Cow Cave Heritage at Risk S17 Project at Cow Cave, Chudleigh Rocks, Teignbridge, Devon (Scheduled Monument 1010726)

Final Report, March 2017

Chris Proctor, Rob Dinnis, John Stewart, Monika Knul, Chris Gleed-Owen, Chris O. Hunt, Dana Challinor, David Richards, Vanessa Fairbank, John Boulton, Hazel Riley and Cressida Whitton.

Chris Proctor BSc (Hons) PhD.
37 Grenville Avenue, Torquay, Devon,TQ2 6DS.
chrisjanet@blueyonder.co.uk

Rob Dinnis BA (Hons) MSc PhD.
RLAHA, University of Oxford, Dyson Perrins Building, South Parks Road, Oxford, OX1 3QY, UK.

John Stewart BSc (Hons) MSc PhD.
Bournemouth University, Faculty of Science and Technology, Talbot Campus, Fern Barrow, Poole, Dorset, BH12 5BB.

Monika Knul Ba Ma.
Bournemouth University, Faculty of Science and Technology, Talbot Campus, Fern Barrow, Poole, Dorset, BH12 5BB.

Chris Gleed-Owen BSc (Hons) PhD MCIEEM.
Director & Principal Ecologist, CGO Ecology Ltd,
27a Ridgefield Gardens, Christchurch, Dorset BH23 4QG

Chris O. Hunt BA MSc PhD FGS FRGS FSA.
School of Natural Sciences & Psychology, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF.

Dana Challinor MA (Oxon) MSc.
Institute of Archaeology, University of Oxford, 36 Beaumont Street, Oxford, OX1 2PG.

David Richards BSc PhD.
School of Geographical Sciences and Bristol Isotope Group, University of Bristol, University Road, Bristol BS8 1SS

Vanessa Fairbank MChem/MSc PhD.
School of Geographical Sciences and Bristol Isotope Group, University of Bristol, University Road, Bristol BS8 1SS

John Boulton
Rock House, Station Hill, Chudleigh, TQ13 0EE

Hazel Riley BA (Hons) ACIFA FSA.
Consultant in Landscape History, Management and Conservation Grazing, New House Cottage, Furley, Axminster, EX13 7TR.

Cressida Whitton MA MSc MCIFA.
Historic Environment Team, Devon County Council, AB3, Lucombe House, County Hall, Topsham Road, Exeter, EX2 4QD.

Abstract

Cow Cave, Chudleigh, Devon (SM 1010726), has a record of fossiliferous sediments and archaeology that is known to extend back into the Middle Pleistocene. In recent years a number of threats to the site have been identified, including natural erosion of the sediment sections and vandalism. The present project was planned as a limited excavation in order to stabilise the sediment faces, followed by installation of a grille to exclude casual visitors and protect the site in future. The project achieved these main aims. The excavation carried out to achieve the core aims allowed a reassessment of the site, which has confirmed it's antiquity. The oldest deposit in the cave, the Stream Deposit, is now referred on the basis of the pollen assemblage, archaeology and U-Th ages to the Aveley interglacial. The lower part of the Reindeer Stratum, previously also identified as Middle Pleistocene, is now dated to the early Devensian on the basis of a Chelford Interstadial type pollen assemblage and ^{14}C ages. The uppermost part of the deposit is of Holocene age but includes cold stage material that may date from the later Devensian. In addition to the archaeology already known to be present in the cave, ^{14}C dating of charcoal found during this investigation has established a late Mesolithic presence in the Chudleigh Rocks area.

Keywords: Cow Cave, Cow Hole, Chudleigh, Pleistocene, Holocene, Aveley Interglacial, Chelford Interstadial, Palaeolithic, Mesolithic.

