: 123–137

Solecki, R. L., Solecki, R. S. and Agelarakis, A. P. 2004. *The Proto-Neolithic Cemetery in Shanidar Cave*. College Station, A&M University Press.

Solecki, R. S. 1963. Prehistory in Shanidar Valley, Northern Iraq: Fresh Insights into Near Eastern Prehistory from the Middle Paleolithic to the Proto-Neolithic Are Obtained. *Science* 139 (3551): 179–193.

Solecki, R. S. 1972. *Shanidar: The Humanity of Neanderthal Man*. London, Allen Lane.

Solecki, R. S. and Solecki, R. L. 1963. Two Bone Hafts from Northern Iraq. *Antiquity* 37: 58–60.

Sołtysiak, A. 2017. Antemortem Cranial Trauma in Ancient Mesopotamia. *International Journal of Osteoarchaeology* 27 (1): 119–128.

Sołtysiak, A., Wiercińska, A. and Kozłowski, S. K. 2015. Human Remains from Nemrik, Iraq. An Insight into Living Conditions and Burial Customs in a Pre-Pottery Neolithic Village. *Paléorient* 41 (2): 101–114.

Speiser, E. A. 1926–27. Southern Kurdistan in the Annals of Ashurnasirpal and Today. *Annual of the American Schools of Oriental Research* 8: 1–41.

Spengler, R. N. 2019. Dung Burning in the Archaeobotanical Record of West Asia: Where Are We Now? *Vegetation History and Archaeobotany* 28 (2): 215–227.

Speth, J. D. 1989. Early Hominid Hunting and Scavenging: the Role of Meat as an Energy Source. *Journal of Human Evolution* 18 (4): 329–343.

Speth, J. D. and Spielmann, K. A. 1983. Energy Source, Protein Metabolism, and Hunter-gatherer Subsistence

Strategies. *Journal of Anthropological Archaeology* 2 (1): 1–31.

Spyrou, A., Maher, L. A., Martin, L. A., Macdonald, D. A. and Garrard, A. 2019. Meat Outside the Freezer: Drying, Smoking, Salting and Sealing Meat in Fat at an Epipalaeolithic Megasite in Eastern Jordan. *Journal of Anthropological Archaeology* 54: 84–101.

Squitieri, A. and Eitam, D. 2016. An Experimental Approach to Ground Stone Tool Manufacture. *Journal of Lithic Studies* (3): 553–564.

Stahl, P. W. 1996. The Recovery and Interpretation of Microvertebrate Bone Assemblages from Archaeological Contexts. *Journal of Archaeological Method and Theory* 3 (1): 31–75.

Stampfli, H. R. 1983. The Fauna of Jarmo, with Notes on Animal Bones from Matarrah, the Amuq, and Karim Shahir, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 431–484.

Starkovich, B. M. and Stiner, M. C. 2009. Hallan Çemi Tepesi: High-Ranked Game Exploitation Alongside Intensive Seed Processing at the Epipaleolithic-Neolithic Transition in Southeastern Turkey. *Anthropozoologica* 44 (1): 41–62.

Starkovich, B., Riehl, S., Zeidi, M. and Conard, N. 2016. Subsistence Strategies in the Aceramic Neolithic at Chogha Golan, Iran, in N. Marom, R. Yeshurun, L. Weissbrod and G. Bar-Oz (eds). *Bones and Identity: Zooarchaeological Approaches to Reconstructing Social and Cultural Landscapes in Southwest Asia*. Oxford, Oxbow Books: 45–71.

Steadman, S. 2005. Reliquaries on the Landscape: Mounds as Matrices of Human Cognition, in S. Pollock and R. Bernbeck (eds). *Archaeologies of the Middle East: Critical Perspectives*. Oxford, Blackwell: 286–307.

Stein, J. K. and Deo, J. N. 2003. Big Sites-Short Time: Accumulation Rates in Archaeological Sites. *Journal of Archaeological Science* 30: 297–316.

Stein, J. K. and Teltser, P. A. 1989. Size Distributions of Artifact Classes: Combining Macro-and Micro-Fractions. *Geoarchaeology* 4 (1): 1–30.

Stépanoff, C., Marchina, C., Fossier, C. and Bureau, N. 2017. Animal Autonomy and Intermittent Coexistences: North Asian Modes of Herding. *Current Anthropology* 58 (1): 57–81.

Stevanović, Z., Iurkiewicz, A. and Maran, A. 2009. New Insights into Karsts and Caves of Northwestern Zagros (Northern Iraq). *Acta Carsologica* 38 (1): 83–96.

Stevens, C. J. and Fuller, D. Q. 2012. Did Neolithic Farming Fail? The Case for a Bronze Age Agricultural Revolution in the British Isles. *Antiquity* 86 (333): 707–722.

Stevens, L. R., Ito, E. and Wright, H. E., Jr. 2008. Variations in Effective Moisture at Lake Zeribar, Iran During the Last Glacial Period and Holocene, Inferred from the Delta O–18 Values of Authigenic Calcite, in K. Wasylikova and A. Witkowski (eds). *The Palaeoecology of Lake Zeribar and Surrounding Areas, Western Iran, During the Last 48,000 Years*. Diatom Monographs 8. Gantner, Ruggell: 283–302.

Stevens, L., Wright Jr, H. and Ito, E. 2001. Proposed Changes in Seasonality of Climate During the Lateglacial and Holocene at Lake Zeribar, Iran. *The Holocene* 11 (6): 747–745.

Stevens, L. R., Djamali, M., Andrieu-Ponel, V. and de Beaulieu, J.-L. 2012. Hydroclimatic Variations over the Last Two Glacial/Interglacial Cycles at Lake Urmia, Iran. *Journal of Paleolimnology* 47 (4): 645–660.

Stevens, L. R., Ito, E., Schwalb, A. and Wright, H. E. 2006. Timing of Atmospheric Precipitation in the Zagros Mountains Inferred from a Multi-Proxy Record from Lake Mirabad, Iran. *Quaternary Research* 66 (3): 494–500.

Stiner, M. C., Munro, N. D. and Surovell, T. A. 2000. The Tortoise and the Hare. *Current Anthropology* 41 (1): 39–79.

Stiner, M. C., Buitenhuis, H., Duru, G., Kuhn, S. L., Mentzer, S. M., Munro, N. D., Pöllath, N., Quade, J., Tsartsidou, G. and Özbaşaran, M. 2014. A Forager–Herder Trade-Off, from Broad-Spectrum Hunting to Sheep Management at Aşıklı Höyük, Turkey. *Proceedings of the National Academy of Sciences* 111 (23): 8404–8409.

Stojanowski, C. M., Johnson, K. M., Paul, K. S. and Carver, C. L. 2016. Indicators of Idiosyncratic Behavior in the Dentition, in J. D. Irish and G. R. Scott (eds). *A Companion to Dental Anthropology*. Chichester, Wiley Blackwell: 377–395.

Stoops, G. 2003. *Guidelines for Analysis and Description of Soil and Regolith Thin-Sections*. Madison, Soil Science Society of America.

Stoops, G. 2010. *Interpretation of Micromorphological Features of Soils and Regoliths*. Oxford, Elsevier.

Stoops, G. 2017. Fluorescence Microscopy. In C. Nicosia and G. Stoops (eds). *Archaeological Soil and Sediment Micromorphology*. Oxford: Wiley Blackwell, 393–397.

Stordeur, D. 2004. Small Finds and Poor Babies: Quelques Objets Divers du Mureybetien du Jerf el Ahmar, Oxford, British Archaeological Reports S1263: 309–322.

