CHAPTER 10

ORGANIC RESIDUE ANALYSIS OF CERAMIC VESSELS

By A.C. Colonese, A. Lucquin, Jane Timby and O.E. Craig

INTRODUCTION

Fragments of ceramic vessels are common and often abundant artefacts in archaeological records. Unglazed sherds potentially preserve a wealth of ancient biomolecules resulting from the production, storage, transport and processing of food and other commodities by past societies. In particular, lipids (fats, oils and waxes) can be readily absorbed by the inorganic porous ceramic matrix (Evershed *et al.* 1999), and preserved for hundreds to thousands of years (Craig *et al.* 2013). Organic residue analysis of archaeological ceramic vessels has therefore advanced our understanding of past culinary practices and the nature of past economies (Evershed *et al.* 1999; Evershed 2008). In Britain organic residue analysis has been extensively undertaken, providing a good overall record of prehistoric pottery use (Copley *et al.* 2003; 2005a; 2005b; 2005c; Cramp *et al.* 2014). Copley *et al.* (2005a) analysed a range of Iron Age pottery vessels from Maiden Castle, Danebury hillfort, Yarnton Cresswell Field and Stanwick, concluding that milk was a particularly important commodity during this period.

Here we present the results of the organic residue analysis from the Iron Age deposits at Silchester. As a late first-century B.C. *oppidum*, Silchester provides a different site type to the Iron Age hillforts and settlements previously analysed. The aims of this analysis were to provide a snapshot of culinary practices during the late Iron Age occupation of Silchester, to provide a comparison with pottery use in the succeeding Roman phases and to provide direct evidence of artefact use to compare with faunal and floral data and pottery form and technology, presented elsewhere in this volume.

To achieve these aims, 29 sherds were analysed using routine methods in organic residue analysis, including gas chromatography (GC) and GC-mass spectrometry (GC-MS) to separate and identify lipids from the solvent extracts. In addition, stable carbon isotope analysis of palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) acids by GC-combustion-stable isotope ratio MS (GC-c-IRMS) provides a complementary method for animal-fat identification in archaeological ceramic vessels (Evershed *et al.* 2002a; 2002b; Copley *et al.* 2003; Mukherjee *et al.* 2008; Craig *et al.* 2013; Salque *et al.* 2013). This latter approach is routinely used to identify ruminant products (Craig *et al.* 2012) and dairying activity in the archaeological record (Copley *et al.* 2003; Dunne *et al.* 2012).

MATERIAL AND METHODS

SELECTED SAMPLES AND LIPID EXTRACTION

Twenty-nine sherds representing a range of typical coarse wares were selected from Period 0 contexts for lipid analysis; two samples came from the early ditch (11631); the rest from various pits (See Table 12). The selection embraced 29 samples of the four main fabric groups encountered at this time: flint-tempered Silchester ware (SILF1); grog-tempered ware (GR1; GR4, GRFL); mixed sand/grog/iron/flint-tempered ware (SF); and sandy wares from the Alice Holt industry

(ALH RE). This was to assess whether pots with different tempering materials might have been used for different methods of food preparation, specific recipes or other purposes. Most of the sherds came from closed jar-type vessels; both handmade and wheel-made. Rim forms include beaded (J1); internally thickened (J16); everted (J2); or everted, cordoned (J6), rim types. In addition, five necked cordoned bowls (B2/6) or beaded-rim bowls (B1) were submitted. The diameters of the vessels ranged from 120 mm through to 240 mm. Three vessels have been illustrated (FIGS 91.148, 92.97 and 93.176). Whilst some vessels had a matt, plain finish, others were part burnished, or even, in one case, with burnished decoration (FIG. 93.176). Most of the sherds selected showed some evidence of cooking in the form of sooting either on the interior or exterior surfaces. Whenever possible, the rim was selected for lipid extraction, since a higher concentration of lipids has usually been reported for this part of vessels (Charters *et al.* 1993).

Ceramic powder drilled (d. 2 mm–5 mm) from the internal sherd surface (~1 g) was lipid-extracted using acidified methanol (e.g. Craig *et al.* 2013; Correa-Ascencio and Evershed 2014). After adding 2 mL of methanol, the samples were ultrasonicated for 15 minutes. Subsequently, 400 µL of H_2SO_4 was added and the samples were heated at 70° C for 4 hours. The samples were then centrifuged (850 xg) for 5 minutes. The supernatant was extracted with hexane (3 × 2 mL) and neutralised with K_2CO_3. The extracts were then dried under a gentle stream of N_2 and an internal standard (10 µg hexatriacontane) added to each sample before further analysis by GC/MS and GC/C/IRMS.

The samples were screened by GC using an Agilent 7890A gas chromatograph (Agilent Technologies, Cheadle, Cheshire, UK). The injector was splitless and maintained at 300° C and injected 1 µL of sample into the GC. The column used was a 100 per cent Dimethylpolysiloxane DB-1 (15 m x 320 µm x 0.1 µm; J&W Scientific, Folsom, CA, USA). The carrier gas was hydrogen with a constant flow rate of 2ml/min. The temperature programme was set at 100° C for two minutes, rising by 20° C/min until 325° C. This temperature was maintained for three minutes. The total run time was 16.25 minutes. The lipids were quantified according to the internal standard and diluted appropriately prior to GC-MS and GC-c-IRMS as described below.

GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS)

GC-MS was carried out on all samples using a 7890A Series chromatograph attached to a 5975C Inert XL mass-selective detector with a quadrupole mass analyser (Agilent Technologies, Cheadle, UK). The carrier gas used was helium, and the inlet/column head-pressure was constant. A splitless injector was used and maintained at 300° C. The GC column was inserted directly into the ion source of the mass spectrometer. The ionisation energy of the mass spectrometer was 70 eV and spectra were obtained by scanning between m/z 50 and 800. Three different analytical columns were used. Samples were analysed using a DB-5ms (5%-phenyl)-methylpolysiloxane column (30 m × 0.250 mm × 0.25 µm; J&W Scientific, Folsom, CA, USA). The temperature for this column was set at 50°C for 2 minutes, then raised by 10° C min^{-1} to 325° C, where it was held for 15 minutes.

GAS CHROMATOGRAPHY-COMBUSTION-ISOTOPE RATIO MASS SPECTROMETRY (GC-C-IRMS)

Carbon stable isotopes were determined on two fatty acid methyl esters: methyl palmitate ($C_{16:0}$) and methyl stearate ($C_{18:0}$), in each extract using an Isoprime 100 (Isoprime, Cheadle, UK) linked to a Hewlett Packard 7890B series gas chromatograph (Agilent Technologies, Santa Clara, CA, USA) with a Isoprime GC5 interface (Isoprime, Cheadle, UK). The gases eluting from the chromatographic column were split into two streams. One of these was directed into an Agilent 5975C inert mass spectrometer detector (MSD), for sample identification and quantification, while the other was directed through the GC5 furnace held at 850° C to oxidise all carbon species into CO_2. All samples were diluted with hexane and subsequently 1 µL of each sample was injected into a DB-5MS fused-silica column. The temperature was set for 0.5 minute at 50°

TABLE 12. THE DESCRIPTION OF THE CERAMIC SHERDS SUBMITTED FOR ANALYSIS AND DETAILS OF THE ABSORBED LIPID RESIDUES DETECTED. COMPOSITION OF LIPID EXTRACTS

Abbreviations: SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; K, mid-chain ketones; ALK, *n*-alkanes; D, diacids; Br, branched fatty acid; O, oxygenated fatty acid derivatives; APAA, C_{18}-ω-(o-alkylphenyl) alkanoic acids; $\delta^{13}C$ values of $C_{16:0}$ and $C_{18:0}$ fatty acids

Samples	Pit	Object	Cxt	Cut	Fabric	Description	Part	Form	Diam. (mm)	Total lipids (mg/g^{-1})	Lipid detected	$\delta^{13}C_{C16:0}$	$\delta^{13}C_{C18:0}$
SLC1	PIT GP2	500190	10726	11670	SILF1	SILCH WARE	RIM	J1	240	6.45	SFA, MUFA, Br, K, ALK, D, O	-27.2	-27.7
SLC2	PIT GP7	500546	10773	11732	GR1	GROG	RIM	J2	200	1.69	SFA, MUFA, PUFA, Br, D	-27.8	-29.5
SLC3	PIT GP3	500492	14693	14658	SILF1	SILCH WARE	RIM	J16	180	0.08	SFA, MUFA, Br, K, ALK, D	-28.0	-29.5
SLC4	PIT GP14	500554	11568	11026	GR1	GROG	RIM	B6	120	1.84	SFA, MUFA, Br, K, ALK, D, O	-28.3	-29.6
SLC5	PIT GP2	500190	11676	11701	SF	SANDY WITH FLINT	RIM	J1	160	0.08	SFA, MUFA, Br, D, O	-29.0	-30.5
SLC6	PIT GP11	500542	16056	16075	GR1	GROG	BODY	-	-	0.66	SFA, MUFA, Br, K, D	-28.2	-30.3
SLC7	PIT GP9	500040	11757	11763	GR4	GROG	BODY	-	-	1.10	SFA, MUFA, PUFA, Br, K, ALK, D	-28.4	-30.5
SLC8	PIT GP11	500542	16585	16688	SILF1	SILCH WARE	RIM	J16	210	5.04	SFA, MUFA, Br	-28.0	-29.3
SLC9	DITCH	500465	11592		GR1	GROG	RIM	J6	120	1.38	SFA, MUFA, PUFA, Br, D, O	-28.9	-31.2
SLC10	PIT GP3	500492	14626	14658	SILF1	SILCH WARE	RIM	J16	180	0.17	SFA, MUFA, PUFA, Br, ALK, D, O, APAA	-28.2	-29.1
SLC11	PIT GP2	500190	15265	15266	GR4	GROG	RIM	J/B6	170	0.08	SFA, MUFA, PUFA, Br, D	-28.3	-29.4
SLC12	PIT GP3	500492	11118	11135	SILF1	SILCH WARE	RIM	J16	240	0.76	SFA, MUFA, PUFA, Br, D, O	-27.7	-29.4
SLC13	PIT GP4	500547	11687	11721	SILF1	SILCH WARE	RIM	J16	240	0.34	SFA, MUFA, Br, D, O, APAA	-28.0	-29.2

TABLE 12 (cont.). THE DESCRIPTION OF THE CERAMIC SHERDS SUBMITTED FOR ANALYSIS AND DETAILS OF THE ABSORBED LIPID RESIDUES DETECTED. COMPOSITION OF LIPID EXTRACTS

Samples	Pit	Object	Cxt	Cut	Fabric	Description	Part	Form	Diam. (mm)	Total lipids (mg/g^{-1})	Lipid detected	$\delta^{13}C_{C16:0}$	$\delta^{13}C_{C18:0}$
SLC14	PIT GP2	200190	10727	11668	SFG	SAND/GROG/FLINT	RIM	J16	150	0.57	SFA, MUFA, PUFA, Br, D	-27.9	-28.4
SLC15	DITCH	500465	11996		SILF1	SILCH WARE	RIM	J16	120	0.40	SFA, MUFA, PUFA, Br, D, O	-29.4	-31.7
SLC16	PIT GP9	500040	11758	11764	GRFL3	GROG AND FLINT	RIM	J6	240	0.09	SFA, MUFA, PUFA, Br, D	-28.1	-28.2
SLC17	PIT GP10	500484	15140	15142	ALHRE	ALICE HOLT SAND	RIM	J16	240	51.16	SFA, MUFA, PUFA, Br, D	-28.9	-31.3
SLC18	PIT GP3	500492	14653	14658	GR1	GROG	RIM	J/B1	90	0.37	SFA, MUFA, PUFA, Br, D, O	-27.3	-27.6
SLC19	PIT GP2	500190	10200	10770	SILF1	SILCH WARE	RIM	J16	220	4.32	SFA, MUFA, PUFA, Br, D, O	-28.3	-30.0
SLC20	PIT GP3	500492	12680	12969	GF	GROG AND FLINT	RIM	J1	180	0.48	SFA, MUFA, PUFA, Br, K, D	-28.1	-29.2
SLC21	PIT GP1	500541	10711	7643	SILF1	SILCH WARE	L	B/J12	240	3.63	SFA, MUFA, PUFA, Br, O	-29.3	-31.8
SLC22	PIT GP2	500190	13745	13749	SILF1	SILCH WARE	RIM	J16	180	8.72	SFA, MUFA, PUFA, Br, D, O	-29.1	-31.5
SLC23	PIT GP5	500525	13660	13684	SILF1	SILCH WARE	RIM	J16	230	2.46	SFA, MUFA, PUFA, Br	-28.7	-30.6
SLC24	PIT GP1	500541	12461	12462	GR4	GROG	RIM	B/J2	160	0.01	SFA, MUFA, Br	-29.3	-29.8
SLC25	PIT GP14	500554	9592	8580	SILF1	SILCH WARE	RIM	J16	180	0.32	SFA, MUFA, PUFA, Br, K, D, O	-28.2	-30.2
SLC26	PIT GP1	500541	10016	7643	GRSA	SANDY GROG	RIM	J1	140	0.54	SFA, MUFA, PUFA, Br, K, D, O	-28.8	-30.9
SLC27	PIT GP4	500547	11687	11721	OR1	ORGANIC	RIM	J1	140	14.12	SFA, MUFA, Br, D	-28.1	-29.8
SLC28	DITCH	500465	1111	1110	SILF1	SILCH WARE	RIM	J16	-	2.67	SFA, MUFA, Br, D, O	-28.4	-30.6
SLC29	PIT GP8	500524	10153	10178	ALHRE	ALICE HOLT SAND	BODY	J/B6	-	0.01	SFA, MUFA, Br	-29.2	-29.6

C, and raised by 10° C min^{-1} until 300° C was reached, at which it stayed for 10 minutes. The carrier gas was ultra-high purity grade helium with a flow rate of 3 mL min^{-1}. Eluted products were combusted to CO_2 and ionized in the mass spectrometer by electron impact. Ion intensities of *m*/*z* 44, 45, and 46 were monitored in order to automatically compute the $^{13}C/^{12}C$ ratio of each peak in the extracts. Computations were made with IonVantage Software (Isoprime, Cheadle, UK) and were based on comparisons with a standard reference gas (CO_2) of known isotopic composition that was repeatedly measured. The results from the analysis are reported in parts per mil (‰) relative to an international standard (V-PDB). Replicate measurements of each sample and a mixture of fames fatty acid methyl esters (FAMEs) with $\delta^{13}C$ values traceable to international standards were used to determine instrument precision (<0.3‰) and accuracy (<0.5‰). Values were also corrected subsequent to analysis to account for the methylation of the carboxyl group that occurs during acid extraction. Corrections were based on comparisons with a standard mixture of $C_{16:0}$ and $C_{18:0}$ fatty acids of known isotopic composition processed in each batch as a sample.

RESULTS AND DISCUSSION

MOLECULAR ANALYSIS OF ORGANIC RESIDUES

Absorbed lipids could be extracted from all the sherds, revealing a highly variable preservation, with concentrations ranging from ~0.01 to ~51 mg g^{-1} (average 3.78 mg g^{-1}) (Table 12). Lipid concentration was aleatory in relation to ceramic fabric, type and shape. The extracted compounds consisted predominantly of a range of saturated mid-chain-length *n*-alkanoic acids (fatty acids) with even carbon numbers, dominated by $C_{16:0}$ (90 per cent), and followed by $C_{18:0}$, $C_{14:0}$, $C_{20:0}$, $C_{22:0}$, $C_{12:0}$ (FIG. 107). These fatty acids are ubiquitous in plant oil and animal fats (Dudd and Evershed 1998; Evershed *et al.* 1999; 2002a). However long-chain fatty acids with 20 to 30 carbon atoms were also recovered from several sherds, and they are more securely associated with plant/seed oil and leaf waxes. The presence of plant lipids is indeed confirmed by the recovery of long-chain alkanes in several samples (17.2 per cent).