Contents

1. Introduction.

1.1 Location of Cow Cave.

The large entrance to Cow Cave is one of a relatively small number of caves in Devon which has always been open in historical times. The cave is also known as Cow Hole, and is marked under that name on the Ordnance Survey maps. It is one of a group of caves located in Chudleigh Glen, a steep sided valley created where the Kate Brook crosses the outcrop of the Chercombe Bridge Limestone, of Middle Devonian age. On the northwest side of the glen lies Chudleigh Rocks, an impressive series of limestone cliffs which forms the west end of a ridge separating the lower Kate Brook valley to the southeast from the valley of the River Teign to the west. The cave is one of three scheduled ancient monuments in the glen: Cow Cave (SM 1010726) and Pixie's Hole (SM 1010740) in Chudleigh Rocks on the northwest side of the glen, and Tramp's Shelter (SM 1017681) below Black Rock on the southeast side (Fig. 1.1.1). Cow Cave and Pixie's hole represent two ends of the same ancient phreatic solution cave passage which forms a loop through the Rock between the two cave entrances (Figure 1.1.2). The entrance of Cow Cave lies at NGR SX 86469 78671, at an altitude of 54.48 metres O.D., and the main entrance of Pixie's Hole lies 58 metres to the east, at NGR SX 86529 78672, at an altitude of 58.34 metres O.D. This solutional cave passage has been intersected at three points by gull fissures (Simons, 2010; J. Boulton and C.J. Proctor, unpublished data). These are later rift caves formed by mass movement of the limestone of Chudleigh Rocks towards the steep valley side, opening up fissures in the rock (Self & Farrant, 2013). The easternmost of these fissures remains largely open and forms the second (west) entrance of Pixie's Hole and a series of high level rift passages within that cave. The other two are partially or wholly choked with sediment. One of them, Chudleigh Rift, is still partially accessible today. It comprises a series of small rifts and open bedding planes directly overlying the Cow Cave-Pixie's Hole solution passage. Immediately to the west of Chudleigh Rift is an entirely choked gull fissure locally known as Jacob's Ladder (Figure 1.1.3). Sediment has penetrated through both these gull fissures and down into the Cow Cave-Pixie's Hole solution passage to create a sediment plug which completely blocks the passage, separating the two main caves. The two closest accessible points within the two caves now lie some 8 metres apart (Figure 1.1.3).

Cow Cave itself forms the west end of the system and consists of a roomy phreatic tube passage 3-4 metres square, running to the sediment choke at the end. The standing face there now forms the most important sediment section in the cave. It was excavated by Simons (2010) as Section C, and formed the focus for the present investigation. The geometry of the caves, and of the sediment choke between Cow Cave and Pixie's Hole, suggest that this might be the exposed face of a substantial deposit. Two further standing sediment faces were recorded by Simons (2010) as Sections A and B on the west side of the cave. He suggested that Section B, on the west side of the inner part of the cave, blocked a westward continuation, the West Passage. Whether this passage actually exists is open to debate, and this section might occupy an alcove in the cave wall. During the course of this investigation further sediment remnants have been found to be widespread within Cow Cave. Most of them probably represent thin skims of sediment adhering to the cave wall.