Stordeur, D. 2015. *Le Village de Jerf el Ahmar: Syrie, 9500–8700 av. J.-C.: l'architecture, Miroir d'une Société Néolithique Complexe*. Paris, CNRS.

Stordeur, D., Brenet, M., Der Aprahamian, G. and Roux, J.-C. 2000. Les Bâtiments Communautaires de Jerf el Ahmar et Mureybet Horizon PPNA (Syrie). *Paléorient* 26 (1): 29–44.

Stout, D. 2002. Skill and Cognition in Stone Tool Production: An Ethnographic Case Study from Irian Jaya [with Comments and Response]. *Current Anthropology* 43 (5): 693–722.

St-Pierre, C. G., Choyke, A. M. and Ikram, S. 2018. Bones and Society: A Short Introduction. *Journal of Archaeological Science: Reports* 20: 853–845.

Strasser, T. F. 2004. Three Axe Groups from Neolithic Knossos. *British School at Athens Studies* 12: 61–65.

Strömberg, C. A. E. 2009. Methodological Concerns for Analysis of Phytolith Assemblages: Does Count Size Matter? *Quaternary International* 193: 124–140.

Stroulia, A. 2010. *Flexible Stones: Ground Stone Tools from Franchthi Cave, Fascicle 14, Excavations at Franchthi Cave, Greece*. Bloomington, Indiana University Press.

Stutz, A. J. and Bocquentin, F. 2017. Biosocial Changes in Health before Agriculture: The Case of the Natufian Hunter-Gatherers. *American Journal of Physical Anthropology* 162: 373–373.

Styring, A. K., Fraser, R. A., Bogaard, A. and Evershed, R. P. 2014. The Effect of Manuring on Cereal and Pulse Amino Acid Delta N–15 Values. *Phytochemistry* 102: 40–45.

Symes, S. A., L'Abbé, E. N., Stull, K. E., LaCroix, M. and Pokines, J. T. 2014. Taphonomy and the Timing of Bone Fractures in Trauma Analysis, in J. T. Pokines and S. A. Symes (eds). *Manual of Forensic Taphonomy*. Boca Raton, CRC Press: 341–365.

Szymczak, K. 1996. PPN Flint Assemblages with Microliths: What Do We Find, and What Do We Lose? in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 145–140.

Szyndlar, Z. 1984. Fossil Snakes from Poland. *Acta zoologica cracoviensia* 28 (1): 1–156.

Szyndlar, Z. 1991a. A Review of Neogene and Quaternary Snakes of Central and Eastern Europe. Part 1: Scolecophidia, Boidae, Colubrinae. *Estudios geológicos* 47 (1–2): 103–126.

Szyndlar, Z. 1991b. A Review of Neogene and Quaternary Snakes of Central and Eastern Europe. Part 2: Natricinae, Elapidae, Viperidae. *Estudios geológicos* 47 (3–4): 237–266.

Taçon, P. S. C. 1991. The Power of Stone: Symbolic Aspects of Stone Use and Tool Development in Western Arnhem Land, Australia. *Antiquity* 65: 192–207.

Tayles, N., Domett, K. and Halcrow, S. 2009. Can Dental Caries Be Interpreted as Evidence of Farming? The Asian Experience, in T. Koppe, G. Meyer, K. W. Alt, A. Brook, M. C. Dean, I. Kjaer, J. R. Lukacs, B. H. Smith and M. F. Teaford (eds). *Comparative Dental Morphology* 13. Basel, Karger: 162–166.

Tayles, N., Domett, K. and Nelsen, K. 2000. Agriculture and Dental Caries? The Case of Rice in Prehistoric Southeast Asia. *World Archaeology* 32 (1): 68–83.

Taylor, V. 2014. *Land Snail Middens in the Late Pleistocene and Early Holocene North Africa: A Case Study from Taforalt (Grotte Des Pigeons), Morocco*. Unpublished Ph.D. Thesis, University of Reading.

Taylor, V. K. and Bell, M. 2017. Land Mollusc Middens, in M. J. Allen (ed.) *Molluscs in Archaeology: Methods, Approaches and Applications*. Oxford, Oxbow Books Studying Scientific Archaeology 3: 195–212.

Taylor, V. K. and Bell, M. 2019. Land Molluscs, in R. N. E. Barton, A. Bouzouggar, S. Collcutt and L. Humphrey (eds). *Cemeteries and Sedentism in the Later Stone Age of North West Africa: Excavations at Grotte des Pigeons, Taforalt, Morocco*. Mainz am Rhein, Romisch-Germanisches Zentralmuseum: 207–235.

Taylor, V., Barton, R., Bell, M., Bouzouggar, A., Collcutt, S., Black, S. and Hogue, J. 2011. The Epipalaeolithic (Iberomaurusian) at Grotte Des Pigeons (Taforalt), Morocco: A Preliminary Study of the Land Mollusca. *Quaternary International* 244 (1): 5–14.

Tchernov, E. 1984. Commensal Animals and Human Sedentism in the Middle East, in J. Clutton-Brock and C. Grigson (eds). *Animals in Archaeology 3. Early Herders and Their Flocks.* Oxford, British Archaeological Reports S202: 91–115.

Temple, D. H. 2016. Caries: The Ancient Scourge, in J. D. Irish and G. R. Scott (eds). *A Companion to Dental Anthropology*. Chichester, Wiley Blackwell: 433–444.

Terradas, X., Ibañez, J. J., Braemer, F., Gourichon, L. and Teira, L. C. 2012. The Natufian Occupations of Qarassa 3 (Sweida, Southern Syria), in O. Bar Yosef and F. R. Valla (eds). *Natufian Foragers in the Levant. Terminal Pleistocene Social Changes in Western Asia.* Ann Arbor, International Monographs in Prehistory: 45–60.

Thaler, D. S. 2016. Toward a Microbial Neolithic Revolution in Buildings. *Microbiome* 4: 14: https://doi.org/10.1186/s40168-016-0157-2.

Thomalsky, J. 2016. The Development of Lithic Industries in Iran in the Light of the Neolithisation Process, in K. Roustaei and M. Mashkour (eds). *The Neolithic of the Iranian Plateau*. Berlin, ex oriente: 169–188.

Thomas, K. D. 2015a. Molluscs Emergent, Part II: Themes and Trends in the Scientific Investigation of Molluscs and their Shells as Past Human Resources. *Journal of Archaeological Science* 56: 159–167.

Thomas, K. D. 2015b. Molluscs Emergent, Part I: Themes and Trends in the Scientific Investigation of Mollusc Shells as Resources for Archaeological Research. *Journal of Archaeological Science* 56: 133–140.

Tilden, F. 1957. *Interpreting Our Heritage*. Chapel Hill, University of North Carolina Press.

Toffolo, M. B., Ullman, M., Caracuta, V., Weiner, S. and Boaretto, E. 2017. A 10,400-Year-Old Sunken Lime Kiln from the Early Pre-Pottery Neolithic B at the Nesher-Ramla Quarry (El-Khirbe), Israel. *Journal of Archaeological Science: Reports* 14: 353–364.

Toll, M. S. 1988. Flotation Sampling: Problems and Some Solutions, with Examples from the American Southwest, in C. A. Hastorf, V. S. Popper, C. A. Hastorf and V. S. Popper (eds). *Current Paleoethnobotany. Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*. Chicago, University of Chicago Press: 36–42.