Odd numbered straight-chain *n*-alkanoic acids were detected in all the samples, and included mainly $C_{15:0}$, $C_{17:0}$, $C_{19:0}$, $C_{21:0}$. Mono- and polyunsaturated fatty acids were also recovered from 100 per cent and 65 per cent of samples respectively, but in much lower abundance compared to $C_{16:0}$ and $C_{18:0}$. These included in order of abundance $C_{18:1}$, $C_{16:1}$, $C_{18:2}$, $C_{21:1}$, $C_{20:1}$ and $C_{23:1}$. Branched-chain alkanoic acids were detected in all but one sample and are predominantly represented by $C_{16:0}$, $C_{17:0}$-iso and -anteiso, followed by $C_{18:0}$, $C_{15:0}$-iso and -anteiso, $C_{19:0}$ and $C_{14:0}$. These compounds are typical constituents of bacterial lipids, but also occur in ruminant fat (Evershed *et al.* 1999; 2002a). Most of the samples (83 per cent) contained trace amounts of α,ω-dicarboxylic acids ranging mainly from C_7 to C_{14}, but some samples also provided smaller (C_6) and larger chains (C_{15}, C_{16} and C_{20}). Some of these samples (52 per cent) also contained other oxygenated saturated carboxylic acids, including 4- and 12-hydroxyoctadecanoic acids, and 10-oxo-octadecanoic acid. These oxygenated fatty acid derivatives probably derive from the degradation of a large variability of unsaturated moieties of fatty acids, as in fact recorded in most of the pots (Copley *et al.* 2005a; Regert *et al.* 1998).

Trace amounts of long-chain ketones (C_{31} to C_{35}) were also found in 28.6 per cent of the analysed sherds. These compounds occur as a component of leaf waxes of higher plants (Evershed *et al.* 2002a), but might also be formed by pyrolysis of free fatty acids or triaglycerols from animal fats (Evershed *et al.* 1995). Pyrolysis occurs when ceramics are heated to high temperatures (>300° C; Evershed *et al.* 1995; Raven *et al.* 1997), thus providing direct evidence that some vessels were used for cooking (Copley *et al.* 2005a). This is also supported by the presence of C_{18}-ω-(o-alkylphenyl) alkanoic acids in some of these sherds (7 per cent). As for long-chain ketones, C_{18}-ω-(o-alkylphenyl) alkanoic acids are produced when unsaturated fatty acids are heated at higher temperatures (Evershed 2008), thus confirming that some of these vessels were effectively used for cooking.

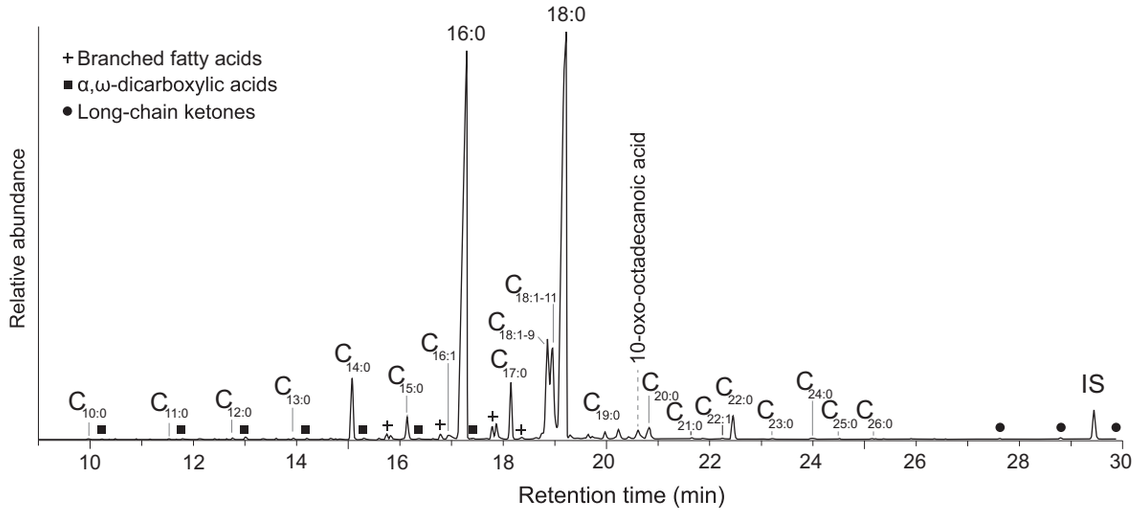


FIG. 107. Partial gas chromatogram of main lipid extracts from a ceramic vessel (Sample 25, Silchester Ware, context 9592). $C_{n:x}$ indicates fatty acid with n carbon atoms and x double bonds, IS indicates internal standard.

In general, the lipid composition of Iron Age ceramic vessels from Silchester contains molecular characteristics pointing toward the processing of animal products (meat, fat) in all the sherds. This is particularly inferred by the abundance of mid-chain saturated, branched chain and unsaturated fatty acids, and their degradation products. Along with animal products, the presence of long-chain saturated fatty acids, alkanes, and C_{18}-ω-(o-alkylphenyl) alkanoic acids suggests the cooking of plant oils and waxes in some vessels (*c.* 10 per cent; Evershed *et al.* 1995; Raven *et al.* 1997; Baeten *et al.* 2013).

STABLE CARBON ISOTOPE COMPOSITION OF FATTY ACIDS

In order to maximise the identification of the degraded animal fats recovered from the sherds the stable carbon isotope composition ($\delta^{13}C$) of palmitic ($C_{16:0}$) and stearic ($C_{18:0}$) acids was measured (FIG. 108). The stable carbon isotope analysis of $C_{16:0}$ and $C_{18:0}$ fatty acids provides a complementary method for animal fat identification in archaeological ceramic vessels. The stable carbon isotopic ratios of monogastric (e.g. pig, bird) and ruminant (e.g. cattle, sheep/goat) adipose fatty acids, and milk/dairy products differ due to fundamental variations in digestive physiology and metabolic processes (Stott *et al.* 1997; Copley *et al.* 2003; Howland *et al.* 2003; Jim *et al.* 2004). This process leads to measurable differences in the $\delta^{13}C$ values of $C_{16:0}$ and $C_{18:0}$ fatty acids, allowing for discrimination of these resources in ceramic vessels (Evershed *et al.* 2002b; Copley *et al.* 2003; Mukherjee *et al.* 2008; Craig *et al.* 2013; Salque *et al.* 2013).

We compared the $\delta^{13}C$ values of $C_{16:0}$ and $C_{18:0}$ extracted from the vessels with fatty acid $\delta^{13}C$ values from modern porcine and ruminant adipose fats, and milk reference for the UK (Dudd and Evershed 1999). The results were also compared with the $\delta^{13}C$ values of $C_{16:0}$ and $C_{18:0}$ extracted from several ceramic vessels from early, middle and late Iron Age sites in Britain (Maiden Castle, Danebury hillfort, Yarnton Cresswell Field and Stanwick; Copley *et al.* 2003; 2005a). The results reveal that the vast majority of the ceramic vessels at Silchester have fatty acid $\delta^{13}C$ values broadly consistent with modern ruminant adipose fat, while some samples fall between the ellipses of modern ruminant and porcine adipose fat (or other monogastric-omnivore fats).

The $\delta^{13}C$ results confirm that ceramic vessels at Silchester were predominantly used for processing ruminant and monogastric meat and fat. Exceptionally, there is no isotopic evidence for the use of milk or dairy products within these ceramics, which is remarkable given their relevance in organic residues extracted from other Iron Age sites in Britain (FIG. 108). Although the data at

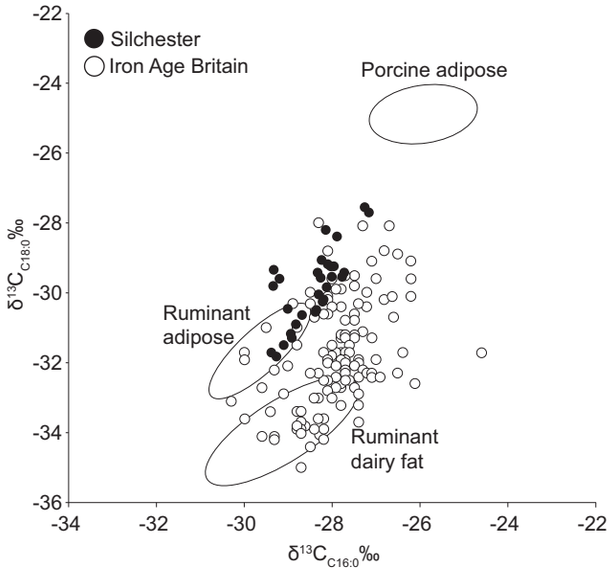


FIG. 108. $\delta^{13}C$ values for the $C_{16:0}$ and $C_{18:0}$ fatty acids extracted from Iron Age vessels from Silchester along with other Iron Age samples from Britain (Copley *et al.* 2005a). Each data point represents an individual vessel. Data are compared with ellipses (68 per cent confidence) calculated for fatty acid $\delta^{13}C$ values of modern samples from the UK (Dudd and Evershed 1998).

hand do not imply that milk and/or dairy products were not consumed at Silchester, they reveal that there may have been a great variability in the use of these resources over geographic areas, time period, and cultural traditions of the Iron Age in Britain. Although we have no comparative data from Roman Silchester yet, historical sources suggest that milk, particularly from cattle, was unpopular in Roman society (White 1970, 277–8) and the same preference may have existed within the Silchester *oppidum*. In this context it is interesting that the scarcity of young calves in the Period 0 animal bone assemblage recovered from Insula IX suggested to Ingrem (below, p. 270) that dairying was not practised on a large scale at Silchester despite the fact that most of the meat eaten came from cattle.

Compared with previous research on Iron Age sites in Britain (Copley *et al.* 2005a), the analyses yielded remarkably similar results for the entire range of vessels sampled. From this work it would thus seem that choice of fabric was not a determinant in how a vessel was to be used as has often been suggested. Whilst all the sherds came from closed forms generally regarded as cooking vessels, the detailed typology, manufacture, surface finish and general vessel size showed no significant differences in terms of how the vessels were used other than confirming that they all played a domestic role and reflect a predominantly meat-based diet.

CONCLUSION

Organic residue analysis was undertaken on ceramic vessels from Silchester in order to derive a snapshot of culinary practices during its Iron Age occupation. The extracted lipids reveal that ceramic vessels were used for processing terrestrial animals' meat and fat, along with some plant products. The stable carbon isotope composition of the main fatty acids also confirms that some vessels were used predominantly for processing ruminant products, while others contained a mix of ruminant and other animals, possibly pig. Our results also highlight a remarkable variability in the way that people valued and processed animal resources during the Iron Age. This variability is represented by the lack of evidence for milk/dairy products in ceramic vessels at Silchester compared to other sites in this region. It is thus plausible that some differences in culinary practices existed during the Iron Age in Britain.

CHAPTER 11

THE QUERNS

By Emma Durham

A total of 86 fragments (although allowing for joining fragments this accounts for some 83 querns) from quernstones was recovered from Period 0 contexts. All are in Lodsworth Greensand except for one fragment of Quartz Conglomerate of the Old Red Sandstone (ORS). The majority of the fragments are small, which means that it was difficult to identify the type of querns from which they came, but saddle querns and upper and lower stones of rotary querns were identified. Some fragments also appear to have been re-used. The small size of the fragments means that the diameters of the querns usually could not be determined, but some measurements were taken, in particular thickness, which helped to identify the quern type. Details of all the querns can be found in Appendix 4, Table 71.

It should be noted that seven fragments were discarded on site. All were identified as fragments of Lodsworth Greensand and weighed on site but could not be examined subsequently to determine the quern type or to see whether they joined other fragments in the assemblage.

LITHOLOGY

The dominance of Lodsworth Greensand in this collection is not unexpected; in fact, Lodsworth is the most common type among the querns found during excavations at the amphitheatre and, particularly, the forum basilica (Wooders 2000, 387), and Greensand, including Lodsworth, at the South Gate (Fulford 1984, 118–20). ORS was only the most common lithology at the North Gate and among the fragments retained from the antiquarian excavations of 1890–1909 (Shaffrey 2003, 147). Although Lodsworth querns had a widespread distribution in southern Britain during the Iron Age and Roman periods, they do seem to have been more commonly used in the late Iron Age and early Roman period, a trend amply illustrated at Silchester, where Lodsworth querns are replaced by ORS as the Roman period progressed (Shaffrey 2003, 161–2; 2006, 133–4).

TYPOLOGY

All of the identified quern types are of Lodsworth Greensand. A relatively small group of three, possibly six, saddle quern fragments was identified. The fragments are small and have been identified as saddle querns on the basis of a concave, smooth grinding surface without the tooling normally seen on rotary querns. One slightly larger fragment (SF 5192) from Ditch 9151 has a straight edge and a smooth, very concave grinding surface (FIG. 109.1). The base is also smooth, worn and iron-stained and both the grinding surface and base may have been subject to secondary use as a whetstone. The straight edge suggests that this fragment may belong to a group of objects, perhaps better termed mortars, identified by Shaffrey and Roe (2011, 316–17, fig. 4 nos 8 and 9) who suggest that their presence in contexts which also contained rotary querns of Lodsworth stone could indicate a use other than processing grain for flour. It is not unusual to find saddle querns on sites of Iron Age and Roman date and fragments in Lodsworth Greensand were also found at the forum basilica (Wooders 2000, 386–7).

The majority of the fragments which could be identified to type are rotary querns, with a roughly equal number of upper and lower stones (Table 13). The small size of the fragments

TABLE 13. THE QUERN TYPES FROM PERIOD 0

Type	No.
Saddle	3 (3?)
Rotary, upper stone	13 (1?)
Rotary, lower stone	10 (1?)
Rotary (undetermined)	11
Total	**42**

? = uncertain identification

meant that few measurements could be taken, but the thicknesses fall within the range identified for the antiquarian collection of between 40 and 100 mm (Shaffrey 2003, 150). The diameters of two upper stones were measured at 320 and 380 mm, which also fall within the expected range.

Lodsworth querns of Iron Age date are generally associated with Curwen's (1937, 142) Sussex type (Peacock 1987, 69). The grinding surface, edge and base were usually pecked, as is the case with the antiquarian examples from Silchester (Shaffrey 2003, 151). Lower stones were identified on the basis of a convex grinding surface. Only one fragment from Pit 11694 has part of the spindle-hole present. A fragment from Pit 17317 has a pecked grinding surface which has been worn smooth at the edge, forming a lip (SF 7804). Some of the upper stone fragments are slightly larger and retain diagnostic features such as part of the central perforation or handle-socket as well as a generally concave grinding surface.

During the late Iron Age and early Roman period Lodsworth querns got thinner and flatter (Peacock 1987, 69), becoming what is known as disc querns, and ten querns of this type were identified. One upper-stone fragment (SF 6224) was recovered from Pit 11026 (FIG. 110.2). It is well made, with pecked grinding surfaces, flattish upper surface, straight side and a partial handle-socket in the upper surface which is typical of Curwen's (1937, 142) flat-topped, Sussex-style quern. A second fragment (SF 6047) from what is obviously the same quern, although it does not join, was found in a Period 1 slump higher up the pit (FIG. 110.2). Several small fragments from upper stones are very thin and were perhaps slightly larger than the lower stones they covered, as a slightly thicker lip has formed around the edge of the stone (SFs 5137, 7251).

RE-USE

A number of fragments have been re-used as whetstones; although this is most obvious when surfaces other than the grinding surface have been utilised, in some cases a particularly smooth working surface may indicate re-use. For example, one fragment of what appears to be a rotary quern lower stone has a very smooth grinding surface and one of the broken surfaces is also worn flat and smooth (FIG. 109.3). A fragment from a rotary quern upper stone has a worn, concave grinding surface which is worn smooth in places. The upper surface is also sharply concave and, while one might associate this shape with a hopper, the surface is worn very smooth which suggests re-use (FIG. 109.4). Finally a fragment from a probable saddle quern has a shallow groove worn in the grinding surface (FIG. 109.5)

CATALOGUE OF ILLUSTRATED QUERNS (FIGS 109 and 110)

1. Saddle quern. The grinding surface is very concave and smooth, the base is also smooth. Lodsworth Greensand. Weight 1,130 g. Max. thickness 70 mm. SF 5192. Ditch 9151, layer 8481.
2. Rotary quern. Two fragments from an upper stone. Part of the central eye and handle-socket are present. The upper surface and sides are pecked and the edge straight. It is well worn, the grinding surface worn to an almost glassy finish at the edge, although tooling in the form of concentric rings is still visible. There is also a shallow groove around the central eye on the grinding surface. Although the two fragments do not join they are from the same quern. Lodsworth Greensand. Weight 1,902 g. Thickness 15 mm at centre to 57 mm at edge. Diameter *c.* 380 mm. SF 6224 and 6047. Pit 11026, layers 11602 and 11112 (Period 1 slump into the pit).