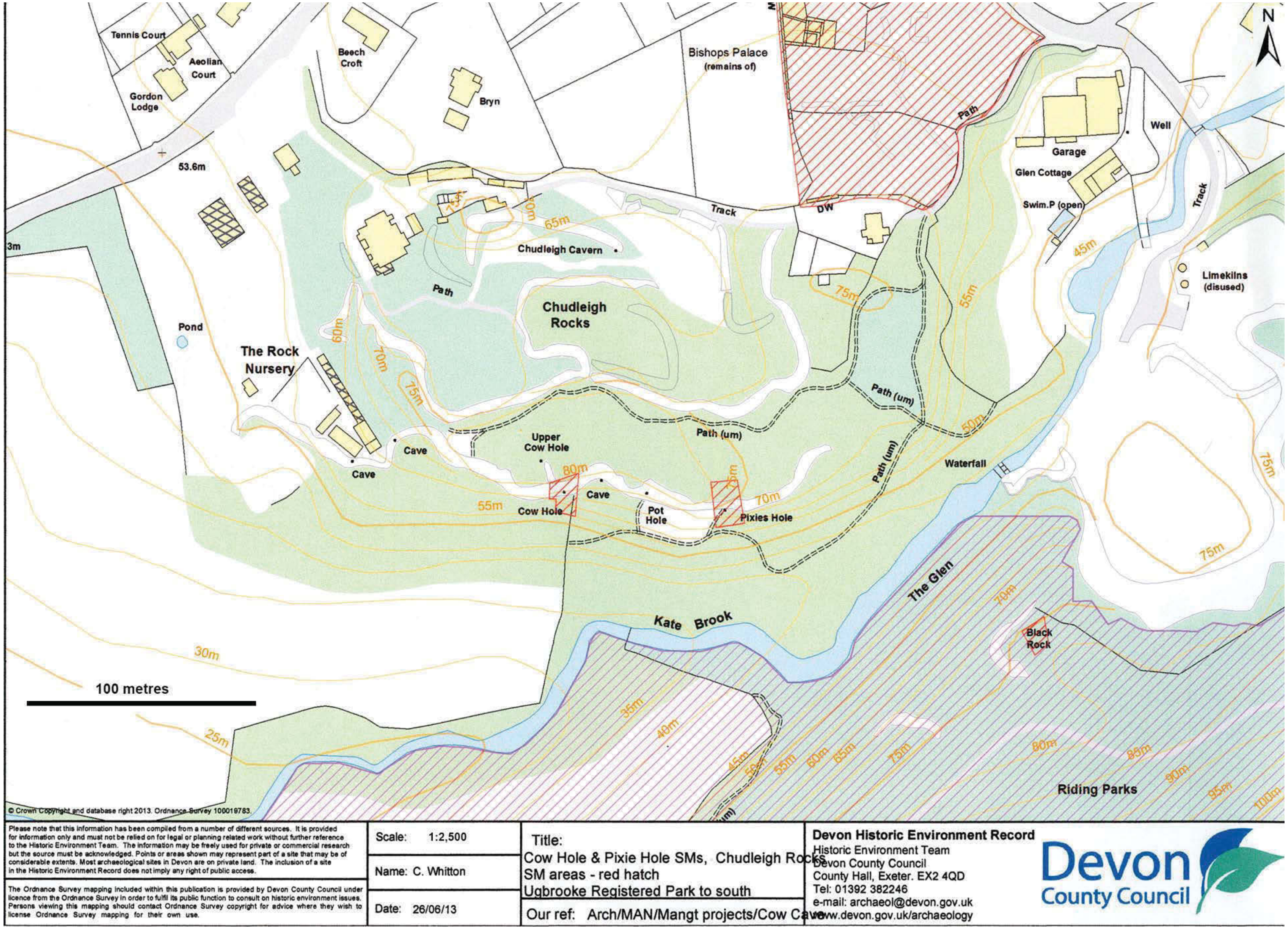

Figure 1.1.1 Map of Chudleigh Glen and Chudleigh Rocks showing scheduled ancient monuments.