Tomka, S. A. 1993. Site Abandonment Behavior among Transhumant Agro-Pastoralists: The Effects of Delayed Curation on Assemblage Composition, in C. M. Cameron and S. A. Tomka (eds). *Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. New Directions in Archaeology*. Cambridge, Cambridge University Press: 11–24.

Tomka, S. A. and Stevenson, M. G. 1993. Understanding Abandonment Processes: Summary and Remaining Concerns, in C. M. Cameron and S. A. Tomka (eds). *Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. New Directions in Archaeology*. Cambridge, Cambridge University Press: 191–195.

Tornero, C., Aguilera, M., Ferrio, J. P., Arcusa, H., Moreno-García, M., Garcia-Reig, S. and Rojo-Guerra, M. 2018. Vertical Sheep Mobility Along the Altitudinal Gradient through Stable Isotope Analyses in Tooth Molar Bioapatite, Meteoric Water and Pastures: A Reference from the Ebro Valley to the Central Pyrenees. *Quaternary International* 484: 94–106.

Torres-Rouff, C. and Knudson, K. J. 2017. Integrating Identities: An Innovative Bioarchaeological and Biogeochemical Approach to Analyzing the Multiplicity of Identities in the Mortuary Record. *Current Anthropology* 58 (3): 381–409.

Townsend, C. C., Guest, E. R. and al-Rawi, A. 1966. *Flora of Iraq*. Baghdad, Ministry of Agriculture of the Republic of Iraq.

Trigger, B. G. 1989. *A History of Archaeological Thought*. Cambridge, Cambridge University Press.

Trinkaus, E. 1982. Artificial Cranial Deformation in the Shanidar 1 and 5 Neandertals. *Current Anthropology* 23 (2): 198–199.

Troels-Smith, J. 1955. Characterisation of Unconsolidated Sediments. *Danmarks Geologiske Undersøgelse. Raekke* IV (3): 38–73.

Trotter, M. 1970. Estimation of Stature from Intact Long Limb Bones, in T. D. Stewart (ed.). *Personal Identification in Mass Disasters*. Washington, Smithsonian National Museum of Natural History: 71–83.

Tsartsidou, G., Lev-Yadun, S., Albert, R., Miller-Rosen, A., Efstratiou, N. and Weiner, S. 2007. The Phytolith Archaeological Record: Strengths and Weaknesses Evaluated Based on a Quantitative Modern Reference Collection from Greece. *Journal of Archaeological Science* 34 (8): 1262–1275.

Tsartsidou, G., Lev-Yadun, S., Efstratiou, N. and Weiner, S. 2008. Ethnoarchaeological Study of Phytolith Assemblages from an Agro-Pastoral Village in Northern Greece (Sarakini): Development and Application of a Phytolith Difference Index. *Journal of Archaeological Science* 35 (3): 600–613.

Tsartsidou, G., Lev-Yadun, S., Efstratiou, N. and Weiner, S. 2009. Use of Space in a Neolithic Village in Greece (Makri): Phytolith Analysis and Comparison of Phytolith Assemblages from an Ethnographic Setting in the Same Area. *Journal of Archaeological Science* 36 (10): 2342–2352.

Tsoraki, C. 2018. The Ritualisation of Daily Practice: Exploring the Staging of Ritual Acts at Neolithic Çatalhöyük, Turkey, in I. Hodder (ed.) *Religion, History and Place in the Origin of Settled Life*. Louisville CO, University Press of Colorado: 238–262.

Tsuneki, A., Rasheed, K., Saber, S. A., Nishiyama, S., Amma, R., Ismail, B. B., Hasegawa, A., Tatsumi, Y., Miyauchi, Y., Jammo, S., Makimo, M. and Kudo, Y. 2015. Excavations at Qalat Said Ahmadan, Slemani, Iraq-Kurdistan: First Interim Report (2014 Season). *Al-Rafidan – Journal of Western Asiatic Studies* 36: 1–63.

Turnbull, P. F. 1983. The Faunal Remains from M'lefaat, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 693–695.

Turnbull, P. F. and Reed, C. A. 1974. The Fauna from the Terminal Pleistocene of Palegawra Cave, a Zarzian Occupation Site in Northeastern Iraq. *Fieldiana. Anthropology* 63 (3): 81–146.

Turner, C. G. 1979. Dental Anthropological Indications of Agriculture among the Jomon People of Central Japan. X. Peopling of the Pacific. *American Journal of Physical Anthropology* 51 (4): 619–635.

Turner, R., Roberts, N. and Jones, M. D. 2008. Climatic Pacing of Mediterranean Fire Histories from Lake Sedimentary Microcharcoal. *Global and Planetary Change* 63 (4): 317–324.

Tusa, S. 1984. Preliminary Report on the Telul El-Rihan Area (Himrin). *Sumer* 40: 39–43.

Tusa, S. 1985. Post-Pleistocene Adaptation in the Hamrin Basin (Middle Diyala) after the Excavation at Tell Rihan. *Cahiers de l'Euphrate* 4: 315–333.

Twiss, K. 2012. The Archaeology of Food and Social Diversity. *Journal of Archaeological Research* 20 (4): 357–95.

Twiss, P. C., Suess, E. and Smith, R. M. 1969. Morphological Classification of Grass Phytoliths. *Soil Science Society of America Journal* 33 (1): 109–115.

Twiss, P. G. 1992. Predicted World Distribution of C3 and C4 Grass Phytoliths, in G. Rapp Jr and S. C. Mulholland (eds). *Phytolith Systematics. Emerging Issues*. New York, Plenum Press: 113–128.

Tyler, P., Madani, G., Chaudhuri, R., Wilson, L. and Dick, E. 2006. The Radiological Appearances of Thalassaemia. *Clinical Radiology* 61 (1): 40–42.

Ucko, P. J., Tringham, R. and Dimbleby, G. W. (eds). 1971. *Man, Settlement and Urbanism*. London, Duckworth.

Uerpmann, H. P. 1973. Animal Bone Finds and Economic Archaeology: A Critical Study of 'Osteo-Archaeological' Method. *World Archaeology* 4 (3): 307–322.

Uerpmann, M. and Uerpmann, H.-P. 1994. Animal Bone Finds from Excavation 520 at Qala'at Al-Bahrain, in F. Hojlund and H. H. Andersen (eds). *Qala'at Al-Bahrain. Vol. 1. The Northern City Wall and the Isl Fortress*. Aarhus, Jutland Archaeological Society: 417–444.

Ulbrich, U., Lionello, P., Belušić, D., Jacobeit, J., Knippertz, P., Kuglitsch, F. G., Leckebusch, G. C., Luterbacher, J., Maugeri, M., Maheras, P., Nissen, K. M., Pavan, V., Pinto, J. G., Saaroni, H., Seubert, S., Toreti, A., Xoplaki, E. and Ziv, B. 2012. Climate of the Mediterranean: Synoptic Patterns, Temperature, Precipitation, Winds, and Their Extremes, in P. Lionello (ed.) *The Climate of the Mediterranean Region*. Oxford, Elsevier: 301–346.

United Nations General Assembly 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*. https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

Usacheva, I. 2013. On the Function of Grooved Stones. *Archaeology, Ethnology and Anthropology of Eurasia* 41 (4): 58–64.

Vahdati Nasab, H., Clark, G. A. and Torkamandi, S. 2013a. Late Pleistocene Dispersal Corridors across the Iranian Plateau: A Case Study from Mirak, a Middle Paleolithic Site on the Northern Edge of the Iranian Central Desert (Dasht-E Kavir). *Quaternary International* 300: 267–281.