FIG. 109. Quernstones, Nos 1 and 3–5.

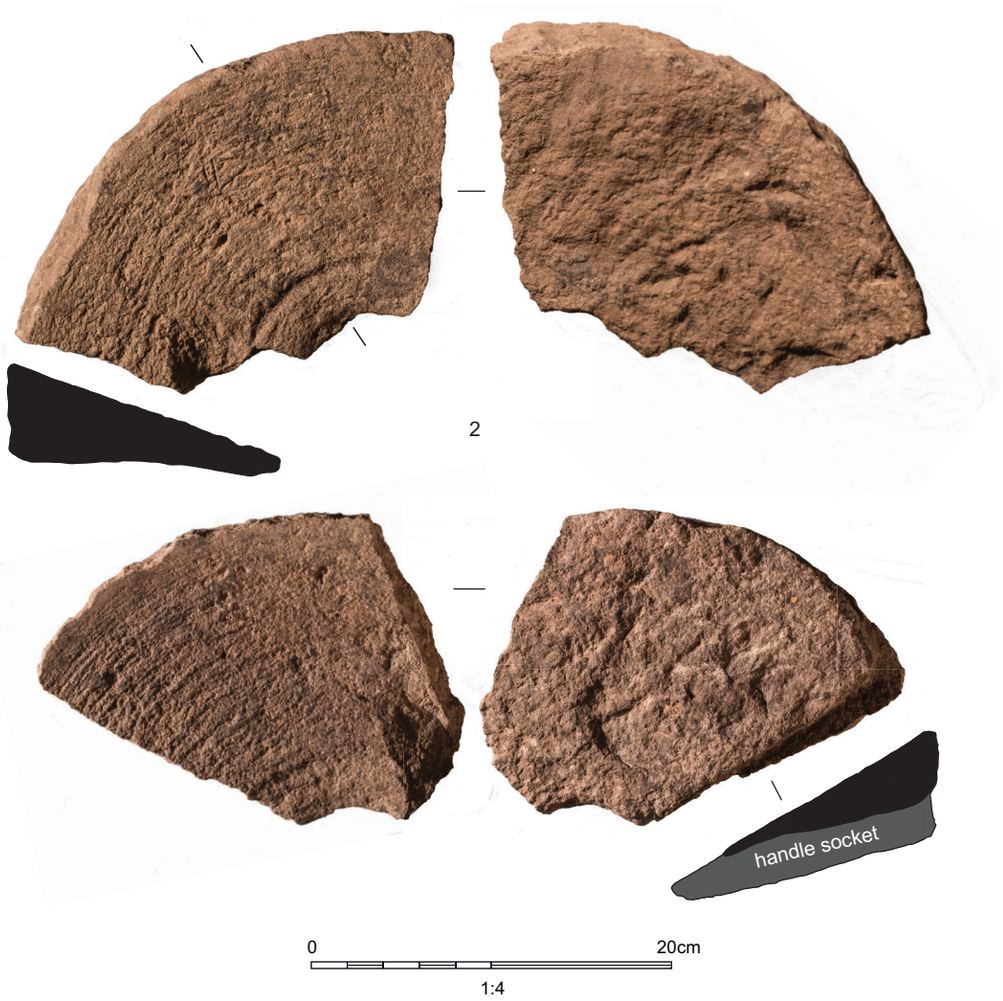


FIG. 110. Quernstone, No. 2.

3. Rotary quern. Small fragment of lower stone. Re-used fragment with a very smooth, convex grinding surface and one adjacent broken edge also worn smooth. Lodsworth Greensand. Weight 242 g. Thickness 47 mm. SF 5672. Pit 8580, layer 9592.
4. Rotary quern. Fragment of upper stone. The concave grinding surface is worn patchily smooth. The upper surface is also concave and worn very smooth in places. Lodsworth Greensand. Weight 1,218 g. Thickness 25–90 mm. SF 6211. Gully 11734, layer 11733.
5. Saddle quern. Both upper and lower surfaces are worn, although the grinding surface is smoother. A shallow groove has been worn along the surface from re-use as a whetstone. Lodsworth Greensand. Weight 428 g. Thickness 45 mm. SF 7555. Pit 15142, layer 15140.

DEPOSITION

The Period 0 querns come from a variety of different features, including pits, post-holes, ditches and gullies (FIG. 111). They are found scattered across the site, although there are perhaps concentrations to the west of the site in Ditch 11631 and Pit Group 14 and to the north of the site in features and layers associated with Trackway 2, Well 8328 and Pit Groups 1 and 9. A relatively large group of 19 fragments was recovered from Ditch 11631, of which five are rotary querns (four upper, one lower stone), two disc rotary and the remainder of undetermined type. To the west of Ditch 11631, Pits 8580, 10410 and 11026 all contained at least two quern fragments, the majority are rotary querns but two saddle quern fragments were found in Pit 8580.

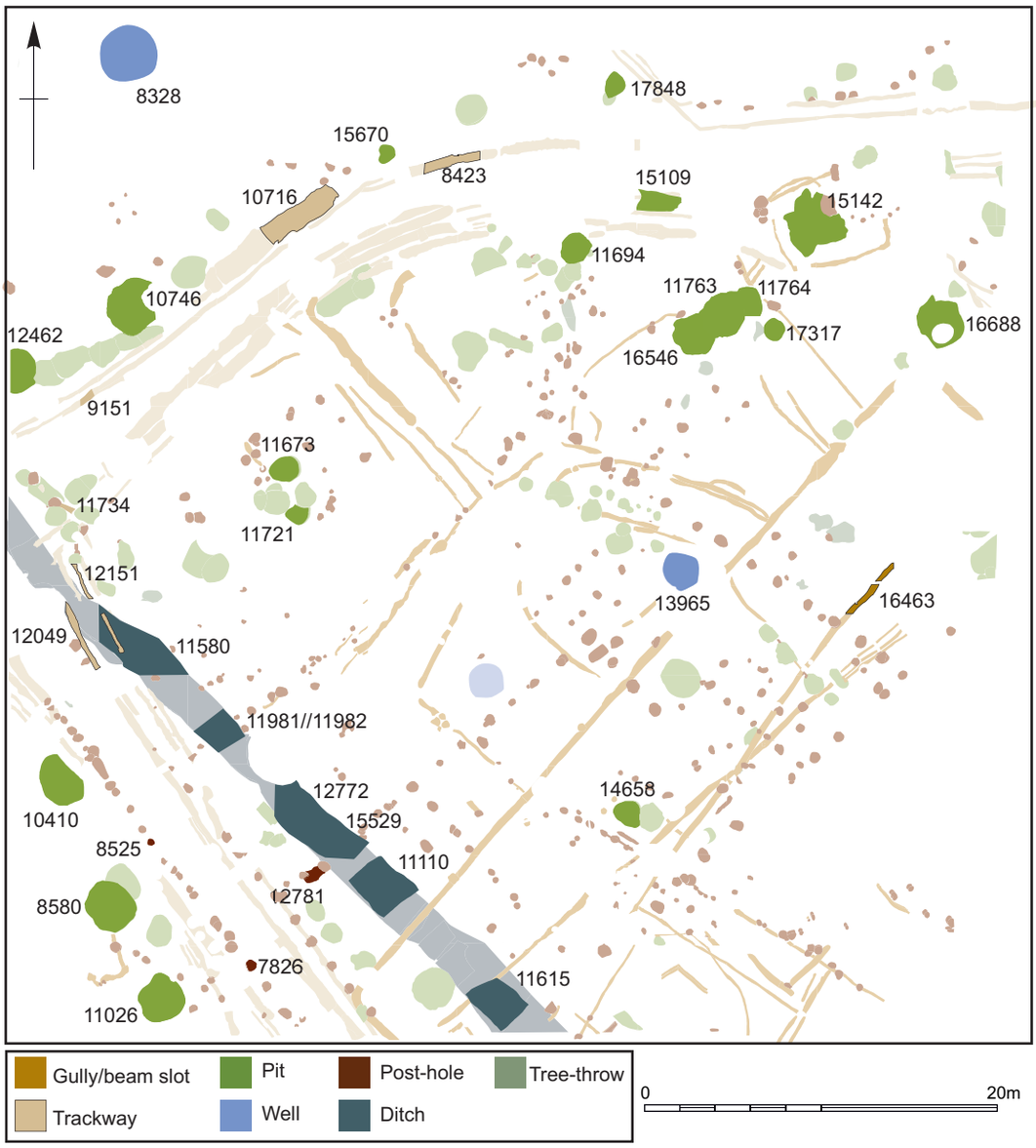


FIG. 111. Distribution of quern fragments in Period 0 features (numbered).

The eight fragments from Well 8328 were recovered from three fills in the middle of the feature, while five pits in Group 1 (10746, 12462, 15109, 15670 and 17848) contained one quern fragment each. The fragment from Pit 12462 is the only Quartz Conglomerate quern from a Period 0 context. Three of the pits in Group 9 (11763, 11764 and 17317) contained two fragments each and Pit 16546 a further single rotary quern fragment. Only one pit in Group 10 (15142) produced querns, but it was a large group of two saddle, two rotary and three undetermined fragments. However, it should be noted that in many of these groups the fragments are small and, although they do not join, some could be from the same quern.

CHAPTER 12

OTHER CERAMICS

By Jane Timby

BRIQUETAGE

Features allocated to Period 0 produced a total of 142 fragments of briquetage (salt container) weighing 415 g and with 0.88 eve (FIG. 112). The material was directly comparable with that recovered from the forum basilica site in terms of form and paste (Timby and Williams 2000, 287). The fabric is pale pink, orange or light grey in colour often bleaching to white where the salt has reacted with the iron oxidised in the clay. It is finely micaceous with a slightly sandy texture and a spare frequency of fine organic material.

The vessels appear to be small conical cups with measurable diameters from 7.5 cm up to 10 cm. The walls are quite thin, averaging around 6 mm near the rims and the vessels may have been pedestalled although no examples were found. The fragmentary nature of the material may be a reflection of a low firing temperature or, more likely, that the vessels were deliberately broken to release the salt. Most of the pieces, 113 in total, came from ten of the pit groups with ten pieces from Ditch 11631, single pieces from Wells 8328 and 10421 and Post-hole 11031 and 17 fragments from Post-hole 13564 (Table 14). The greatest concentrations of fragments came from Pit Groups 3 and 11.

The forum basilica yielded some 482 pieces in total from a considerably smaller area of which 84 came from pre-conquest levels. The greatest amount came from the Claudio-Neronian deposits (Period 3) with the remaining 78 fragments from later phases and probably residual.

TABLE 14. THE BRIQUETAGE FROM PERIOD 0 FEATURES

Context	No.	No. %	Wt	Wt %	EVE	EVE%
Ditch 11631	10	7.0	15	3.6	6	6.8
Pit Group 1	11	7.7	18.5	4.5	2	2.3
Pit Group 3	33	23.2	104	25.1	25	28.4
Pit Group 4	16	11.3	36.5	8.8	0	0.0
Pit Group 5	2	1.4	2	0.5	1	1.1
Pit Group 7	1	0.7	10	2.4	0	0.0
Pit Group 8	2	1.4	1.5	0.4	2	2.3
Pit Group 9	6	4.2	55	13.3	5	5.7
Pit Group 10	8	5.6	17	4.1	15	17.0
Pit Group 11	22	15.5	96.25	23.2	27	30.7
Pit Group 14	12	8.5	25	6.0	0	0.0
Well 8328	1	0.7	12	2.9	0	0.0
Well 10421	1	0.7	2	0.5	0	0.0
Post-holes	17	12.0	20	4.8	5	5.7
TOTAL	**142**	**100.0**	**414.8**	**100.0**	**88**	**100.0**

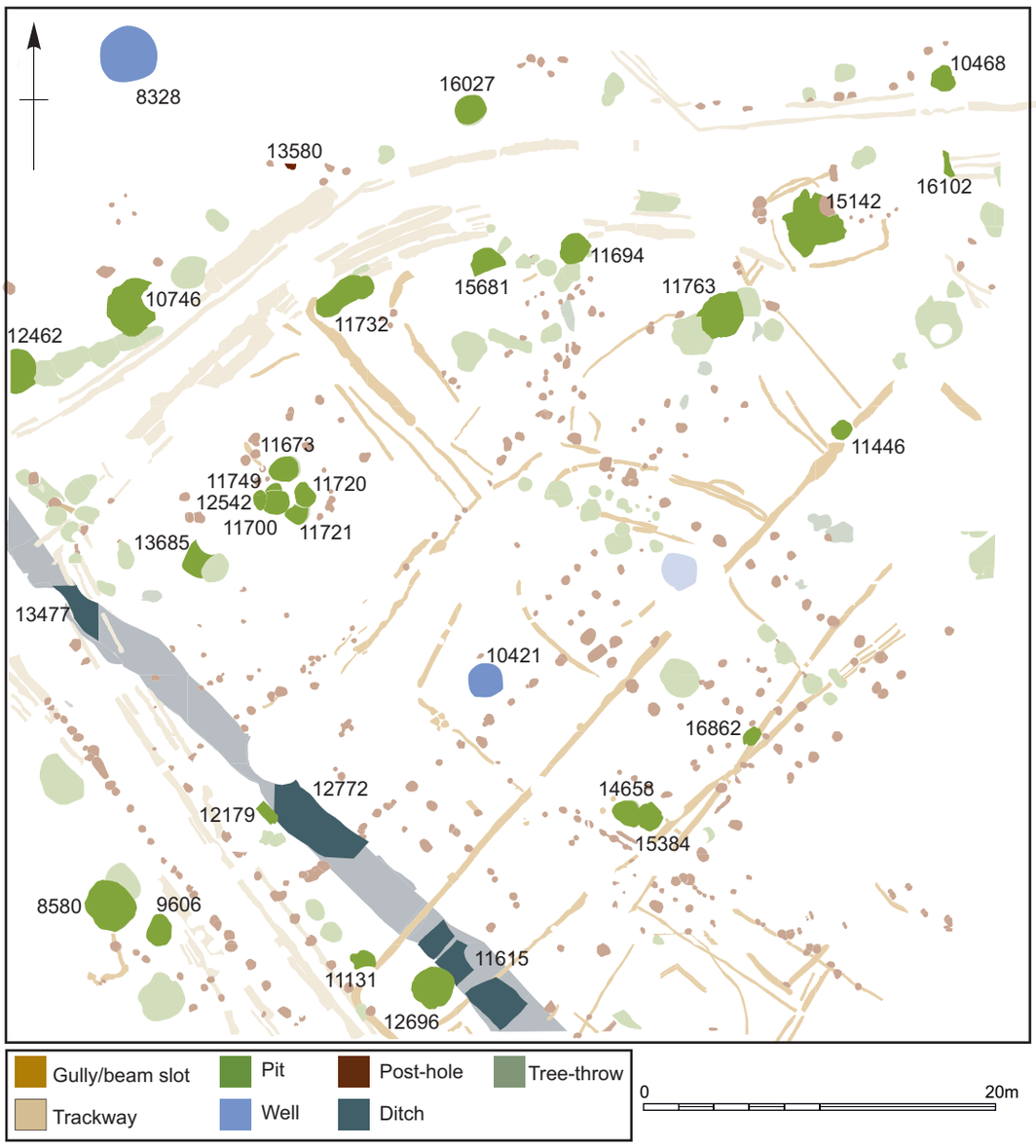


FIG. 112. Distribution of briquetage in Period 0 features (numbered).

This was, at the time, one of the largest collections of later Iron Age-early Roman material to be documented from an inland site. A similar quantity of briquetage was recovered from Danebury, Hants. (Poole 1991a, 404), covering a longer timespan, but with most of the material coming from the latest occupation dating to the later Iron Age. Four forms were recognised at Danebury embracing cylindrical, trough, rounded bowl and flared wall with a flat base, none of which equate with the small cups found at Silchester. Poole (1984b, 429–30) suggested the Dorset and Hampshire coast as likely sources for the Danebury material. One observation that can be made is that the Silchester vessels have a much smaller volume compared to the earlier to middle Iron Age containers such as those found at Danebury, and if used to transport the salt from its source, would have been easier to handle.