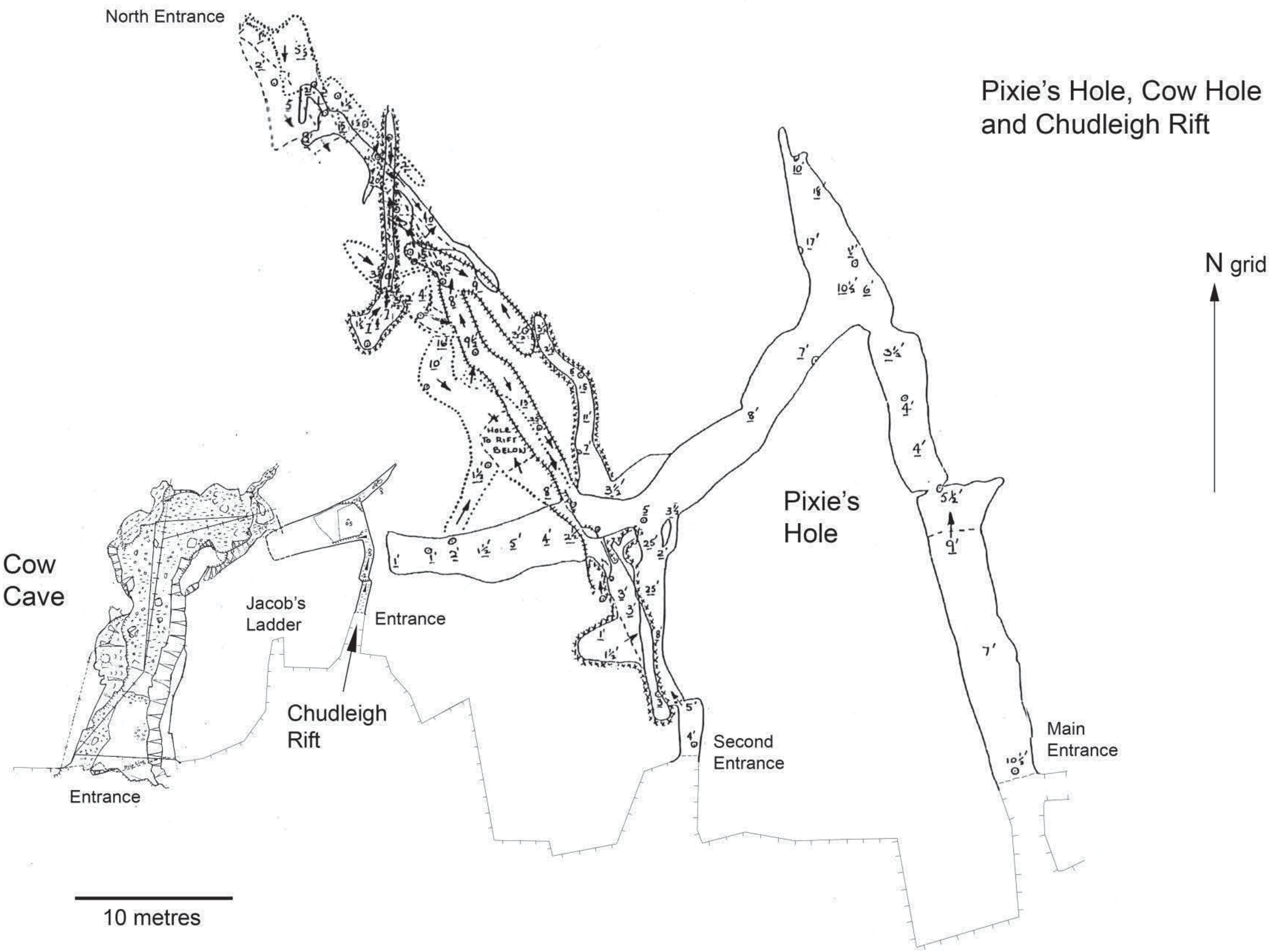

Figure 1.1.2 Plan of the Cow Cave - Pixie's Hole system (Hacking *et al*, 1947; C.J. Proctor and J. Boulton, unpublished data)