Vahdati Nasab, H., Jayez, M., Reza Qorbani, H., Darabi, H. and Taylor, H. 2013b. Preliminary Techno-Typological Analysis of Chipped Stone Materials from Sheikh-e Abad, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 117–130.

Valamoti, S. M. 2013. Towards a Distinction between Digested and Undigested Glume Bases in the Archaeobotanical Record from Neolithic Northern Greece: A Preliminary Experimental Investigation. *Environmental Archaeology* 18 (1): 31–42.

Valla, F. R. 2018. Sedentism, the Point of No Return, and the Natufian Issue. An Historical Perspective. *Paléorient* 44 (1): 19–33.

van Andel, T. H. and Sutton, S. B. 1987. *Landscape and People of the Franchthi Region*. Bloomington, Indian University Press, Excavations at Franchthi Cave, Greece Fascicule 2.

Van de Noort, R. and O'Sullivan, A. 2006. *Rethinking Wetland Archaeology*. London, Duckworth.

van der Plicht, J. and Bruins, H. J. 2001. Radiocarbon Dating in Near-Eastern Contexts: Confusion and Quality Control. *Radiocarbon* 43 (3): 1155–1166.

van der Plicht, J. and Bruins, H. 2005. Quality Control of Groningen ^{14}C Results from Tel Rehov: Repeatability and Intercomparison of Proportional Gas Counting and Ams, in T. Levy and T. Higham (eds). *The Bible and Radiocarbon Dating: Archaeology, Text and Science*. London, Equinox: 256–270.

van der Veen, M. 2007. Formation Processes of Desiccated and Carbonized Plant Remains – the Identification of

Routine Practice. *Journal of Archaeological Science* 34 (6): 968–990.

Van Ess, M. and Luciani, M. 2015. Northwestern Sulaimaniyah Survey, in K. Kopanias, J. MacGinnis and J. A. Ur (eds). *Archaeological Projects in the Kurdistan Region in Iraq*. Erbil, Directorate of Antiquities of Kurdistan: 33.

van Geel, B. 2006. 'Quaternary Non-Pollen Palynomorphs' Deserve Our Attention! *Review of Palaeobotany and Palynology* 141: vii–viii.

van Geel, B. and Aptroot, A. 2006. Fossil Ascomycetes in Quaternary Deposits. *Nova Hedwigia* 82 (3–4): 313–329.

van Geel, B., Buurman, J., Brinkkemper, O., Schelvis, J., Aptroot, A., van Reenen, G. and Hakbijl, T. 2003. Environmental Reconstruction of a Roman Period Settlement Site in Uitgeest (the Netherlands), with Special Reference to Coprophilous Fungi. *Journal of Archaeological Science* 30 (7): 873–83.

van Gijn, A. L. 1989. *The Wear and Tear of Flint: Principles of Functional Analysis Applied to Dutch Neolithic Assemblages*. *Analecta Praehistorica Leidensia* 22.

van Gijn, A. L. 2007. The Use of Bone and Antler Tools. Two Examples from the Late Mesolithic in the Dutch Coastal Zone, in C. Gates St-Pierre and R. B. Walker (eds). *Bones as Tools. Current Methods and Interpretations in Worked Bone Studies*. Oxford, British Archaeological Reports S1622: 81–92.

van Gijn, A. L. 2010. *Flint in Focus: Lithic Biographies in the Neolithic and Bronze Age*. Leiden, Sidestone Press.

Van Hoeve, M. and Hendrikse, M. 1998. *A Study of Non-Pollen Objects in Pollen Slides*, Utrecht, Utrecht University.

Van Neer, W., Zohar, I. and Lernau, O. 2005. The Emergence of Fishing Communities in the Eastern Mediterranean Region: A Survey of Evidence from Pre-and Protohistoric Periods. *Paléorient* 31 (1): 131–157.

Van Neer, W., Gravendeel, R., Wouters, W. and Russell, N. 2013. The Exploitation of Fish at Çatalhöyük, in I. Hodder (ed.). *Humans and Landscapes of Çatalhöyük: Reports from the 2000–2008 Seasons*. Los Angeles, British Institute of Archaeology at Ankara and Cotsen Institute of Archaeology UCLA: 317–327.

van Zeist, W. 2008. Late Pleistocene and Holocene Vegetation at Zeribar, in K. Wasylikova and A. Witkowski (eds). *The Palaeoecology of Lake Zeribar and Surrounding Areas, Western Iran, During the Last 48,000 Years*. Diatom Monographs 8. Gantner, Ruggell: 53–104.

van Zeist, W. and Bottema, S. 1977. Palynological Investigations in Western Iran. *Palaeohistoria* 19: 19–85.

van Zeist, W. and Bottema, S. 1982. Vegetational History of the Eastern Mediterranean and the Near East During the Last 20,000 Years, in J. Bintliff and W. van Zeist (eds). *Palaeoclimates, Palaeoenvironments, and Human Communities in the Eastern Mediterranean Region*. 133. Oxford, British Archaeological Reports: 277–321.

van Zeist, W. and Wright, H. E. 1963. Preliminary Pollen Studies at Lake Zeribar, Zagros Mountains, Southwestern Iran. *Science* 140 (3562): 65 LP–67.

van Zeist, W., Smith, P. E. L., Palfenier-Vegeter, R. M., Suwijn, M. and Casparie, W. A. 1984. An Archaeobotanical Study of Ganj Dareh. *Palaeohistoria* 26: 201–24.

Vardi, J. and Gilead, I. 2013. Keeping the Razor Sharp: Hafting and Maintenance of Sickles in the Southern Levant During the 6th and 5th Millennia BC, in F. Borrell, J. J. Ibáñez Estévez and M. Molist (eds). *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East. Papers Presented to the 7th Conference on PPN Chipped and Ground Stone Industries of the Fertile Crescent*. Bellaterra, Universitat Autònoma de Barcelona, Servei de Publicacions: 377–94.

Vasileiadou, K., Hooker, J. J. and Collinson, M. E. 2009. Paleocommunity Reconstruction and Accumulation of Micromammalian Remains (Late Eocene, Southern England). *Palaios* 24 (9): 553–67.

Vera, F. W. M. 2000. *Grazing Ecology and Forest History*. Oxford, Cabi Publishing.

Verdugo, M. P., Mullin, V. E., Scheu, A., Mattiangeli, V., Daly, K. G., Delser, P. M., Hare, A. J., Burger, J., Collins, M. J., Kehati, R., Hesse, P., Fulton, D., Sauer, E. W., Mohaseb, F. A., Davoudi, H., Khazaeli, R., Lhuillier, J., Rapin, C., Ebrahimi, S., Khasanov, M., Farhad Vahidi, S. M., MacHugh, D. E., Ertuğul, O., Koukouli-Chrysanthaki, C., Sampson, A., Kazantzis, G., Kontopoulos, I., Bulatovic, J., Stojanović, I., Mikdad, A., Benecke, N., Linstädter, J., Sablin, M., Bendrey, R., Gourichon, L., Arbuckle, B. S., Mashkour, M., Orton, D., Horwitz, L. K., Teasdale, M. D. and Bradley, D. G. 2019. Ancient Cattle Genomics, Origins, and Rapid Turnover in the Fertile Crescent. *Science* 365 (6449): 173–76.

Verheyden, S., Nader, F. H., Cheng, H. J., Edwards, L. R. and Swennen, R. 2008. Paleoclimate Reconstruction in the Levant Region from the Geochemistry of a Holocene Stalagmite from the Jeita Cave, Lebanon. *Quaternary Research* 70 (3): 368–81.