Chalice-like vessels with pedestalled bases found at Halle on Saale, Germany led to some experiments by Riehm (1961, 183) who found them unsuitable as boiling vessels and suggested that they were salt-cake moulds. Filled with freshly boiled salt obtained from larger evaporation vessels they would have been dried out slowly but had to be broken when the hardened salt-cake was removed. There was probably a degree of standardisation in these vessels and Riehm (ibid.)

deduced that the salt-cakes were marketed together with their 'packaging'. He also suggested that the pillar foot of the chalice was knocked off before trading. This would certainly explain the difficulty in reconstructing the original vessels at the consumer sites and the general lack of bases at Silchester.

Amongst other things salt was an important food preservative and used in activities such as cheese-making. There seems to have been a much more intensive, or more visible, period of production in the later Iron Age and an increasing number of production sites have been recognised, particularly on the Essex, Kent, Hampshire and Dorset coasts. A very large sample of 6,641 fragments was recorded from Heybridge, Essex (Tyrell 2015). These appear to be rectangular containers along with other production/oven debris and do not compare with the Silchester briquetage.

It was concluded in the forum basilica report that the briquetage essentially derived from a pre-conquest salt industry and typological parallels were found with material at Canterbury (Macpherson-Grant 1980; Barford 1983). The Kent vessels have a thin-walled conical form with a pedestalled base. Petrological analysis comparing the Silchester samples with material from five sites in Kent (Williams 2000b) was slightly inconclusive but did not refute the possibility of a source somewhere along the Kent coast. A number of salt production sites have been documented in the North Kent marshes (Miles 1973), an area also known for its pottery production.

Since the forum basilica report was published there has been more recent work in Kent. The A2 Pepperhill to Cobham road scheme produced a sizeable assemblage of later prehistoric briquetage from five of the sites investigated (Morris 2012). Three fabric groups were defined: fine quartzose, shelly and organic-tempered (ibid., 229). The former two were considered likely to be local; the organic was unsourced but the Medway estuary was postulated (ibid., 241). Nearly all the briquetage came from contexts dating to the early to middle Iron Age and the vessel forms show some similarities to some of the Danebury types.

Recent work along the East Kent access road immediately south of the Isle of Thanet has also produced evidence of salt production with an extensive assemblage of briquetage, including vessel, structural debris and associated furniture dating from the early Iron Age through to the early/mid-Roman period. Within the group are vessels of an identical fabric and form to the Silchester examples (Poole 2015, fig. 12.7.47). This is added confirmation that the Silchester briquetage did indeed originate from the North Kent coast and that there seems to be a distinct difference in the types of evaporation vessels found at a production site and the salt containers traded inland.

Illustrated sherds (FIG. 113)

1. Fragment of briquetage. Possibly part of a pedestalled base. Pit 16852 (16853), Pit Group 3.
2. Rim sherd. Diameter 10 cm. Pit 15128 (15072), Pit Group 10.

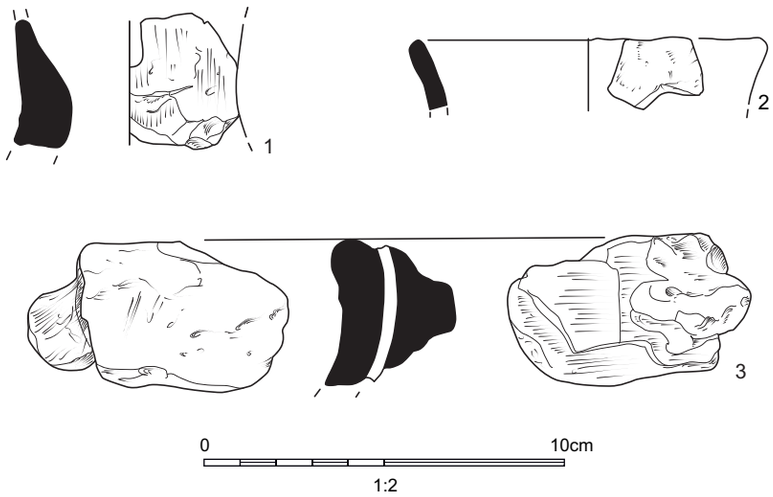


FIG. 113. The illustrated briquetage. Scale 1:2.

3. Fragment of briquetage. A briquetage vessel sandwiched between an irregular clay lump on one side and a more formed, thicker wall on the other which may be part of the clip used to separate and secure evaporating vessels. A similar fragment was found from the East Kent Access road (Poole 2015, fig. 12.7.38). Pit 10468 (10470), Pit Group 9. SF 6124.

FIRED CLAY

A total of 825 fragments of fired clay weighing 11.9 kg was recovered from Period 0 contexts (FIG. 114). The assemblage can be divided into four categories: triangular oven-brick; portable oven-furniture; daub; and miscellaneous fired clay. Most pieces were recovered from the various pit groups which effectively account for 81 per cent by count, 86 per cent by weight. Ditch 11631 produced a further 5 per cent (2 per cent weight) and the remaining 14 per cent came from various post-holes, gullies and trackway ditches.

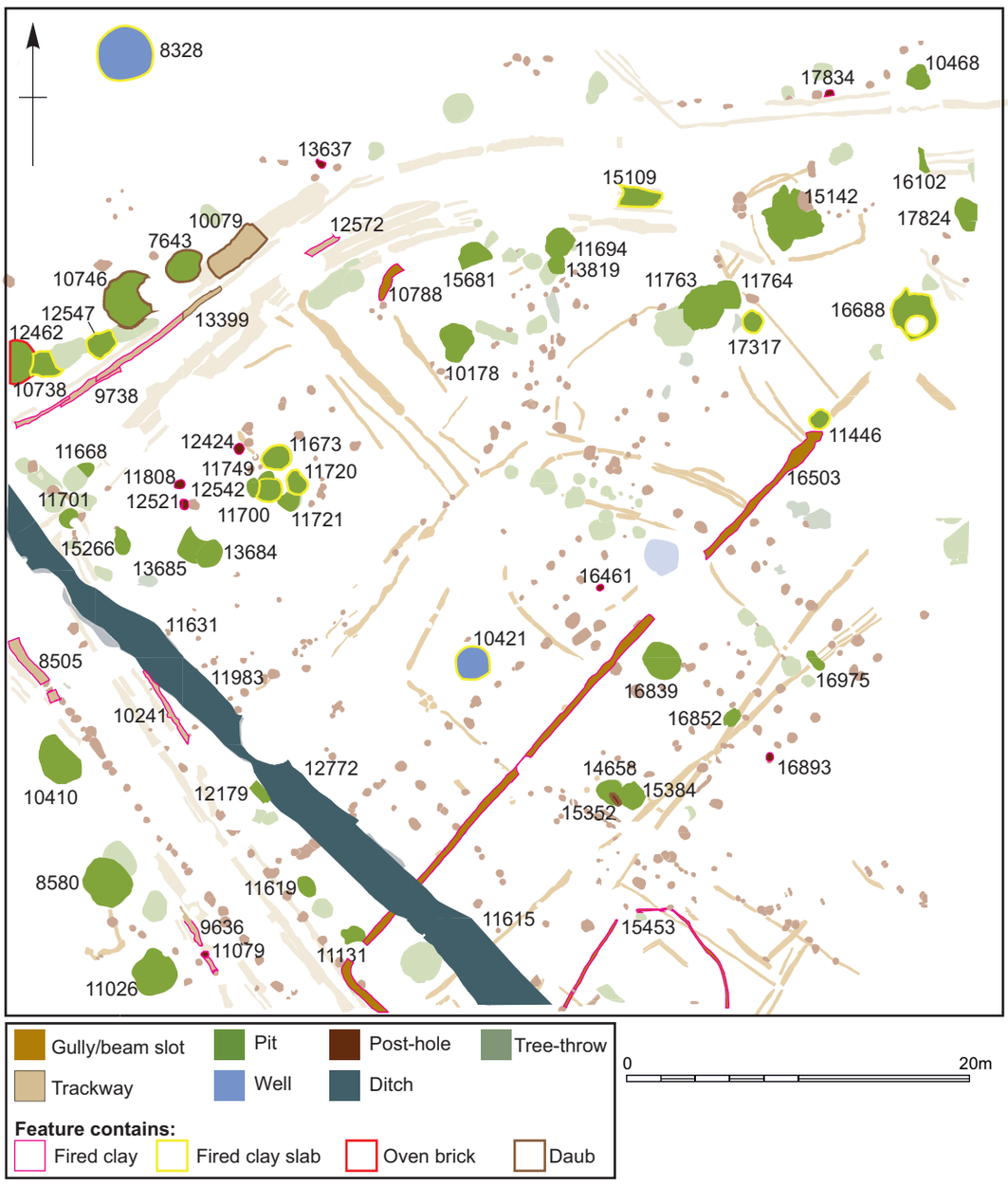


FIG. 114. Distribution of fired clay in Period 0 features (numbered).

TRIANGULAR PERFORATED BRICK

One incomplete fragment of triangular perforated brick of the type traditionally interpreted as a loomweight (FIG. 115.1) was recovered from Pit Group 1. These are a common find on Iron Age sites as both fired and unfired objects. Although most are perforated through all three corners this is not universal (Poole 1991b, 380). At Danebury it was observed that not only was there a great variation in the objects, but also that the lack of wear around the holes cast doubt on their function as loomweights. A great many occurred in association with oven daub and it was suggested that at least some of the assemblage of 'weights' were associated with the construction of the ovens (ibid.). This interpretation seems to be corroborated by subsequent finds of such 'weights', particularly where they are incompletely perforated or occur as isolated finds or small assemblages. The East Kent Access road-work provided definitive evidence that such items were used as oven or hearth furniture (Poole 2015, 304).

PORTABLE OVEN FURNITURE

All the pieces included here have two flat opposing surfaces with the thickness ranging from 21 to 55 mm. The assemblage is divided into four groups on the basis of probable shape: Type 1: triangular; Type 2: straight-edged slab; Type 3: circular slab; and Type 4: small fragments with two flat opposing surfaces but no edges to classify. There are no complete examples or complete edges to assess the overall size of the objects, although the diameter of the circular plates can be measured. The items are made from moderately soft, fine sandy clay with rare rounded pebbles of flint up to 80–100 mm. Some pieces have a sparse frequency of added organic material. Although fired, none of the fragments appears to be excessively burnt, suggesting they had not been associated with industrial activity such as metal-working where high temperatures would have been involved. One or two pieces show slight sooting on one surface.

Type 1 (FIG. 115.2). Triangular-shaped. A single, quite thin fragment (20–1 mm) with rounded edges. One surface is smoother than the other. Possibly a wedge or firebrick.
Type 2 (FIG. 115.3). Slab fragments which appear to have one straight edge. The surviving lengths range from 50 mm to a maximum of 100 mm. The thicknesses are generally around 22 mm but one piece from Pit 11700 is 40 mm thick. Seven pieces fall into this group; three from Pit Group 4 and four from Pit Group 9.
Type 3 (FIG. 116.4, 5). Circular. Plate fragments with one curved edge suggesting these are circular plate forms. A total of nine pieces are present, of which eight could be measured to give an estimated diameter. These ranged from a minimum of 110 mm (FIG. 116.4) to a maximum of 400 mm. Four examples had a diameter of 220 mm suggesting a certain standardisation. The remaining two measured 280 mm and 300 mm. The fragments have one flat surface and one slightly domed, more smoothed surface tapering to a rounded edge with thicknesses ranging from 21 to 25 mm. Three fragments were recovered from Pit Group 4, four from Pit Group 9 and two from Pit Group 11.
Type 4. Unclassified: some 72 fragments weighing 3.3 kg could only be identified as from slabs, with no edges or insufficient edge to classify them. The thicknesses ranged from 20–2 mm through to 55 mm. This latter piece, from Pit 11720 (Pit Group 4), had a centrally-placed finger-groove around the edge on the small bit of surviving face. One fragment from Pit 16688 (Pit Group 11) had patches of burning on the upper face.

In terms of distribution six fragments came from Pit Group 1, 37 from Pit Group 4, 17 from Pit Group 9 and five from Pit Group 11. The remaining seven fragments came from Ditch 11631, post-holes and one each from Wells 8328 and 10421 (FIG. 114).

The most likely interpretation of these plate fragments is that they are of portable oven furniture. None appears excessively burnt but, on the other hand, they are too sandy and soft to have functioned as kneading or mixing boards. Similar slabs have been found on other Iron Age sites and Poole (2007, 267 ff.) makes the distinction between clay discs and oven plates. Examples of clay discs found at Sites 2 and 4 on the Great Barford bypass, Beds. showed a

variety of sizes, ranging from 9 mm to 32 mm thick and 100 mm to 400 mm in diameter. Whilst some were circular, others were polygonal or rectangular with straight or rounded edges. The oven plates were larger, measuring 20–40 mm thick. A semi-complete plate found in a kiln on Site 8 of the Great Barford Bypass measured 355 mm in diameter and 23–43 mm thick (ibid., pl. 8.1). Examples have also been found at several Iron Age sites in the Upper Thames valley, including Farmoor (Lambrick and Robinson 1979, fig. 28) and Gravelly Guy (Barclay and Wait 2004, 384, fig. 8.13) in Oxfordshire. The Farmoor examples ranged in size from 148 mm to 240 mm, whilst at Gravelly Guy two types were defined by their diameters; one 200 mm diameter with a thickness of 55 mm; the other up to 44 mm in diameter and 66 mm thick. The rectangular pieces of fired clay found at Prae Wood, Verulamium, interpreted as pre-Roman brick (Wheeler and Wheeler 1936, pl. lvi) may be similar such material. Although there were no complete pieces, one measured 110 mm in length on one side with a thickness averaging around 25 mm and so within the same range as the Silchester pieces. Their association with triangular perforated bricks (ibid., 178), clay fire bars and perforated fragments suggests these bricks are also oven or kiln components.

In the absence of any pottery wasters from the excavated features in Insula IX and the paucity of metal-working debris, it is likely that this assemblage of fired clay comes from domestic structures used in the preparation of food. It is suggested by Poole (2007, 276) that, on the evidence from Great Barford Bypass, most of the kilns/ovens may have had temporary superstructures such as turves or were open at the top with the fired clay coming from the lower part of the structure.

DAUB

Fragments classified as daub were restricted to those pieces which had either the impression of a rounded wattle or flat lath impressions. This comprised a moderately small group of just nine pieces mainly in fabric B with single examples in fabrics A and C (fabric descriptions below). Two pieces, respectively from Pit Groups 1 and 9, showed wattle impressions; the diameter of the sticks was moderately small (10–15 mm) and suggested a small structure such as an oven rather than a larger building.

FIRED CLAY

A total of 725 fragments, weighing 5,172 g, of fired clay was recorded. Most of the pieces are very small fragments recovered from sieving and none shows any form to suggest their original function. It is likely that the majority are generic structural fragments from ovens, hearths or possibly walls of timber buildings. Some of the fragments, if larger, might have been classified as daub.

Five main fabric groups were defined on the basis of macroscopic observation. A small amount of fired clay recorded during the pottery scanning or from sieved samples was not sorted into the fabrics groups:

A. Fine sandy paste with sparse iron oxides and a moderate frequency (10–15 per cent) of organic material mixed into the clay.
B. Sandier textured clay, although still of a fine nature, with sparse organic and rare flint up to 3 mm in size.
C. Fine sandy fabric with a marked presence of fine mica in the paste. Individual quartz grains not macroscopically visible.
D. As fabric A but with occasional coarser rounded flint gravel up to 10–15 mm.
E. Very fine compact clay with no visible inclusions.