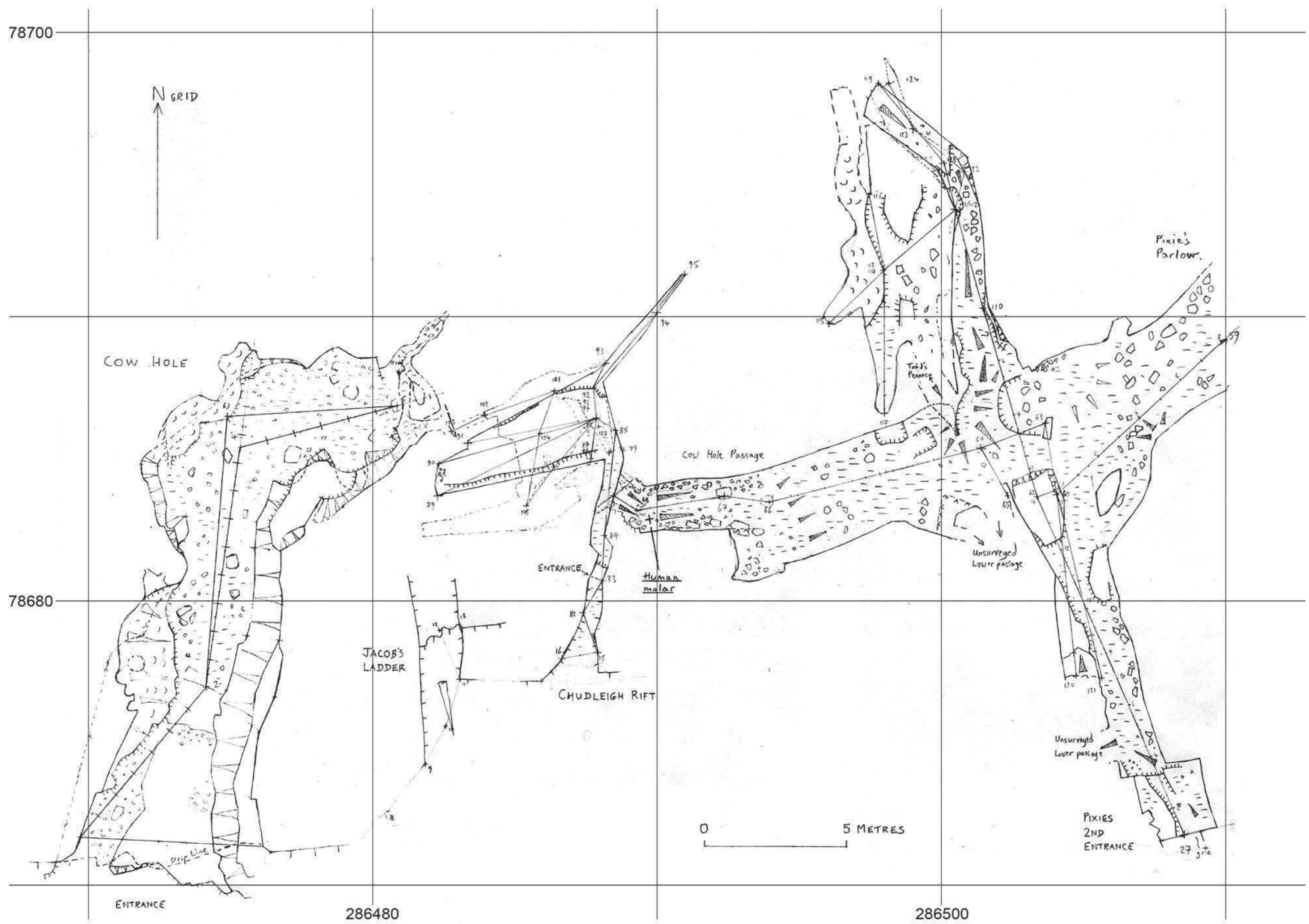

Figure 1.1.3 Detailed plan of west end of the Cow – Pixie's system, from C.J.Proctor & J. Boulton (unpublished data).

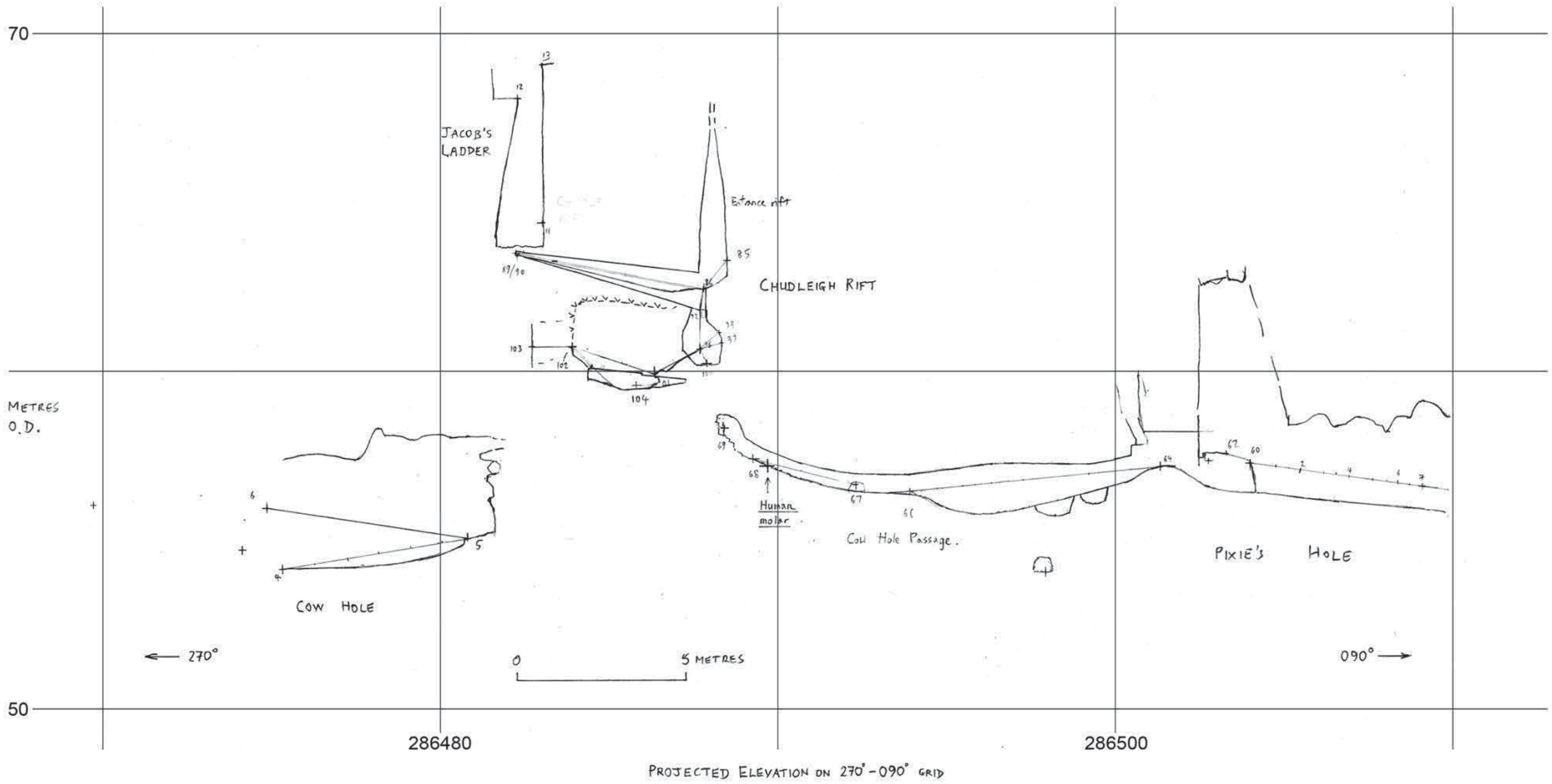

Figure 1.1.4. Detailed elevation of the west end of Cow – Pixie's system, from C.J.Proctor & J. Boulton (unpublished data).