Verhoeven, M. 2006. Equifinality, Clay and Tradition: Towards an Understanding of Tell Formation. *Neo-Lithics* 1/06: 32–37.

Verhoeven, M. 2007. Losing One's Head in the Neolithic: On the Interpretation of Headless Figurines. *Levant* 39: 175–83.

Vidal, N., Delmas, A.-S., David, P., Cruaud, C., Couloux, A. and Hedges, S. B. 2007. The Phylogeny and Classification of Caenophidian Snakes Inferred from Seven Nuclear Protein-Coding Genes. *Comptes rendus biologies* 330 (2): 182–87.

Vigne, J.-D. 1995. *Détermination Ostéologique des Principaux Éléments du Squelette Appendiculaire d'Arvicola, d'Eliomys, de Glis et de Rattus*. APDCA.

Vigne, J.-D. 2011. The Origins of Animal Domestication and Husbandry: A Major Change in the History of Humanity and the Biosphere. *Comptes rendus biologies* 334 (3): 171–81.

Vigne, J.-D., Carrere, I., Briois, F. and Guilaine, J. 2011. The Early Process of Mammal Domestication in the Near East: New Evidence from the Pre-Neolithic and Pre-Pottery Neolithic in Cyprus. *Current Anthropology* 52 (S4): S255-S71.

Villa, P. and Mahieu, E. 1991. Breakage Patterns of Human Long Bones. *Journal of Human Evolution* 21 (1): 27–48.

Villagran, X. S. 2014. A Redefinition of Waste: Deconstructing Shell and Fish Mound Formation among Coastal Groups of Southern Brazil. *Journal of Anthropological Archaeology* 36 (0): 211–27.

Villagran, X. S., Huisman, D. J., Mentzer, S. M., Miller, C. M. and Jans, M. M. 2017. Bones and Other Skeletal Remains, in C. N. Nicosia and G. Stoops (eds). *Archaeological Soil and Sediment Micromorphology*. New York, John Wiley & Sons Ltd. : 9–38.

Vinther, B. M., Clausen, H. B., Johnsen, S. J., Rasmussen, S. O., Andersen, K. K., Buchardt, S. L., Dahl-Jensen, D., Seierstad, I. K., Siggaard-Andersen, M. L. and Steffensen,

J. P. 2006. A Synchronized Dating of Three Greenland Ice Cores Throughout the Holocene. *Journal of Geophysical Research: Atmospheres* 111 (D13).

Voigt, M. M. 1983. *Hajji Firuz Tepe, Iran: The Neolithic Settlement*. Hasanlu Excavation Reports v 1. Philadelphia, University Museum, University of Pennsylvania.

Voigt, M. M. 1985. Village on the Euphrates. Excavations at Neolithic Gritille in Turkey. *Expedition* 27 (1): 10–24.

Voigt, M. M. 2000. Çatal Höyük in Context: Ritual at Early Neolithic Sites in Central and Eastern Turkey, in I. Kuijt (ed.) *Life in Neolithic Farming Communities: Social Organisation, Identity, and Differentiation*. New York, Kluwer: 253–93.

Volhard, F. 2016. *Light Earth Building: A Handbook for Building with Wood and Earth*. Basel, Birkhäuser.

Wahida, G. 1975. *A Reconsideration of the Upper Palaeolithic in the Zagros Mountains*. Ph.D., Cambridge University.

Wahida, G. 1981. The Re-Excavation of Zarzi, 1971. *Proceedings of the Prehistoric Society* 47: 19–40.

Wahida, G. 1999. The Zarzian Industry of the Zagros Mountains, in W. Davies and R. Charles (eds). *Dorothy Garrod and the Progress of the Palaeolithic: Studies in the Prehistoric Archaeology of the Near East and Europe*. Oxford, Oxbow: 181–208.

Waldron, T. 2008. *Palaeopathology*. Cambridge, Cambridge University Press.

Walker, G. C., Bowen, J. W., Matthews, W., Roychowdhury, S., Labaune, J., Mourou, G., Menu, M., Hodder, I. and Jackson, J. B. 2013. Sub-Surface Terahertz Imaging through Uneven Surfaces: Visualizing Neolithic Wall Paintings in Çatalhöyük. *Optics Express* 21 (7): 8126–34.

Walker, M. J., Berkelhammer, M., Björck, S., Cwynar, L. C., Fisher, D. A., Long, A. J., Lowe, J. J., Newnham, R. M., Rasmussen, S. O. and Weiss, H. 2012. Formal Subdivision of the Holocene Series/Epoch: A Discussion Paper by a Working Group of Intimate (Integration of Ice-Core, Marine and Terrestrial Records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). *Journal of Quaternary Science* 27 (7): 649–49.

Walker, P., Keable, R. I., Martin, J. and Maniatidis, V. 2005. *Rammed Earth: Design and Construction Guidelines*. Watford, Building Research Establishment (BRE) Bookshop.

Walker, P. L., Bathurst, R. R., Richman, R., Gjerdrum, T. and Andrushko, V. A. 2009. The Causes of Porotic Hyperostosis and Cribra Orbitalia: A Reappraisal of the Iron-Deficiency-Anemia Hypothesis. *American Journal of Physical Anthropology* 139 (2): 109–25.

Wallace, M. and Charles, M. 2013. What Goes in Does Not Always Come Out: The Impact of the Ruminant Digestive System of Sheep on Plant Material, and Its Importance for the Interpretation of Dung-Dervived Archaeobotanical Assemblages. *Environmental Archaeology* 18 (1): 18–30.

Wallace, M., Jones, G., Charles, M., Forster, E., Stillman, E., Bonhomme, V., Livarda, A., Osborne, C. P., Rees, M. and Frenck, G. 2019. Re-Analysis of Archaeobotanical Remains from Pre-and Early Agricultural Sites Provides No Evidence for a Narrowing of the Wild Plant Food Spectrum During the Origins of Agriculture in Southwest Asia. *Vegetation History and Archaeobotany* 28 (4): 449–63.

Wallach, J. C., Samartino, L. E., Efron, A. and Baldi, P. C. 1997. Human Infection by Brucella Melitensis: An Outbreak Attributed to Contact with Infected Goats. *FEMS Immunology & Medical Microbiology* 19 (4): 315–21.

Walsh, S. and Matthews, W. 2018. Articulating the Disarticulated: Human Remains from the Early Neolithic of the Eastern Fertile Crescent (Eastern Iraq and Western Iran), in P. Bickle and E. Sibbeson (eds). *Neolithic Bodies. Neolithic Studies Group Seminar Papers (15)*. Oxford, Oxbow Books.

Wang, Y. and Lyu, H. 1992. *The Study of Phytolith and Its Application*. Beijing, Ocean Press.

Warinner, C., Herbig, A., Mann, A., Yates, J. A. F., Weiss, C. L., Burbano, H. A., Orlando, L. and Krause, J. 2017. A Robust Framework for Microbial Archaeology, in A. Chakravarti and E. D. Green (eds). *Annual Review of Genomics and Human Genetics, Vol 18*. Annual Review of Genomics and Human Genetics 18: 321–46.

Warinner, C., Speller, C. and Collins, M. J. 2015a. A New Era in Palaeomicrobiology: Prospects for Ancient Dental Calculus as a Long-Term Record of the Human Oral Microbiome. *Philosophical Transactions of the Royal Society B: Biological Sciences* 370 (1660): 20130376.