Most of the classified fragments, 66 per cent by count, are in sandy fabric B with 26.7 per cent in fabric A. The other groups only contribute minor amounts. Fragments from Post-hole 16893 and Pit 12462 appear to be lining laid directly onto a soil surface with a smooth, upper surface but rough lower surface with flints attached. There are only two surviving deliberately-shaped

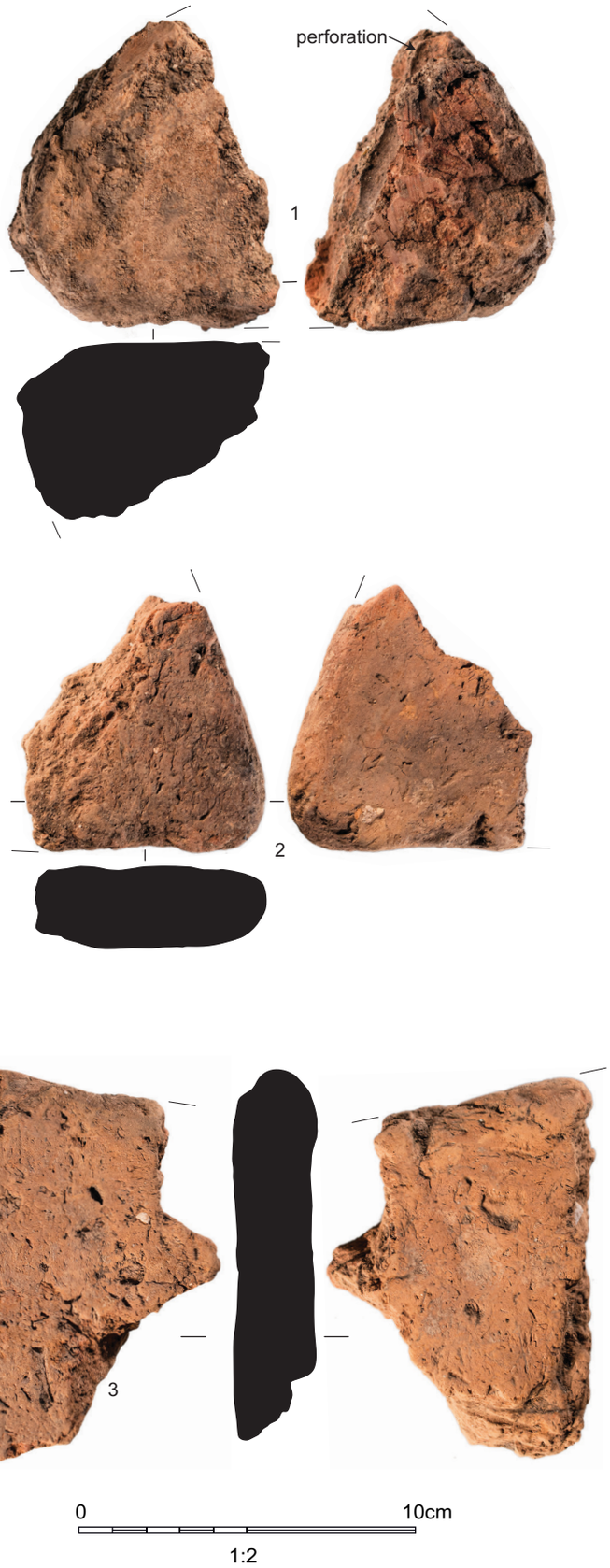


FIG. 115. Fired clay objects, Nos 1–3.

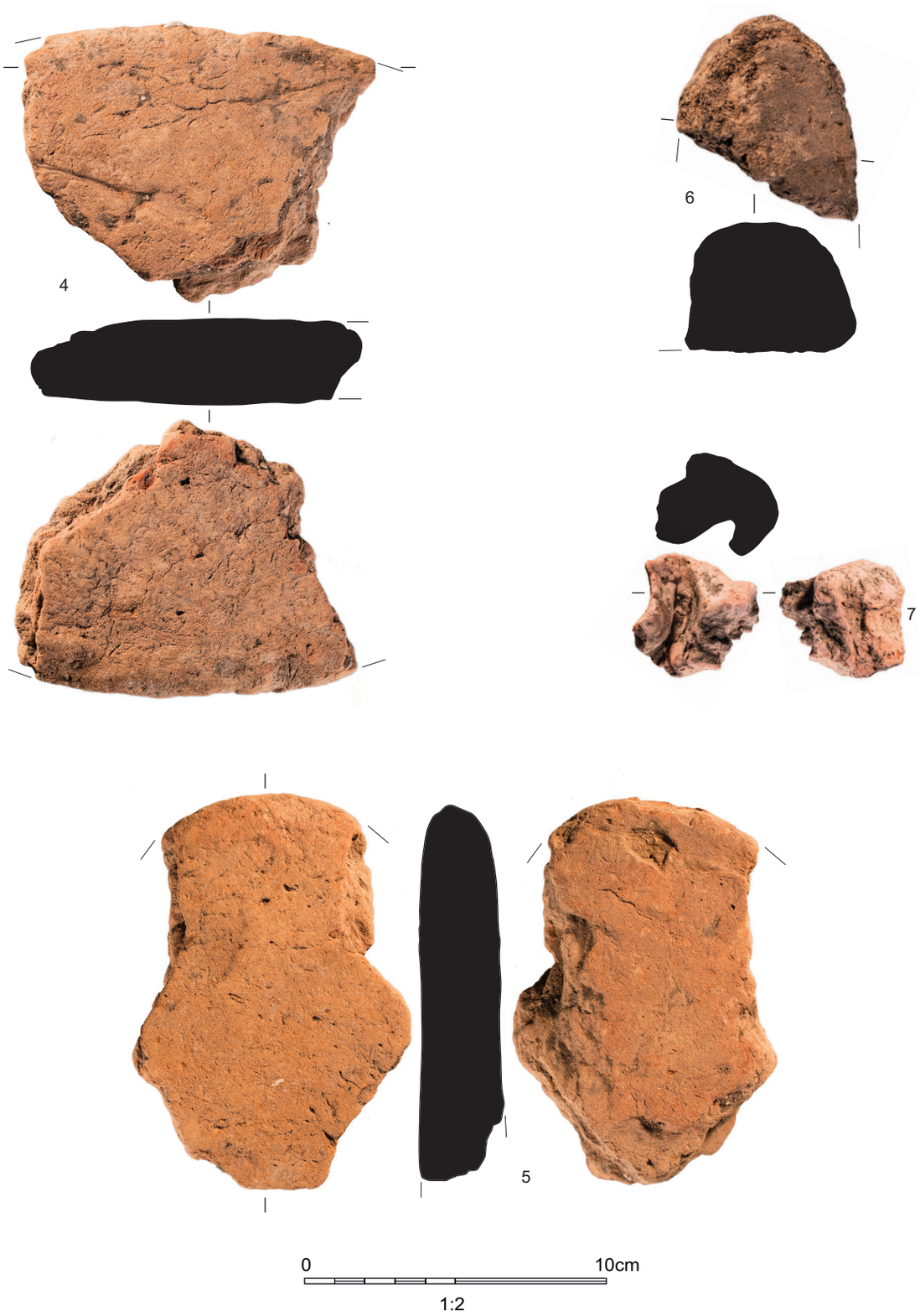


FIG. 116. Fired clay objects and fragments, Nos 4–7.

pieces. One from Well 8328 (FIG. 116.6) is a tapered end-piece with a flat surface and a domed upper, perhaps part of a kiln/oven bar or similar. The other piece from Pit 11721 (FIG. 116.7) has a slightly curved channel and has been subjected to quite intensive heat.

DISTRIBUTION OF FIRED CLAY

The distribution of fired clay across the site shows some significant concentrations which may reflect small-scale industrial activity or more likely the nearby presence of domestic ovens or hearths (FIG. 114). Small collections of miscellaneous fired clay were recovered from Pit Groups 2, 3, 5, 8, 10, 12 and 14, ranging from a single fragment (Pit Group 12) to a maximum of 81 fragments (681 g) from Pit Group 10, which probably reflects a general background scatter. Added to these are Wells 8328 and 10421, Ditch 11631, various post-holes and ditches/gullies associated with the trackways. Pit Groups 1, 4, 9 and 11, however, all show significantly higher concentrations of material with a mixture of oven furniture, daub and miscellaneous fired clay. The largest number of plate fragments came from Pit Group 4 with 43 pieces (2,588 g) followed by Pit Group 9 with 26 fragments (2,206 g), Pit Group 11 with seven fragments (747 g), and Pit Group 1 with six fragments (274 g). The triangular oven-brick also came from Pit Group 1.

Illustrated pieces (FIGS 115 and 116)

1. Part of a triangular perforated brick with a single extant perforation across the broken face. Fine sandy, poorly mixed clay with iron oxides, occasional calcined flint fragments and sparse organic matter. Pit 12462 (12435), Pit group 1.
2. Broken slab with a triangular shape (Type 1) and one broken edge. Thickness 20–2 mm. Pit 15109 (11757), Pit Group 9. SF 6268.
3. Fragment of flat slab with one straight edge (Type 2). Pit 15109 (11757), Pit Group 9. SF 6268.
4. Fired clay circular plate, Type 3. Pit 15109 (11757), Pit Group 9. SF 6268.
5. Fired clay circular plate, Type 3. Pit 15109 (11757), Pit Group 9. SF 6268.
6. Shaped piece of clay, perhaps from a kiln bar. Fabric C. Well 8328 (9309).
7. Small irregular fragment with a slightly curved channel expanding out at one end. Dark pink, well fired clay, as fabric A. Pit 11721 (11687), Pit Group 4.

CHAPTER 13

IRON-MAKING AND OTHER HIGH-TEMPERATURE ACTIVITIES

By J.R.L. Allen

IRON-MAKING DEBRIS

A total of 3,129 g of iron-making debris came from contexts assigned to Period 0 (see also Crummy p. 143). The great majority was recovered from pits, with ditches and post-holes trailing behind. The debris was found in only one or two examples in each of several other types of contexts: gravel surfaces, gullies, levelling deposits, linear features and wells. No trace of furnaces was found.

Of the components relating to iron-making, three kinds of residue are present: small fragments or pillules of slag, SIM-lumps and slag basins. The greatest weight (1,402 g) is of small, broken-to-pillulose, fragments of vesicular fayalitic slag, commonly with white-green fuel-ash slag attached. These are non-diagnostic.

Three small SIM-lumps (168 g) were recovered from Pit Group 2 Pits 11698 (10798) and 11701 (11676). These are smooth, potato-shaped and slightly-to-strongly magnetic SIM-lumps, interpreted as proto-blooms, and are known from other Iron Age-Roman iron-making sites, where they consist of variable mixtures of fayalitic slag, magnetite and incompletely-reacted ore (Allen 2012, 80). The largest, weighing 78 g (SF 6234) from Pit 11698, had been broken open, to reveal a laminated, partly limonitic ore that could originally have been bog ore or from a boxstone which fills joints and fissures in some of the early Cretaceous sandstones to the east of Silchester. A fragment weighing 24 g from Ditch 10024 (9719) is similar. This is the only evidence from Period 0 for an iron ore.

Thirteen substantially whole to complete slag basins (furnace-bottoms) were recovered (1,535 g), with an average weight of 118 g and a range from 58 to 188 g (FIG. 117). They are roughly oval to circular in shape with a plano-convex to concavo-convex, transverse profile. The convex undersides are rough and irregular, with entrapped quartz sand, chips of flint and occasionally

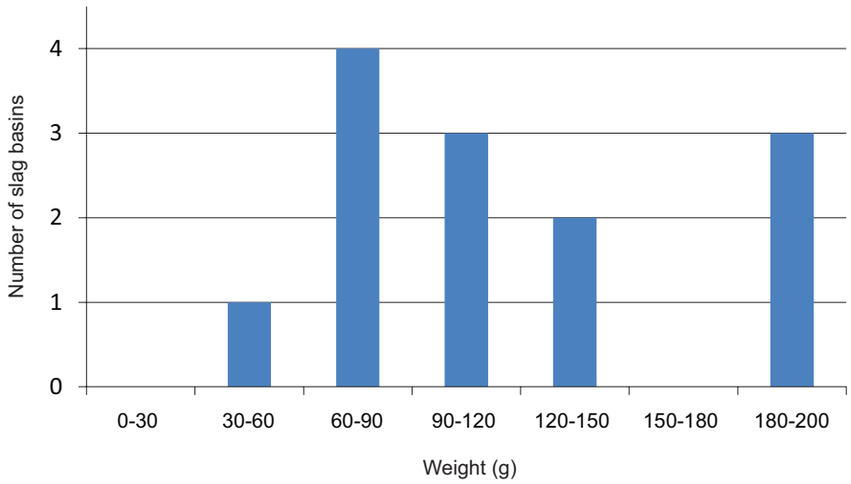


FIG. 117. Slag basins: distribution by weight.

TABLE 15. CHEMICAL COMPOSITION BY X-RAY FLUORESCENCE ANALYSIS OF IRON-MAKING AND OTHER METALLURGICAL RESIDUES

A: Major and minor elements (Wt %)

Context	SF	Description	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI	Sum
12013		Ditch 11631	0.25	0.43	2.05	25.33	0.91	1.06	2.05	0.18	0.08	80.86	–4.46	108.74
12021		Ditch 11631	0.56	0.54	1.98	31.48	0.45	1.47	0.95	0.16	0.06	75.81	–4.92	108.54
10782		Pit 11665, Pit Group 1	0.37	0.53	1.95	33.43	1.74	1.19	1.20	0.17	0.10	66.51	–2.85	103.33
11747		Pit 11730, Pit Group 1	0.80	0.74	3.28	30.50	0.53	0.70	0.63	0.22	0.04	79.18	–4.21	112.4
10200		Pit 10770, Pit Group 2	0.40	0.56	2.69	27.16	0.97	1.20	2.00	0.22	0.07	77.87	–5.27	107.87
11677-1		Pit 11701, Pit Group 2	2.13	0.69	2.65	34.67	1.11	1.34	1.64	0.21	0.08	70.06	–4.09	110.48
11677-2		Pit 11701, Pit Group 2	0.48	0.56	2.40	40.15	1.39	1.32	1.48	0.22	0.09	62.09	–2.99	107.19
11677-1	6265	Pit 11701, Pit Group 2	0.38	0.46	2.30	22.76	0.91	1.25	0.84	0.19	0.05	74.34	–4.05	104.4
11677-2	6265	Pit 11701, Pit Group 2	0.27	0.57	3.66	40.57	0.87	2.02	1.31	0.30	0.07	56.11	–3.45	102.30
12117		Pit 12179, Pit Group 3	0.45	0.54	2.12	27.59	0.50	1.09	1.42	0.12	0.05	68.99	–6.15	96.78
9592-1		Pit 8580, Pit Group 14	0.49	0.66	3.59	31.89	0.49	1.39	1.71	0.28	0.05	69.95	–4.53	105.97
9592-2		Pit 8580, Pit Group 14	0.21	0.61	3.25	26.98	0.56	1.44	3.11	0.24	0.07	72.52	–5.37	103.62
9719		Ditch 10024, Trackway 2	0.22	0.45	2.55	28.99	0.63	1.13	0.97	0.21	0.04	78.03	–5.84	107.37

B: Trace elements (parts per million, ppm)

Context	SF	Description	V	Cr	Co	Ni	Cu	Zn	Rb	Sr	Y	Zr	Pb
12013		Ditch 11631	22	13	187	247	41	20	15	66	–	81	107
12021		Ditch 11631	15	10	73	67	39	13	23	43	–	72	22
10782		Pit 11665, Pit Group 1	21	7	–	9	37	32	29	142	5	76	54
11747		Pit 11730, Pit Group 1	24	12	10	23	41	19	19	34	–	82	60
10200		Pit 10770, Pit Group 2	20	13	–	11	40	15	24	83	5	102	28
11677-1		Pit 11701, Pit Group 2	23	13	–	16	56	23	32	92	5	102	80
11677-2		Pit 11701, Pit Group 2	25	10	31	69	115	27	29	148	6	110	65
11677-1	6265	Pit 11701, Pit Group 2	31	12	–	–	43	31	23	62	–	79	61
11677-2	6265	Pit 11701, Pit Group 2	38	25	–	11	44	23	43	103	9	164	42
12117		Pit 12179, Pit Group 3	15	6	30	17	137	7	20	57	5	71	3
9592-1		Pit 8580, Pit Group 14	31	20	49	36	190	7	33	34	8	115	68
9592-2		Pit 8580, Pit Group 14	25	14	11	–	42	18	29	69	7	72	17
9719		Ditch 10024, Trackway 2	15	7	29	60	40	16	28	55	5	83	55