1.2 Previous work

Cow Cave has been excavated twice prior to the present investigation. The first investigation was carried out by members of the Torquay Natural History Society from 1927 to 1935. Beynon (1932) described the earlier part of this excavation. Brief summaries in the annual reports of the society's section for archaeology and geology for 1933-35 (Alexander *et al*, 1933; 1934; 1935) provide the only published descriptions of the later years, but the excavation archive in Torquay Museum includes the field notebook covering the whole period of the excavation. Unfortunately the excavators did not fully recognise the complex stratigraphy now known to exist in the cave so the precise context of their finds is not known. The excavators found a varied Quaternary fauna and 9 flints which they regarded as implements. This material remains in Torquay Museum, and only 3 of the flints are now regarded as humanly modified. These include 2 early Middle Palaeolithic flakes and a small trapezoidal backed blade that can probably be referred to the late Magdalenian.

At an unknown date the cave was investigated by Anthony Sutcliffe, who recovered an almost complete bear skull from the area later recorded by Jim Simons as Section A (Simons, 2010). The cave was next investigated by Jim Simons who excavated in the cave from 1962-1963 (Simons, 2010). This was a small scale excavation intended to determine the stratigraphy of the cave and obtain a representative sample of the fauna, in order to help in interpreting the earlier excavation and existing collection from the cave. He investigated Sections A and B on the west side, and Section C at the end of the cave. Standing sediment sections were left in all three places. Limited trenching of the floor was undertaken at the base of the sections: these were infilled on completion of the excavation. Simons' excavation was conducted to a high standard and his stratigraphic scheme for the cave has been used by all workers since, with minor modification. He established that a complex sequence of deposits are present in the cave, which certainly span a long period of Quaternary history, with two distinct bone-bearing deposits (the basal Stream deposit and the Reindeer Stratum) separated by a broken stalagmite floor. A flint flake from the Stream Deposit was tentatively identified by R. Clarke as Levallois in type, implying a Middle Quaternary age for that layer. These Quaternary sediments were found to be overlain by thin stalagmite floors and a dark earth of probable Holocene age, the Frog Stratum.

Sutcliffe and Kowalski (1976) identified *Microtus nivalis* in Simon's material from the Reindeer Stratum and used it to suggest that a pre-Last Interglacial deposit was present in the cave. However, all Sutcliffe and Kowalski's (1976) identifications of *Microtus nivalis* from British sites have since been shown to be a form of *Microtus oeconomus*, a species of little stratigraphic value beyond showing that deposits of Pleistocene age are present (Stuart, 1982; Collcutt, 1985; Danielle Schreve, pers. comm). Collcutt (1985, p 886) excavated outside the cave during the 1970's finding only 2 metres of tip from old excavations. Sheridan *et al*. (2008) carried out stable isotope analyses and AMS dates for two human bones from the cave, obtaining earlier Neolithic calibrated ages of 3895-3657 BC, and 3761-3640 BC, at 95% probability. Lundberg *et al*., (2008) obtained two U-Th dates on stalagmite fragments from Layer 5 of Simons (2010) (the broken stalagmite floor). These produced ages of 167 ± 2 ka and 148 ± 1 ka BP, providing a valuable fixed point in the stratigraphic sequence recognised by Simons. Lastly, Chris Proctor and John Boulton carried out a topographic survey of the cave in 2011, as part of a wider survey of the Chudleigh Glen area that is still ongoing.