Warinner, C., Speller, C., Collins, M. J. and Lewis Jr, C. M. 2015b. Ancient Human Microbiomes. *Journal of Human Evolution* 79: 125–36.

Wasylikowa, K. 2005. Palaeoecology of Lake Zeribar, Iran, in the Pleniglacial, Lateglacial and Holocene, Reconstructed from Plant Macrofossils. *The Holocene* 15 (5): 720–35.

Wasylikowa, K., van Zeist, W., Wright, H. E., Jr., Stevens, L. R., Witkowski, A., Walanus, A., Hutorowicz, A., Alexandrowicz, S. W. and Langer, J. J. 2008. The Lake Zeribar Palaeoecology: A Synthesis, in K. Wasylikova and A. Witkowski (eds). *The Palaeoecology of Lake Zeribar and Surrounding Areas, Western Iran, During the Last 48,000 Years*. Diatom Monographs 8. Gantner, Ruggell: 303–321.

Wasylikowa, K., Witkowski, A., Walanus, A., Hutorowicz, A., Alexandrowicz, S. W. and Langer, J. J. 2006. Palaeolimnology of Lake Zeribar, Iran, and Its Climatic Implications. *Quaternary Research* 66 (3): 477–493.

Watkins, T. 2004. Building Houses, Framing Concepts, Constructing Worlds. *Paléorient* 30 (1): 5–24.

Watkins, T. 2008. Supra-Regional Networks in the Neolithic of Southwest Asia. *Journal of World Prehistory* 21 (139–171): 139–171.

Watkins, T. 2010. New Light on Neolithic Revolution in South-West Asia. *Antiquity* 84: 621–634.

Watkins, T. 2017. From Pleistocene to Holocene: The Prehistory of Southwest Asia in Evolutionary Context. *History and Philosophy of the Life Sciences* 39 (3): 22.

Watkins, T., Baird, D. and Betts, A. 1989a. Qermez Dere and the Early Aceramic Neolithic of N. Iraq. *Paléorient* 15 (1): 19–24.

Watkins, T., Betts, A. V. G., Dobney, K. and Nesbitt, M. 1989b. *Qermez Dere, Tell Afar: Interim Report* 2. Edinburgh, Department of Archaeology, University of Edinburgh.

Watson, J. P. 1979. The Estimation of the Relative Frequencies of Mammalian Species: Khirokitia 1972. *Journal of Archaeological Science* 6 (2): 127–137.

Watson, P. J. 1979. *Archaeological Ethnography in Western Iran*. Tuscon, University of Arizona Press for the Wenner-Gren Foundation for Anthropological Research.

Watson, P. J. 1983a. A Note on the Jarmo Plant Remains, in L. S. Braidwood, R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 501–503.

Watson, P. J. 1983b. Jarmo Worked Bone, in L. S. Braidwood,

R. J. Braidwood, B. Howe, C. A. Reed and P. J. Watson (eds). *Prehistoric Archeology Along the Zagros Flanks*. Chicago, Oriental Institute of the University of Chicago Publication 105: 347–367.

Wattez, J. 1990. Contribution à la Connaissance des Foyers Préhistoriques par l'Étude des Cendres. *Bulletin Societé Préhistorique Français* 87: 352–366.

Watts, N., Adger, W. N., Ayeb-Karlsson, S., Bai, Y., Byass, P., Campbell-Lendrum, D., Colbourn, T., Cox, P., Davies, M. and Depledge, M. 2017. The Lancet Countdown: Tracking Progress on Health and Climate Change. *The Lancet* 389 (10074): 1151–1164.

Watts, S. 2012. *The Structured Deposition of Querns: The Contexts of Use and Deposition of Querns in the South-West of England from the Neolithic to the Iron Age*. Unpublished Ph.D. thesis, University of Exeter.

Wedel, V. L. and Galloway, A. 2013. *Broken Bones: Anthropological Analysis of Blunt Force Trauma*. Springfield, Charles C. Thomas.

Weeks, L. 2013. The Neolithisation of Fars, Iran, in R. Matthews and H. Fazeli Nashli (eds). *The Neolithisation of Iran: The Formation of New Societies*. Oxford, BANEA/ Oxbow Books: 97–107.

Weide, A., Riehl, S., Zeidi, M. and Conard, N. J. 2015. Using New Morphological Criteria to Identify Domesticated Emmer Wheat at the Aceramic Neolithic Site of Chogha Golan (Iran). *Journal of Archaeological Science* 57: 109–118.

Weide, A., Riehl, S., Zeidi, M. and Conard, N. J. 2017. Reconstructing Subsistence Practices: Taphonomic Constraints and the Interpretation of Wild Plant Remains at Aceramic Neolithic Chogha Golan, Iran. *Vegetation History and Archaeobotany* 26 (5): 487–504.

Weide, A., Riehl, S., Zeidi, M. and Conard, N. J. 2018. A Systematic Review of Wild Grass Exploitation in Relation to Emerging Cereal Cultivation Throughout the Epipalaeolithic and Aceramic Neolithic of the Fertile Crescent. *PloS one* 13 (1): e0189811.

Weinberg, P. 2001. On the Status and Biology of the Wild Goat in Daghestan (Russia). *Journal of Mountain Ecology* 6: 31–40.

Weiner, S. 2010. *Microarchaeology: Beyond the Visible Archaeological Record*. Cambridge, Cambridge University Press.

Weismantel, M. and Meskell, L. 2014. Substances: 'Following the Material' through Two Prehistoric Cases. *Journal of Material Culture* 19: 233–241.

Weiss, E., Kislev, M. E. and Hartmann, A. 2006. Autonomous Cultivation before Domestication. *Science* 312: 1608–1610.

Weissbrod, L., Malkinson, D., Cucchi, T., Gadot, Y., Finkelstein, I. and Bar-Oz, G. 2014. Ancient Urban Ecology Reconstructed from Archaeozoological Remains of Small Mammals in the Near East. *PloS one* 9 (3): e91795.

Weissbrod, L., Marshall, F. B., Valla, F. R., Khalaily, H., Bar-Oz, G., Auffray, J.-C., Vigne, J.-D. and Cucchi, T. 2017. Origins of House Mice in Ecological Niches Created by Settled Hunter-Gatherers in the Levant 15,000 Y Ago. *Proceedings of the National Academy of Sciences* 114 (16): 4099–4104.

Wengrow, D. and Graeber, D. 2015. Farewell to the 'Childhood of Man': Ritual, Seasonality, and the Origins of Inequality. *Journal of the Royal Anthropological Institute* 21 (3): 597–619.

White, D. J. 1997. Dental Calculus: Recent Insights into Occurrence, Formation, Prevention, Removal and Oral Health Effects of Supragingival and Subgingival Deposits. *European Journal of Oral Sciences* 105 (5): 508–22.

Whitehouse, N. J. and Kirleis, W. 2014. The World Reshaped: Practices and Impacts of Early Agrarian Societies. *Journal of Archaeological Science* 51: 1–11.

Whitlam, J. 2015. *Plant Use and Neolithic Societies of the Eastern Fertile Crescent, C.10,000–5500 BC* Ph.D. thesis, University of Reading.

Whitlam, J., Ilkhani, H., Bogaard, A. and Charles, M. 2013. The Plant Macrofossil Evidence from Sheikh-e Abad: First Impressions, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 175–184.

Whitlam, J., Bogaard, A., Matthews, R., Matthews, W., Mohammadifar, Y., Ilkhani, H. and Charles, M. 2018. Pre-Agricultural Plant Management in the Uplands of the Central Zagros: The Archaeobotanical Evidence from Sheikh-e Abad. *Vegetation History and Archaeobotany* 27 (6): 817–831.