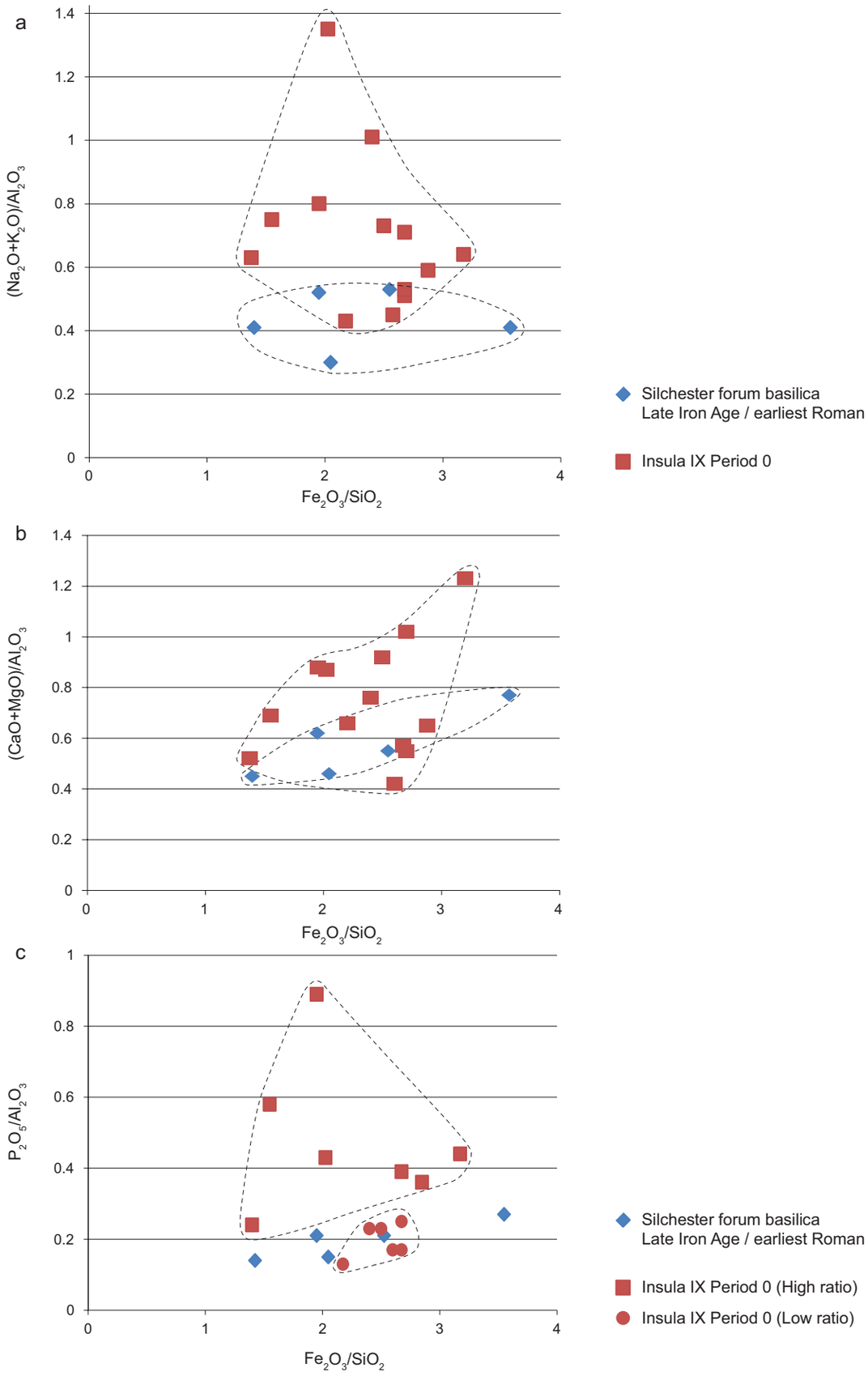
charcoal. The often reddish-black, upper surfaces, although occluded in places, are uneven but smooth and in some cases with a marginal meniscus, giving the appearance of having been liquid but without flowage. The basins consist of dense vesicular, occasionally locally crystalline, fayalitic slag. They are considered to have accumulated at the bottoms of simple bowl furnaces during iron-smelting. Morphologically, they compare closely with slag basins previously reported from Silchester (Allen 2012, 79), including examples dating to the late Iron Age at the forum basilica. The latter, however, are roughly twice as heavy (ibid., table 6.2) as those of Period 0 at Insula IX. As was the case at the forum basilica, no tap slags were recovered from Period 0 contexts.

X-ray fluorescence analysis of the 13 slag basins (Franz Street, University of Reading) (Table 15) allows a comparison to be made with morphologically similar late Iron Age material from the forum basilica (which also includes Period 3, Claudio-Neronian material) (Allen 2012, table A). FIG. 118a compares slag basins from Period 0 with those of the late Iron Age at the forum basilica (ibid., table 6.3) in terms of the alkali/alumina ratio, $(Na_20+K_2O)/Al_2O_3$. There is some overlap between the two fields but the Period 0 basins, with a mean of 0.707 and standard deviation of 0.227, are much the more variable in terms of this ratio. The comparison may not be entirely fair, as the slag basins from Period 0 all had detectable sodium (Table 15A), whereas, inexplicably, only one example from the forum basilica showed any of the metal, and that a mere trace. A similar difference between the two assemblages is nonetheless seen in a plot of the alkaline-earth/alumina ratio $(CaO+MgO)/Al_2O_3$ (FIG. 118b). The Period 0 group yields a mean ratio of 0.765 and standard deviation of 0.229 in comparison with a mean of 0.596 and standard deviation of 0.196 at the forum basilica (ibid., table 6.3).

Direct evidence for the ore smelted during Period 0 is meagre in the extreme, but on geochemical grounds at least two kinds were exploited. In terms of the phosphorus/alumina ratio, P_2O_5/Al_2O_3, two groups can be recognised in the assemblage (FIG. 118c). Six slag basins yield a mean ratio of 0.197 with a standard deviation of 0.042, which is closely comparable to the mean of 0.194 and standard deviation of 0.051 for the late Iron Age assemblage at the forum basilica (Allen 2012, table 6.3). However, the great majority of these basins at Insula IX were found in contexts which could date to Period 1. Without overlap between the fields, the remaining seven basins afford much higher ratios, with a mean of 0.476 and standard deviation of 0.194. Such high ratios are typical of all post-Iron Age smelting at Insula IX (ibid.), but the great majority of these basins occurred in sound Period 0 contexts, including an example from the primary fill of Ditch 11631 and two examples from Pit 11701 from Pit Group 2 (FIG. 119). Thus Insula IX provides evidence for continuity in the use of high phosphorus ores from the late Iron Age onwards, the low phosphorus ores appearing somewhat anomalous at both sites in contexts which could be Claudio-Neronian.

The analytical programme reveals important differences in smelting practice during the late Iron Age between Insula IX and the forum basilica, just a few hundred metres away. Although simple bowl furnaces were used at both sites, there could have been some differences of technique, as Period 0 afforded much the smaller slag basins. The higher alkali/alumina and alkaline-earth/alumina ratios in Insula IX may point to the use of different furnace-lining materials, which in the course of smelting become incorporated into the slags. In part, as shown by the phosphorus/alumina ratio, the same ore was used at both sites. However, another, different ore was used in Insula IX that was later exploited throughout the subsequent Roman period. This ore, yielding slags characterised by high phosphorus/alumina ratios, was possibly not introduced until late in Period 0, after the use of low-phosphorus ores ceased.

FIG. 118 (opposite). (a) Values for the alkali/alumina ratio for slag basins from Insula IX, Period 0, compared to values from the late Iron Age/earliest Roman basins at the forum basilica (Periods 1–3); (b) Values for the alkaline-earth/alumina ratio for slag basins from Insula IX, Period 0, compared to values from the late Iron Age/earliest Roman at the forum basilica (Periods 1–3); (c) Values for the phosphorus/alumina ratio for slag basins from Insula IX, Period 0, compared to values from the late Iron Age/earliest Roman at the forum basilica (Periods 1–3).


a
(Na2O+K2O)/Al2O3
Fe2O3/SiO2
Silchester forum basilica
Late Iron Age / earliest Roman
Insula IX Period 0
b
(CaO+MgO)/Al2O3
Fe2O3/SiO2
c
P2O5/Al2O3
Fe2O3/SiO2
Silchester forum basilica
Late Iron Age / earliest Roman
Insula IX Period 0 (High ratio)
Insula IX Period 0 (Low ratio)

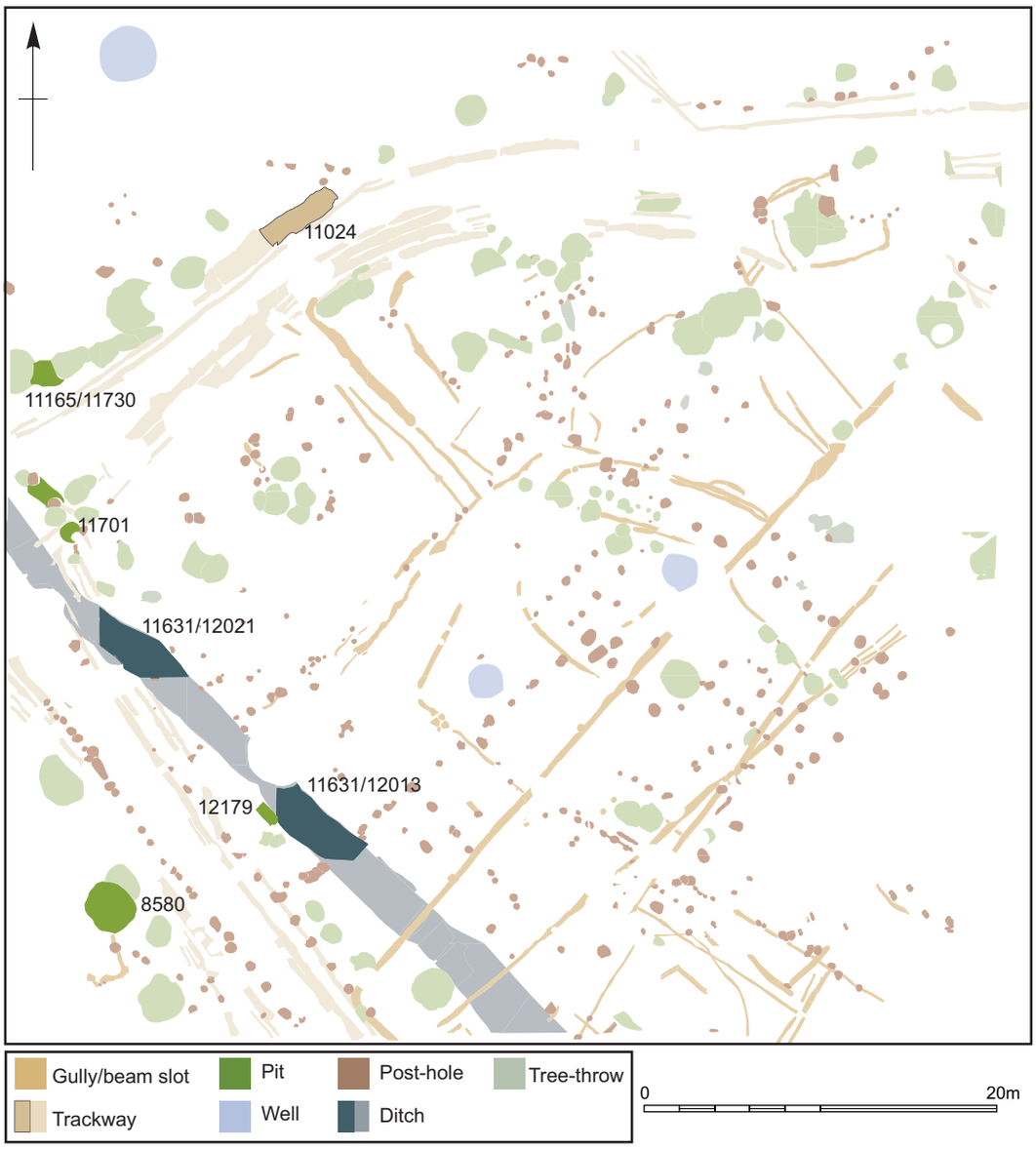


FIG. 119. Distribution of slag basins from Period 0 features (numbered).

MAGNETIC RESIDUES

Hammer scale is extremely rare in the Period 0 deposits. Of the 33 magnetic separations made, only seven yielded hammer scale: Pits 12462 (12435 and 12461) and 12547 (12546) in Pit Group 1; Pits 11701 (11677) and 10770 (10200) in Pit Group 2; Pit 11026 (11568) in Pit Group 14; and Post-hole 13580 (13564). The scale is in the form of very occasional, dull lead-grey to silvery, submetallic-to-metallic-looking, spheroidal and flake-like particles. These suggest a very low level of hot-forging of iron in the area, but they are insufficient to tell whether blooms were being refined or artefacts manufactured.

CRUCIBLE FRAGMENT

A small concavo-convex fragment from a crucible (16 g) in a mid-grey fine-grained fabric with much quartz silt and very fine sand was recovered from Pit 11026 (11568) in Pit Group 14. Grass in mouldic preservation occurs on the underside. Scattered over the concave inner surface

are a few bright green specks, probably a corrosion product suggesting that copper or copper alloy had been melted in the crucible. This was confirmed by x-ray fluorescence analysis (Franz Street, University of Reading), which showed the presence of copper to the extent of 15047 ppm and lead at 7688 ppm. The association of copper with substantial amounts of lead is most unusual and links this fragment to the mixed copper-lead crucible content from contexts 11584 and 11599 (see below).

COPPER-WORKING

Pit 8580 (9592) in Pit Group 14 yielded two small fragments of vesicular fuel-ash slag replete with large patches of a bright green corrosion product taken to be cuprous. Similar pellets of slag were present in Ditch 11631 (11111) and Well 13965 (13950). These fragments suggest that copper or copper alloy was being worked, or copper being smelted. Three of the slag basins have copper in excess of 100 ppm (Table 15B), considerably more than in the remainder (*c.* 40 ppm). These excessive values are nonetheless relatively modest and point to furnace-linings of some contaminated material rather than iron-slags from copper-smelting.

LEAD-WORKING

Pit 13685 (13649) in Pit Group 5 yielded a small fragment of folded lead sheet. Gully 11635 (11584) and Ditch 11601 (11599) yielded fragments from a substantial pool of metal that had chilled in the bottom of a wide crucible. These fragments proved to be a most unusual lead-copper mixture with small amounts of silver and arsenic. The copper, partly crystallised, is disseminated within the lead but occurs closest to the crucible wall. What may be recorded is either an experiment or the use of the same crucible for the two metals, first copper then lead.

GLASS FRIT

Three contexts yielded small pieces of what appear to be opaque-to-semi-translucent glass frit (15 g). Two from Pit 11694 (11671) in Pit Group 8 and Gully 16684 (16554) are dark red with scattered grey-white particles and occasional vesicles. The third, from Pit 17848 (17847) in Pit Group 1, is jet black. All three show signs of viscous flowage. These fragments could be evidence for bead-making at Silchester.

CHAPTER 14

THE COIN-MOULDS

By J.R.L. Allen

Coin-moulds, also known as trays, are ceramic items used in the making of pellets of metal, the first stage in the production of coinage. They are not uncommon on substantial sites dating to the later Iron Age and Roman conquest periods in south-east England. Silchester is not exceptional in this regard, as testified by Boon's (1954) early report, findings at the forum basilica by Fulford and Timby (2000) and, most recently, the assemblage from Insula IX, the entirety of which is described below. The trays are small, thin, flat slabs of clay into the upper surfaces of which, while still plastic, generally regular arrays of pits or cups of uniform size have been impressed using some kind of tool. The trays, fragmentary or not, may be characterised in terms of their dimensions and weight and the nature of any preserved edge-faces, and the pits by reference to their spacing, width across the rim and depth. In addition, and adapting architectural terms, the exposed cross-shaped area between each group of four associated pits may be termed for descriptive purposes the spandrel and the narrow spaces between adjacent pits the ribs (FIG. 120). The fabric of the trays holds important clues as to their origin, manufacture and thermal history. The assemblage from Insula IX compares well with material described from many other late Iron Age sites (Landon 2016).

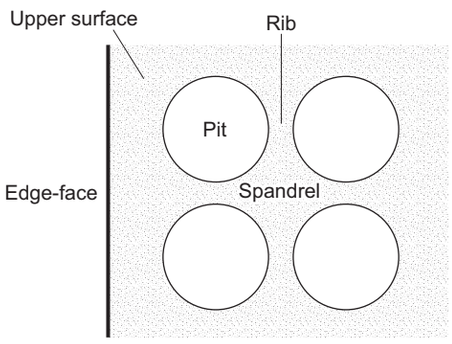


FIG. 120. Descriptive nomenclature for coin-moulds.