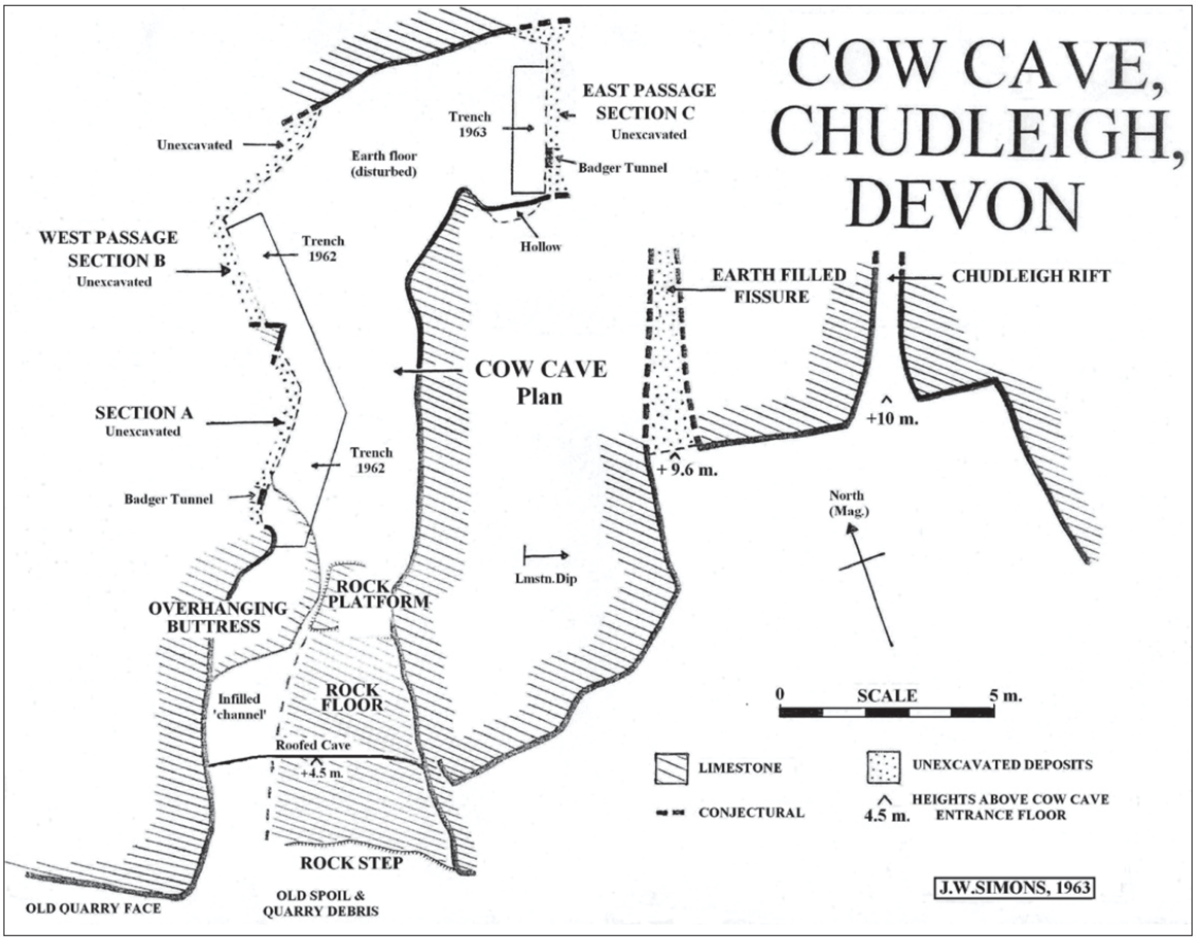

Figure 1.2.1. Plan of the cave from Simons (2010), figure 2, showing sections excavated by Jim Simons in 1962-3.

1.3 Background to the project

Prior to this project, Cow Cave was listed as at ‘high risk’ due to vandalism (Heritage at Risk (H@R) Register 2015). The Heritage at Risk case for the S17 funding rested on the significance of exposed Pleistocene cave sediments within the cave, which were vulnerable to open access and occasional acts of vandalism including fires set against the wall of the cave, where the sediments are exposed to damage through heating. In addition, some cave sediments, especially towards the rear of the cave (Section C in the 1962-3 Excavations) were actively eroding and vulnerable to collapse.

The Cave was fully accessible to the general public (mainly climbers and cavers, but also local walkers and young people) including the vulnerable cave sediment sections to the rear of the cave. A significant ongoing risk to Cow Cave came from the number of fires set against the cave wall, which have impacted on cave sediments where they are present at these locations. A Historic England (HE) Damage Report for Cow Cave by C. Vulliamy (HARPO) recorded a significant act of vandalism in 2005. This included modern ‘cave art’, creation of a hearth and disturbance to cave deposits by scraping of the walls and ‘digging’ in the floor at the rear of the cave. More recently, disturbance of cave sediments through further fire-setting against the cave walls, especially at the rear of the cave, was noted during a visit on 21/10/2015 by, among others, Cressida Whitton (Devon CC) and Vanessa Straker (HE SW Science Advisor). Although classified as vandalism in H@R terms, the damage may not be deliberate in the sense that the cave had open access in an area popular with climbers and cavers. There was no information present on site to indicate that the cave is a nationally important archaeological site and designated as a Scheduled Monument.