Wick, L., Lemcke, G. and Sturm, M. 2003. Evidence of Lateglacial and Holocene Climatic Change and Human Impact in Eastern Anatolia: High-Resolution Pollen, Charcoal, Isotopic and Geochemical Records from the Laminated Sediments of Lake Van, Turkey. *The Holocene* 13 (5): 665–675.

Wicks, K. The Chronology and Cultural Phases of WF16, in S. Mithen, B. Finlayson, D. Maricevic, S. Smith, E. Jenkins and M. Najjar. *WF16: Excavations at an Early Neolithic Site in Southern Jordan. Stratigraphy, Chronology, Architecture, Burials*. London, Council for British Research in the Levant: 649–652.

Wilke, P. J. 1996. Bullet-Shaped Microblade Cores of the Near Eastern Neolithic: Experimental Replicative Studies, in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 289–310.

Wilke, P. J. and Quintero, L. A. 1996. Near Eastern Neolithic Millstone Production: Insights from Research in the Arid Southwestern United States in S. K. Kozłowski and H. G. Gebel (eds). *Neolithic Chipped Stone Industries of the Fertile Crescent and Their Contemporaries in Adjacent Regions: Proceedings of the Second Workshop on PPN Chipped Lithic Industries, Institute of Archaeology, Warsaw University, 3rd–7th April 1995*. Berlin, ex oriente Studies in Early Near Eastern Production, Subsistence, and Environment: 243–260.

Wilkinson, T. 1999. Demographic Trends from Archaeological Survey: Case Studies from the Levant and Near East, in J. Bintliff and K. Sbonias (eds). *Reconstructing Past Population Trends in Mediterranean Europe (3000 BC–AD 1800)*. Oxford, Oxbow Books: 45–64.

Willcox, G. 2005. The Distribution, Natural Habitats and Availability of Wild Cereals in Relation to Their Domestication in the Near East: Multiple Events, Multiple Centres. *Vegetation History and Archaeobotany* 14 (4): 534–541.

Willcox, G. 2013. The Roots of Cultivation in Southwestern Asia. *Science* 341 (6141): 39.

Willcox, G. and Stordeur, D. 2012. Large-Scale Cereal Processing before Domestication During the Tenth Millennium Cal BC in Northern Syria. *Antiquity* 86 (331): 99–114.

Willcox, G., Buxo, R. and Herveux, L. 2009. Late Pleistocene and Early Holocene Climate and the Beginnings of Cultivation in Northern Syria. *Holocene* 19 (1): 151–148.

Williams, H. R. S. 2013. Heavy Residue Analysis from Sheikh-e Abad, in R. Matthews, W. Matthews and Y. Mohammadifar (eds). *The Earliest Neolithic of Iran: 2008 Excavations at Sheikh-e Abad and Jani*. CZAP Report 1. Oxford, British Institute of Persian Studies and Oxbow Books: 207–215.

Williams, M., Zalasiewicz, J., Haff, P., Schwägerl, C., Barnosky, A. D. and Ellis, E. C. 2015. The Anthropocene Biosphere. *Anthropocene Review* 2 (3): 196–219.

Wilson, B. 1996. *Spatial Patterning Among Animal Bones in Settlement Archaeology: An English Regional Exploration.* Oxford, British Archaeological Reports 251.

Wilson, C. A., Davidson, D. A. and Cresser, M. S. 2008. Multi-Element Soil Analysis: An Assessment of Its Potential as an Aid to Archaeological Interpretation. *Journal of Archaeological Science* 35 (2): 412–424.

Wilson, D. E. and Reeder, D. M. 2005. *Mammal Species of the World: A Taxonomic and Geographic Reference*. Baltimore, Johns Hopkins University Press.

WISE 2012. *Women in Science, Technology, Engineering and Mathematics: From Classroom to Boardroom – UK Statistics 2012*, Leeds, WISE Campaign.

Witmore, C. L. 2014. Archaeology and the New Materialisms. *Journal of Contemporary Archaeology* 1 (2): 203–246.

Wolfe, N. D., Dunavan, C. P. and Diamond, J. 2007. Origins of Major Human Infectious Diseases. *Nature* 447 (7142): 279–283.

Wollstonecroft, M. M. 2011. Investigating the Role of Food Processing in Human Evolution: A Niche Construction Approach. *Archaeological and Anthropological Sciences* 3 (1): 141–140.

Wollstonecroft, M., Hroudová, Z., Hillman, G. and Fuller, D. 2011. Bolboschoenus Glaucus (Lam.) S.G. Smith, a New Species in the Flora of the Ancient Near East. *Vegetation History and Archaeobotany* 20 (5): 459–470.

Wrangham, R. 2017. Control of Fire in the Paleolithic: Evaluating the Cooking Hypothesis. *Current Anthropology* 58 (S16): S303–S313.

Wrangham, R. W. 2010. *Catching Fire: How Cooking Made Us Human*. New York, Basic Books.

Wright, H. E. 1993. Environmental Determinism in Near Eastern Prehistory. *Current Anthropology* 34 (4): 458–469.

Wright, H. E. and Howe, B. 1951. Preliminary Report on Soundings at Barda Balka. *Sumer* 7: 107–118.

Wright, K. 1991. The Origins and Development of Ground Stone Assemblages in Late Pleistocene Southwest Asia. *Paléorient* 17 (1): 19–45.

Wright, K. 1992a. A Classification System for Ground Stone Tools from the Prehistoric Levant. *Paléorient* 18 (2): 53–81.

Wright, K. 1992b. *Ground Stone Assemblage Variations and Subsistence Strategies in the Levant, 22,000 to 5500 BP*. Ph.D. thesis, Yale University.

Wright, K. 1994. Ground-Stone Tools and Hunter-Gatherer Subsistence in Southwest Asia: Implications for the Transition to Farming. *American Antiquity* 59 (2): 238–263.

Wright, K. 2000. The Social Origins of Cooking and Dining in Early Villages of Western Asia. *Proceedings of the Prehistoric Society* 66: 89–121.

Wright, K. 2008. Craft Production and the Organization of Ground Stone Technologies, in Y. Rowan and J. Ebeling (eds). *New Approaches to Old Stones: Recent Studies of Ground Stone Artefacts*. London, Equinox: 130–143.

Wright, K. 2014. Domestication and Inequality? Households, Corporate Groups and Food Processing Tools at Neolithic Çatalhöyük. *Journal of Anthropological Archaeology* 33: 1–33.

Wright, K. and Garrard, A. 2003. Social Identities and the Expansion of Stone Bead-Making in Neolithic Western Asia: New Evidence from Jordan. *Antiquity* 77: 267–284.

Wright, K., Tsoraki-Chan, C. and Siddall, R. 2013. The Ground Stone Technologies of Çatalhöyük, in I. Hodder (ed.) *Substantive Technologies at Çatalhöyük: Reports from the 2000–2008 Seasons. Çatalhöyük Research Project* 9. London & Los Angeles, British Institute for Archaeology at Ankara & Cotsen Institute of Archaeology UCLA: 365–416.

Wyncoll, G. and Tangri, D. 1991. The Origins of Commensalism and Human Sedentism. *Paléorient* 17 (2): 157–159.

Yadin, Y. 1963. *The Art of Warfare in Biblical Lands: In the Light of Archaeological Study*. London: Weidenfeld and Nicolson.