GENERAL CHARACTER

Fragmentary trays with a total weight of not less than 0.929 kg were recovered over an eighteen-year period from Insula IX (Table 16). The largest number came from contexts of Period 1 and a lesser quantity from Period 0 (FIG. 121.1), the finds from Periods 2–4 being fairly definitely residual. The trays range from 13–22 mm in thickness, with the majority in the range 16–18 mm (FIG. 121.2). The number of pits represented — a measure of fragment size — varies between 2 and 25 in a frequency distribution (FIG. 121.3) that seems to follow Rosin's law of natural breakage (Krumbein and Tisdel 1940) over most of its range or, over the full range, a Poisson-type distribution. Typically, the pits are arranged in rows on a regular square grid. Their centre-spacing varies between 12 and 21 mm, with a strong mode at 15 mm (FIG. 121.4). Pit diameter increases steeply from a least value of 8 mm to a strong mode at 11 mm, 2 mm less than the mode at Old Sleaford (Elsdon 1997, 57), but there is a long tail of values reaching as high as 18

TABLE 16. SUMMARY OF CHARACTERISTICS OF COIN-MOULDS RECOVERED FROM INSULA IX

Period	Context	Feature	SF	Dimensions (mm)	Weight (g)	No. of pits	Centre-spacing (mm)	Pit width (mm)	Pit depth (mm)
0	9660	Ditch 9674, Trackway 2	5411	87x73x16	124	25	16–17	11	8
0	9719	Ditch 10024, Trackway 2	5582	46x34x21	18	3	21	17	11
0	9674	Ditch cut, Trackway 2	5710	42x38x18	23	6	12	10	6
0	15417	Gully 15453, Enclosure 7	7577	24x17x13	6	2	13	9	5–6
0	15069	Pit 15109, Pit Group 1	7882	25x24x13+	7	2	12	11	7–8
0	10197	Pit 10738, Pit Group 3	6415	68x47x18	54	5	14–15	13	10
0	17847	Pit 17848, Pit Group 3	7838	52x34x14+	19	6	15	12	5+
0	15141	Pit 15142, Pit Group 10	7571	98x67x15–19	115	22	15	14	5–9
0	9152	Well 8328	5359	61x33x22	35	9	15	9	7
0	10439	Well 10421	5668	62x48x18	58	13	15	11	10
0/1?	15355	Upper fill of Ditch 11631	7537	45x18x16–19	17	3	16	14	10
1	9097	Cleaning context	5553	43x40x13–17	25	6	12	8	6
1	10233	Accumulation deposit over Trackway 1	5785	41x22x16	15	3	20	14	8
1	10111	Slump into Period 0 Pit 10746	5870	74x50x17	42	15	15	13	9
1	11640	Dumping/ levelling over Ditch 11631	6365	45x36x18+	26	5	15	12–13	6+
1	12009	Pit 12005	6598	49x27x17	21	9	16	11–12	9
1	12655	Accumulated silt	6633	50x46x20	36	5	14	13	7
1	14331	Clay spread	6859	50x42x16+	22	7	14	?	6+
1	14229	Pit 14217	6951	46x36x17	14	4	18	16–17	7–9
1	14229	Pit 14217	6952	57x38x15–18	39	6	13–14	11	9–10
1	4429	Pit/Post-hole 4440	3488	47x36x18	31	8	15	10–12	10
1/2	7761	Occupation deposit	5349	47x43x22	38	5	20	18	11–12
1/2	7118	Cleaning context	4289	47x36x21	27	6	20	15–16	14
2	13827	Cobbles	6691	60x51x18	59	12	18	11–12	9
3	3200	Cleaning in House 1	1992	70x43x20	58	10	15–16	10	7–8
4	4380	Accumulation deposit	3330	35x29x16	-	6	-	10	8

mm (FIG. 121.5). The latter are linked to large values of the centre-spacing. Like at least three trays at the forum basilica (Northover and Palk 2000, fig. 189), the pits of SF 5349 are markedly conical (FIG. 122.1) with a bottom only about half the width across the rim. Small Finds 4289,

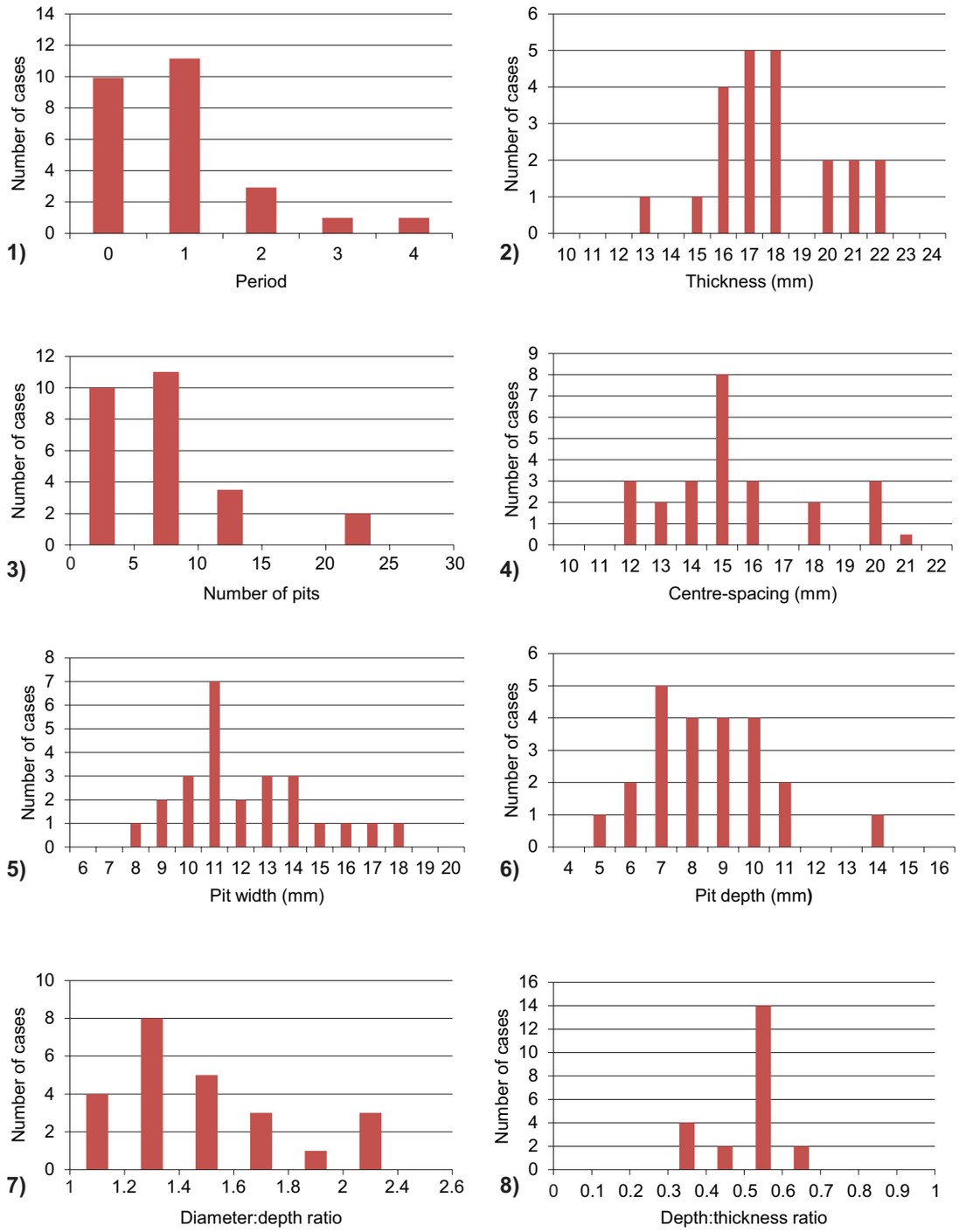


FIG. 121. Statistical properties (frequency distributions) of the coin-mould assemblage from Insula IX. 1 – incidence by period; 2 – tray thickness; 3 – number of pits per fragmentary tray; 4 – centre-spacing of pits; 5 – pit width; 6 – pit depth; 7 – pit diameter:depth ratio; 8 – pit depth:tray thickness ratio.

5582, 5785 and 6951, however, reveal pits that are deep and steep-sided as well as wide, and therefore virtually as much across the base as the top. Generally speaking, the sides of the pits in profile vary from parallel to slightly inclined inward. Their depth ranges from 5 to 14 mm with a broad mode between 7 and 10 mm (FIG. 121.6). In every fragment examined the pits proved to be wider than deep (FIG. 121.7). Most were impressed to a depth of about half the final thickness of the tray (FIG. 121.8).

SHAPE

Work elsewhere in Britain has led to the generally accepted view that coin-moulds were tablet-like and either square/rectangular or pentagonal, but with two parallel or very slightly curved long sides, although circular ones are known from Gaul (Tournaire *et al.* 1982, figs 5, 6; Landon 2016). It is impossible to form a definite view of the shape of the trays from Insula IX because of the fragmentary nature of the assemblage, but some clues are available.

Some trays seem to have been pentagonal, as noted by Frere (1983, 31) at Verulamium. Small Find 6951 (FIG. 122.2), with two edge-faces joining at distinctly more than a right-angle, is interpreted as from the upper right-hand corner of a pentagonal tray. That this tray was moulded in some kind of box is suggested by the burr at the foot of each edge-face, an example of Landon's (2016, 201) 'lazy-S' profile. A second example is afforded by SF 7571 (FIG. 122.3), the lower edge of which is straight with a burr at the foot, again suggesting moulding. The upper edge is not preserved but the topmost row of pits is differently aligned to those below, hinting that it followed a nearby, but now lost, edge inclined to sides tracked by other rows.

Eleven fragments preserve vertical to slightly inclined edge-faces (SFs 3488, 5411, 5553, 5710, 5668, 5785, 5870, 6691, 6951, 6952, 7571). The great majority appear to have been moulded, for a more or less pronounced burr appears at the foot, and in one case (SF 6691) a faint longitudinal grooving is seen, as illustrated by Landon (2016, fig. 6.4), suggesting a mould with sides of roughly split wood. Small Find 5411 (FIG. 122.4), the most substantial fragment from Insula IX, is perhaps a little over half of a full tray. It shows two edge-faces at right-angles, a feature also of SF 6951 and SF 6952, and could have come from a square/rectangular tray. One edge-face has been moulded but the other appears to have been cut. This face is smooth and slightly uneven and carries a short burr along part of the *top* of the edge, perhaps either clay caught on a knife or upturned by a slight upward tilt of the tool. A probably cut edge-face, a feature observed elsewhere by Landon (2016, 20), appears on two other fragments (SFs 3488, 6952).

The undersides of the fragments are invariably flat and smooth, and the tops between the pits also present little variety. The spandrels are also smooth but mostly slightly convex, although a few are flat, as though pressed against a flat surface. For the most part, the ribs are slightly depressed below the level of the spandrels, narrow and strongly convex in profile and, in a few cases, transversely fractured where narrowest, a feature noticeable on a tray from Old Seaford (Elsdon 1997, pl. 13).

FABRIC

The coin-moulds are remarkably uniform in fabric under the hand-lens. In colour very dark grey to black, the material is porous and permeable, fine-grained, uniform in texture and silty, with abundant burnt-out plant fragments up to several millimetres long in mouldic preservation. In contrast to Silchester, Landon (2016, fig. 12.49) finds organic inclusions to be generally extremely rare compared to mineral inclusions. Mineral inclusions are rare or lacking at Silchester but a very little mica is generally present. These inclusions, where present, are of two sorts. Angular chips of flint are seen in SFs 5411, 5582, 5668, 6365, 6598 and 6951, as Williams (2000c, 423) occasionally noted in moulds from the forum basilica, pointing to relatively local manufacture. By contrast, the mineral inclusions of SFs 3330, 3488, 5349, 7537 and 7838 are comparatively large, polished, and in some cases rose-tinted, grains and granules of quartz, strongly reminiscent of the 'grits' used to armour Oxfordshire mortaria (e.g. Young 1977). Inclusions of broken shell or chalk have not been seen at Silchester. The plant fragments are most evident on the undersides of the trays, where some display anatomical structure in the form of delicate longitudinal ridges (?grasses or similar). These seem to be a normal part of the temper used in the clay for the moulds, rather than evidence that the moulds were dried on beds of grass, as favoured by Landon (2016). Strongly evident in the fabrics, whether observed under the hand-lens or microscopically, is a patterned, preferred orientation of particles and voids.

Five of the moulds were thin-sectioned for microscopical examination (SFs 3330, 3488, 4289,

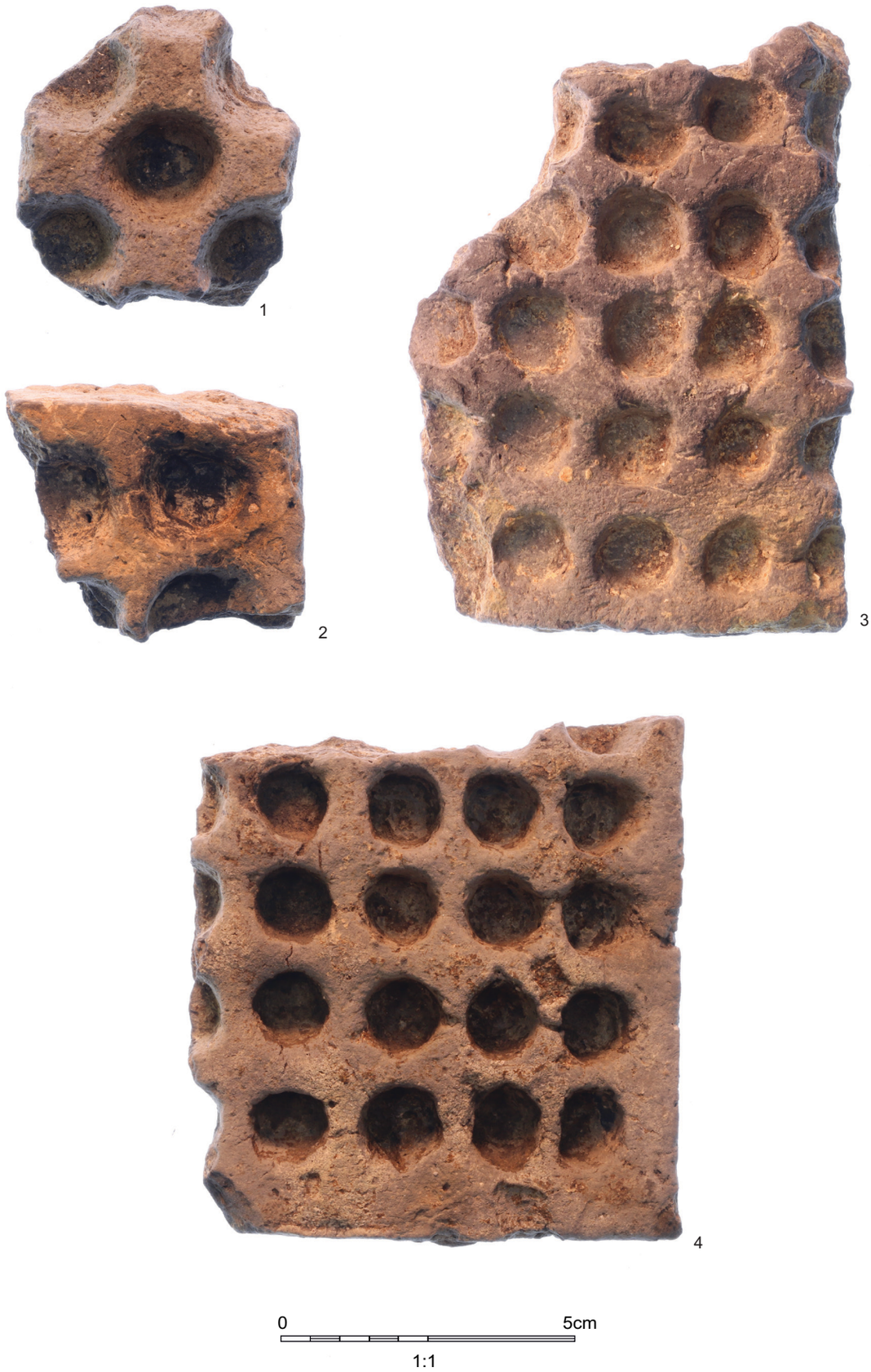


FIG. 122. Coin-moulds from Insula IX. (1) SF 5349; (2) SF 6951; (3) SF 7571; (4) SF 5411.