Yaghubpur, A. and Mehrabi, B. 1997. Kushk Zinc-Lead Deposit. A Typical Black-Shale-Hosted Deposit in Yazd State, Iran. *Journal of Science, Islamic Republic of Iran* 8 (2): 117–126.

Yaroshevich, A., Kaufman, D., Nuzhnyy, D., Bar-Yosef, O. and Weinstein-Evron, M. 2010. Design and Performance of Microlith Implemented Projectiles During the Middle and the Late Epipaleolithic of the Levant: Experimental and Archaeological Evidence. *Journal of Archaeological Science* 37 (2): 368–388.

Yi, M., Barton, L., Morgan, C., Liu, D., Chen, F., Zhang, Y., Pei, S., Guan, Y., Wang, H., Gao, X. and Bettinger, R. L. 2013. Microblade Technology and the Rise of Serial Specialists in North-Central China. *Journal of Anthropological Archaeology* 32 (2): 212–223.

Yokoe, K. and Mannoji, T. 1986. Stress Fracture of the Proximal Phalanx of the Great Toe: A Report of Three Cases. *The American Journal of Sports Medicine* 14 (3): 240–242.

Young, T. C., Smith, P. E. L. and Mortensen, P. (eds.)1983. *The Hilly Flanks and Beyond: Essays on the Prehistory of Southwestern Asia Presented to Robert J. Braidwood.* Chicago, Oriental Institute of the University of Chicago Studies in Ancient Oriental Civilization 36.

Zalasiewicz, J., Waters, C. N., Williams, M., Barnosky, A. D., Cearreta, A., Crutzen, P., Ellis, E., Ellis, M. A., Fairchild, I. J. and Grinevald, J. 2015. When did the Anthropocene Begin? A Mid-Twentieth Century Boundary Level is Stratigraphically Optimal. *Quaternary International* 383: 196–203.

Zeder, M. A. 1999. Animal Domestication in the Zagros: A Review of Past and Current Research. *Paléorient* 25 (2): 11–25.

Zeder, M. A. 2001. A Metrical Analysis of a Collection of Modern Goats (*Capra hircus aegargus* and *C. h. hircus*) from Iran and Iraq: Implications for the Study of Caprine Domestication. *Journal of Archaeological Science* 28 (1): 61–79.

Zeder, M. A. 2005. A View from the Zagros: New Perspectives on Livestock Domestication in the Fertile Crescent, in J.-D. Vigne, J. Peters and D. Helmer (eds). *First Steps of Animal Domestication: New Zooarchaeological Approaches. Proceedings of the 9th Conference of the International Council of Archaeozoology, Durham, August 2002*. Oxbow, Oxbow Books: 125–146.

Zeder, M. A. 2006. Archaeological Approaches to Documenting Animal Domestication, in M. A. Zeder, D. Bradley, E. Emshwiller and B. Smith (eds). *Documenting Domestication: New Genetic and Archaeological Paradigms*. Berkeley, University of California Press: 171–180.

Zeder, M. A. 2008a. Animal Domestication in the Zagros: An Update and Directions for Future Research, in E. Vila, L. Gourichon, A. M. Choyke and H. Buitenhuis (eds). *Archaeozoology of the Near East VIII*. Lyon, Maison de l'Orient et de la Méditerranée: 243–277.

Zeder, M. A. 2008b. Domestication and Early Agriculture in the Mediterranean Basin: Origins, Diffusion, and Impact. *Proceedings of the National Academy of Sciences* 105 (33): 11597–11604.

Zeder, M. A. 2009. The Neolithic Macro-(R)Evolution: Macroevolutionary Theory and the Study of Culture Change. *Journal of Archaeological Research* 17: 1–63.

Zeder, M. A. 2011. The Origins of Agriculture in the Near East. *Current Anthropology* 52 (S4): S221–S235.

Zeder, M. A. 2012a. The Broad Spectrum Revolution at 40: Resource Diversity, Intensification, and an Alternative to Optimal Foraging Explanations. *Journal of Anthropological Archaeology* 31 (3): 241–264.

Zeder, M. A. 2012b. Pathways to Animal Domestication, in P. Gepts, T. R. Famula and R. L. Bettinger (eds). *Biodiversity in Agriculture: Domestication, Evolution, and Sustainability*. Cambridge, Cambridge University Press: 227–249.

Zeder, M. A. 2015. Core Questions in Domestication Research. *Proceedings of the National Academy of Sciences* 112 (11): 3191–3198.

Zeder, M. A. 2016. Domestication as a Model System for Niche Construction Theory? *Evolutionary Ecology* 30: 325–348.

Zeder, M. A. and Hesse, B. 2000. The Initial Domestication of Goats (*Capra hircus*) in the Zagros Mountains 10,000 Years Ago. *Science* 287: 2254–2247.

Zeder, M. A. and Lapham, H. A. 2010. Assessing the Reliability of Criteria Used to Identify Postcranial Bones in Sheep, Ovis, and Goats, Capra. *Journal of Archaeological Science* 37 (11): 2887–2905.

Zeder, M. A. and Pilaar, S. E. 2010. Assessing the Reliability of Criteria Used to Identify Mandibles and Mandibular Teeth in Sheep, *Ovis*, and Goats, *Capra*. *Journal of Archaeological Science* 37 (2): 225–242.

Zeder, M. A. and Smith, B. D. 2009. A Conversation on Agricultural Origins: Talking Past Each Other in a Crowded Room. *Current Anthropology* 50 (5): 681–690.

Zeder, M. A., Bradley, D., Emshwiller, E. and Smith, B. (eds). 2006. *Documenting Domestication: New Genetic and Archaeological Paradigms*. Berkeley, University of California Press.

Zeidi, M. and Conard, N. J. 2013. Chipped Stone Artifacts from the Aceramic Neolithic Site of Chogha Golan, Ilam Province, Western Iran, in F. Borrell, J. J. Ibáñez Estévez and M. Molist (eds). *Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East. Papers Presented to the 7th Conference on PPN Chipped and Ground Stone Industries of the Fertile Crescent*. Bellaterra, Universitat Autònoma de Barcelona, Servei de Publicacions: 315–326.

Zeidi, M., Riehl, S., Napierela, H. and Conard, N. J. 2012. Chogha Golan: A PPN Site in the Foothills of the Zagros Mountains, Ilam Province, Iran. Report on the First Season of Excavation in 2009, in R. Matthews and J. Curtis (eds). *Proceedings of the 7th International Congress on the Archaeology of the Ancient Near East: 12 April–16 April 2010, the British Museum and UCL, London*. Wiesbaden, Harrassowitz: 259–276.

Zhang, L., Zhang, X., Wu, G. K., Chen, P., Wang, P., Wang, H. and Wang, K. 2018. Ancient Mud-Brick Architecture of Northwest China. *Paléorient* 44 (1): 93–103.

Zohary, D. 1996. The Mode of Domestication of the Founder Crops of Southwest Asian Agriculture, in Harris (ed.) 1996: 142–148.

Zohary, D. and Hopf, M. 2000. *Domestication of Plants in the Old World: The Origin and Spread of Cultivated Plants in West Asia, Europe, and the Nile Valley. Third Edition*. Oxford, Oxford University Press.

Zohary, M. 1973. *Geobotanical Foundations of the Middle East*. Stuttgart, Fischer.

Zuckerman, M. K., Kamnikar, K. R. and Mathena, S. A. 2014. Recovering the 'Body Politic': A Relational Ethics of Meaning for Bioarchaeology. *Cambridge Archaeological Journal* 24 (3): 513–522.