6598, 6952). The uniformity of the fabric across this small group is again striking. Angular, well-sorted, medium- to coarse-grained quartz silt is dominant, as Williams (2000c, 423) noted at the forum basilica, with subordinate clay minerals, occasional mica and feldspar, and abundant voids up to a millimetre or so in length left by burnt-out plant fragments. Given these textural characteristics, it seems highly likely that the coin-moulds were fashioned from loess, a texturally distinctive Pleistocene wind-blown sediment with refractive properties of localised occurrence especially in south-east Britain (Catt 1979; 1985). Some very finely powdered charcoal may have been included in the mix. Many voids retain some fibrous material, with traces of cellular structure and occasional phytoliths. Attached to one plant shred in SF 4289 was a group of *cf.* neidiinid diatoms (Round *et al.* 1990), a freshwater epiphytic group, suggesting that plants from damp places (e.g. reeds/sedges) occur among the organic inclusions. Coin-moulds from Braughing reveal a closely similar fabric to the above (Freestone 1979, 129).

Almost without exception, the fabric of the coin-moulds displays to the naked eye as well as under the hand-lens and microscope a strong, complex preferred orientation of the longer voids and particles, as recorded by Tite *et al.* (1985, fig. 24) in a mould from Cressingham. Below the level of the pits in SF 6598 (FIG. 123.1) and SF 6952 the orientation is roughly parallel with the base of the moulds. Within each rib, however, the voids and particles define a narrow, upward-pointing, symmetrical arch, like a geologist's anticline, with limbs almost parallel with the sides of the adjacent pits (FIG. 123.4). Downwards these limbs become increasingly less steep, finally passing into the base-parallel structure noted.

Only one coin-mould (SF 5411) showed any visible sign of the metal that might have been cast in it, in the form of meniscus-like deposits in two of its pits. After being scraped out and powdered, these were subject to pXRF analysis by Dr Stuart Black (University of Reading), who detected the presence of 85 ppm of silver (but no gold), which is roughly two orders of magnitude more than the natural background level.

MAKING A COIN-MOULD

A weathered silty clay (Reading Beds) from the Berkshire Downs west of Reading was compounded with abundant coarse mica flakes to form a mixture thought to approximate texturally to the clay mixture used for the coin-moulds. Experiments with this compound and some simple tools were conducted as follows.

Some Silchester trays could have been cut from a slab of clay rolled on a flat surface, although many would appear to have been shaped, like bricks or tiles, within probably wooden moulds, both methods being tried by Landon (2016, 185–7) in his experiments. In Experiment A a ball of clay *c.* 80 mm in diameter was rolled on a flat surface into a slab *c.* 20 mm thick, from which a vertical slice was cut, allowed to dry, faced using medium-grade sandpaper, and then thin-sectioned. Rolling clearly induces in the clay a substantial, preferred particle-orientation parallel with the base and top (FIG. 123.2, Experiment A).

There are three ways of forming the pits of a coin-mould. In order of increasing efficiency, they are: (1) repeatedly indent the clay with a single tool, (2) impress pits into the clay using a single row of pegs mounted permanently on a board, and (3) indent the clay using a square/rectangular array of permanently mounted pegs (pegboard). All three seem to have been employed at different times and places in the late Iron Age, and at some sites more than one technique was applied.

In Experiment B pits scattered or in rows were repeatedly made in the surface of a rolled slab of clay using a single indenter in the form of a debarked, squared-off, rounded stick 8.5 mm in diameter. Pits randomly arranged or in curved rows apparently made in this way are recorded from Braughing (Partridge 1982, pl. 1), Jublains (Tournaire *et al.* 1982, fig. 6), Old Sleaford (Elsdon 1997, figs 36.2, 36.4) and Leicester (Kipling 2008, fig. 1), but none is known from Insula IX. In the experiments, undistorted pits could be formed only so long as the centre-spacing was more than about one-half to three-quarters of the diameter of the indenter. At a closer spacing, the making of each new pit modified the shape of its immediate predecessor, the near side of which was forced inward while the mouth assumed the shape of a quarter-moon. In such cases a strong, preferred base-parallel grading up to upturned particle orientation is

evident in thin-section, but it is not symmetrical. Distorted pits are recorded at Camulodunum (Hawkes and Hull 1947, pl. XVI 2–6) and Bagendon (Clifford 1961, pl. XL). None of the trays from Insula IX shows these particular defects.

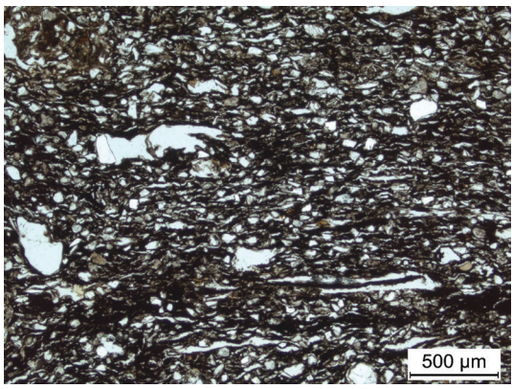
For Experiments C–F an indenter was made by permanently mounting pegs of 8.5 mm diameter and 14 mm length upright on a flat board in a square array at a centre-spacing of 13 mm (FIG. 123.6). Trays were then simulated by evenly pressing this pegboard into rolled slabs of clay to a range of depths (5, 9, 14 mm). These trays (e.g. FIG. 123.7, Experiment F) reproduced exactly the features of coin-moulds from Insula IX, the pits being undistorted and in a regular array with slightly convex spandrels and slightly depressed, sharply rounded, and occasionally transversely fractured ribs. In thin-section (e.g. FIGS 123.3, 123.5), these trays display the same symmetrical pattern of preferred particle-orientation — base-parallel below but increasingly arched upward — as the original moulds (FIGS 123.1, 123.4). It was found, however, that if the pegboard was withdrawn unevenly, with a final sideways tilt, a distortion was introduced into the pits of one row, the last to be voided. A slope developed on one side and the mouths became oval, some with a slight burr, all features of some moulds from Insula IX (SFs 5411, 5870, 6415). Regular trays like the experimental ones are perhaps the commonest form of coin-mould from Iron Age sites, as exemplified by Saintes (Tournaire *et al.* 1982, pl. 31b) and Old Sleaford (Elsdon 1997, pl. 13). Landon's (2016, 190–4) experiments were made using a single row of pegs mounted on a board, but experienced many difficulties — deformation of the tray, cracking of the clay and adhesion of the clay — and yielded uncertain results. There seemed to be little difference, however, between pits made by single and multiple indenters; it was concluded that multiple indenters were suitable for the making of larger pits.

The observed symmetrical particle-orientations seen in vertical sections have an explanation related to that of mammalian footprint-tracks. A single set of mechanical principles governs the making of pits in a coin-mould using pegs and the creation of footprint-tracks as a mammal moves across soft mud. In each case the peg/foot (indenter/impacter) forces the substrate downward, outward and upward, with the result that the surface is lifted (heaved) and the surrounding material deformed, to a lateral distance of not less than about half the width of the indenter (Allen 1997, figs 8, 9). In the case of a coin-mould shaped by a pegboard with multiple, evenly distributed pits, the heave, H, equals $\pi hd^2/4s^2$, where h and d are respectively pit depth and diameter and s is the centre-spacing (in the limit the heave becomes a maximum of $\pi h/4$). Moreover, since the forces in the horizontal plane act equally in all directions, a symmetrical, internal particle-preferred orientation necessarily arises within the ribs and spandrels, as observed (FIGS 123.1, 3–5). The detection of such structures within a tray is therefore clear evidence that a pegboard was used to shape it.

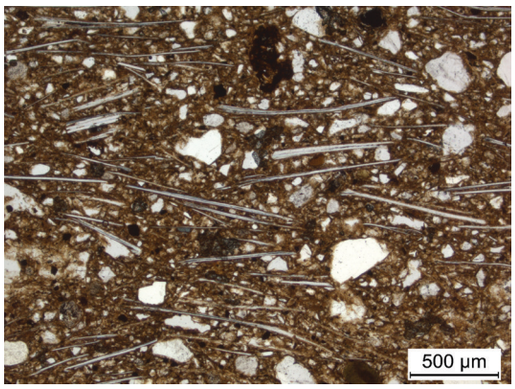
THERMAL HISTORY OF THE COIN-MOULDS

The coin-moulds from the Insula experienced high but uneven temperatures in short-lived thermal events. Typically, the undersides are marked by superficial orange-red patches, pointing to some oxidation, but lack evidence for sintering or vitrification of the clay. The temperature beneath the trays is, therefore, unlikely to have exceeded 700–800°C. The upper surfaces of well-preserved trays, however, show a whitish, glassy, finely vesicular crust (e.g. SFs 3488, 5411, 6598, 6952), pointing to firing under reducing conditions and temperatures of the order of 1000–1200°C. Moulds examined by Tylecote (1962, 104) and Tournaire *et al.* (1982, 432) also gave evidence for higher temperatures on top than beneath. A mould from Bagendon, however,

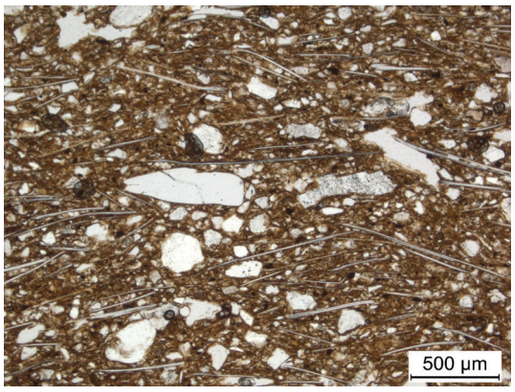
FIG. 123 (opposite). Fabrics and manufacture of coin-moulds. (1) Insula IX, vertical slice (thin-section) from base of SF 6598, ordinary light; (2) Experiment A, vertical slice (thin-section) from clay slab, ordinary light; (3) Experiment D, vertical slice (thin-section) from base of tray, ordinary light; (4) Insula IX, vertical slice (thin-section) through rib of SF 6598, ordinary light; (5) Experiment E, vertical slice (thin-section) through a typical rib of tray, ordinary light; (6) pegboard used in Experiments C–F; (7) Experiment F, tray made using pegboard shown in (6).



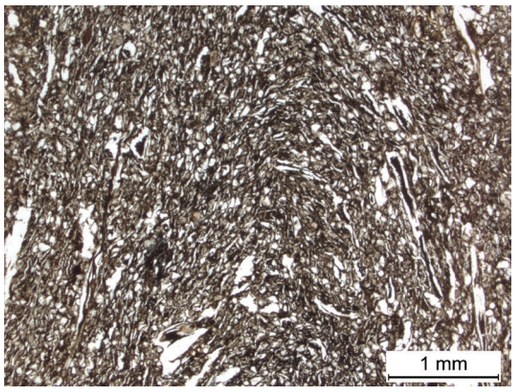
1



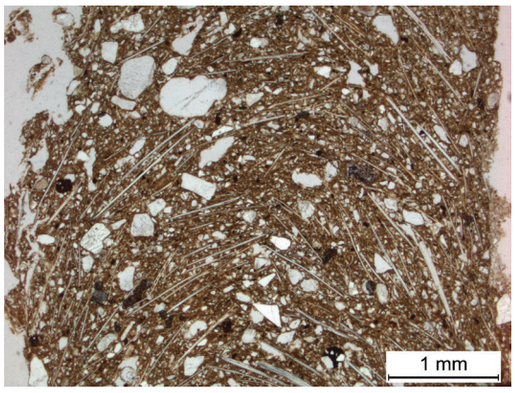
2



3

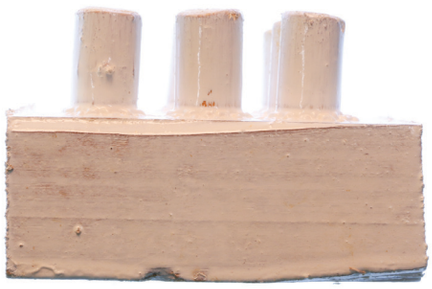


4



5

6



7

0 5cm

1:1

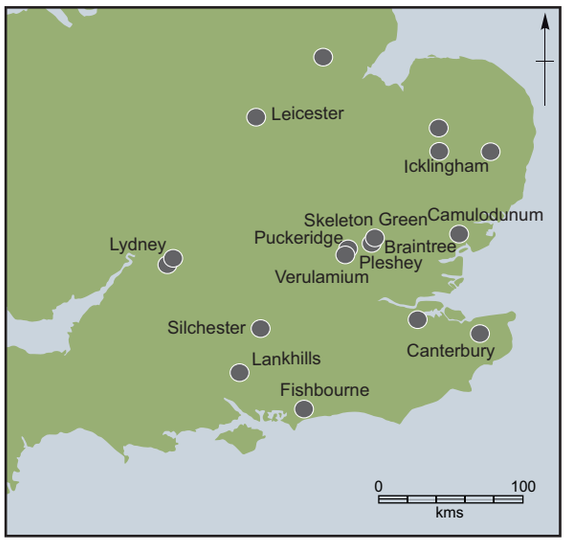


FIG. 124. The distribution of coin-moulds in south-east England.

was suggested by Landon (2016, 118) to have been heated most intensely on the underside. Basal vitrification, however, is rare, although reported from moulds at Braughing (Freestone 1979, 129) and Old Sleaford (Elsdon 1997, 54). Where an extensive upper surface is available on a Silchester mould (e.g. SF 5411), the vitrification is seen to be evenly developed, showing that heat was applied uniformly. For this and other compelling reasons (Tylecote 1962, 101), it is unlikely that the pits were heated one by one, as proposed by Castelin (1960) and Clifford (1961, fig. 26). The trays must therefore have been fired in some sort of small enclosed furnace, probably of the reverberatory type, in which the burning fuel and the object being fired are kept separate, so that radiant heat, hot gases and flames combine to raise the temperature only from above (cf. a muffle furnace). A reducing atmosphere would meanwhile have been ensured by the burning-off of the plant material in the clay. The burned-off plant material may also have helped to prevent the melting metal from wetting the tray and so facilitated its release after cooling (a conical shape for the pits would have the same effect). Furthermore, that the heating was brief is suggested by the slight thickness of the vitrified crusts as well as by the differences observed between base and top. Landon's (2016, 4) model for the firing of coin-moulds is quite different. He envisages the tray, covered in granulated charcoal, and mounted on a bed of charcoal, heated from above with the help of a tuyere.

DISCUSSION

More than enough metallurgical evidence is now available to prove that coin-moulds were used to make pellets of metal — copper/copper alloy, silver, gold — that could be hammered into flans and subsequently struck as coins. That a general tradition of coining in this way existed in Belgic Britain (FIG. 124) and Gaul (Tournaire *et al.* 1982, appendix I) is evident from the geographical spread of the moulds, but it is also clear from published accounts that there were significant regional variations in terms of technological practice. At Silchester, the evidence suggests that two sizes of pellet were made (FIG. 121.5) — a small size for most coins and a bigger size for a small minority of larger ones. Fragments of solid metal were seemingly placed in pits shaped in mainly square/rectangular clay trays using boards on which tens of regularly-arranged pegs were mounted, the trays subsequently being briefly heated from above in order to fuse the metal. Small reverberatory furnaces could have been used.

It is difficult to see the wide distribution of the Silchester coin-moulds as other than significant. Twenty-one fragmentary trays are scattered about the site of the forum basilica (Northover and Palk 2000, 413) and they are also found in the adjoining Insula II (Boon 1954, 69) as well as in rubbish pits at the West Gate. The moulds are also widely distributed, mainly in association with trackways, 200 m or so to the north-west in the larger site at Insula IX. Comparably wide

scatters of trays were noted by Hawkes and Hull (1947, 129–30) and Frere (1983, 30–1) at respectively Camulodunum and Verulamium. At Old Sleaford, Elsdon (1997, fig. 34) found one main concentration but 'isolated finds' at 12 other sites up to *c*. 150 m away.

The recycling of rubbish as buildings and other structures came and went offers a convincing partial but not necessarily complete explanation of these wide dispersals at so many locations. Tournaire *et al*. (1982, 431) recognised at least four categories of worker engaged in the coining process, thereby drawing attention to a considerable division of labour in the industry. It is therefore not beyond the bounds of possibility that many hands within a Belgic community undertook pellet-making as a strictly controlled form of outwork, the pellets later going forward to a central place — the mint proper — for the final stages of the coining process, when the products achieved their greatest value. That trays made in different ways can be found at some sites may be material evidence of this practice. Coining in the Iron Age may have been a relatively sophisticated industry.