The cave sediment sequence, especially ‘Section C’ is vulnerable to natural erosion and disturbance. The formerly vertical section had developed an overhang and appears to be still actively eroding due to its loose nature and wetting by percolation water during the winter months. Bone-bearing Pleistocene and early Holocene sediments including parts of the Reindeer Stratum and Frog Stratum were being lost by active erosion, especially on sloping/overhanging faces where sediments are more unstable. Some historic bioturbation (possibly from animals or humans) is also present and some very recent small scrapes, probably made by people were also recorded on the site visit of 21/10/15.

In the light of these issues, the following management recommendations were made:

(a) That a very limited recording and sampling rescue excavation would help to stabilise and preserve a record of overhanging deposits, and vulnerable bone and artefacts could be recovered. Recovery of in situ Reindeer Stratum bones would allow radiocarbon dating to test the findings of previous excavations, notably whether the Reindeer Stratum is of Devensian period or earlier as hitherto surmised. In addition to study of animal bones, environmental analysis including sampling for pollen could be carried out for the first time at the site, thus giving a better understanding of the potential of the cave sediments for environmental reconstruction.

(b) Installation of a metal grille which would allow access at specified days within the year, protect the archaeology and be likely to have added benefit for bats. It is, however, important that access is still permitted albeit on a limited basis. The grille would be placed to restrict access to the middle and back sections of the cave. It would be custom-made to fit the cross-section of the cave profile, the preferred option being to site it at a narrowing section about mid-way into the cave, where a rocky wall intrudes slightly on the western cave face. This would mean that the grille could be bolted securely to the side of the cave and that no cave sediments on the wall of the cave would be disturbed during installation. In addition, the siting of the grille was influenced by the need to reduce the grille's visual impact on the setting of the cave, in particular its open aspect and appearance from the front view of the cave mouth. Installation of the new grille would require a small section of the floor cave sediments to be removed in order to secure the grille to the floor and to prevent possible attempts to gain access by digging underneath.

Other locations were discussed including setting the grille closer to the entrance of the cave, which would beneficially increase the amount of cave sediment that could be actively protected. As the cave widens considerably towards the entrance, this would have meant a much larger (and more expensive) grille. It would also have been much more visually intrusive from the approach to the cave and would severely restrict any visitor access to the front of the cave.

1.4. Cow Cave S17 Project Excavation Method Statement

1.4.1. Introduction

The purpose of the excavation in Cow Cave is to establish the following:

(1.4.1.a) To test the integrity of the sequence reported by earlier excavators.

(1.4.1.b) To record in detail the Main section at the back of the cave (Section C). It is not intended to record the other Sections (A and B) as they are both currently stable and are very dirty. The cleaning necessary for their inspection would in itself constitute unnecessary erosion. However they will be inspected to see if any critical stratigraphic boundaries can be identified.

(1.4.1.c) To excavate Section C back sufficiently to stabilise it and excavate exposed bones. The small section in the “Stream deposit” to the right of the main section, which comprises an extension of Section C, will be included in this work.

(1.4.1.d) To excavate and record a trench in the floor at the position of the proposed grille, prior to its installation. The dimensions of this trench are to be no more than 0.3x0.3m.

1.4.2. Method

(1.4.2.a) Survey

An EDM survey will be carried out prior to excavation to plot in the pre-existing survey points in the cave and survey the points which have been placed during section drawing. Sufficient further points will be taken to establish the 3 dimensional shape of Section C and adjacent sediment exposures, with particular emphasis on the areas selected for excavation.

If any visible stratigraphy has been established in Sections A and B that will also be plotted in, and a further task at this point will be to establish and survey in datum points for the floor survey.

(1.4.2.b) Excavation (Section C)

The excavation team are listed, with relevant areas of experience, at the end of this document. Section C and the adjacent “Stream Deposit” section will be cleaned by Dr. Chris Proctor (CP), Mr John Boulton (JB) and Ms Cressida Whitton (CW) where necessary and then drawn by CP (assisted by Mrs Janet Proctor (JP)) at a scale of 1:10. Vertical control will be provided by use of a laser line level, using the existing survey station at the cave entrance as a height datum. Horizontal control will be achieved by placement of a horizontal datum line across the sediment face. The ends of this line will be marked and during the plotting process, further fixed survey points may be placed on the face to allow surveying in during the main EDM survey. The other Sections (A and B) will be inspected, and if it is possible to distinguish stratigraphy in their current state then they will be plotted at a less detailed scale (probably 1:20 but this will depend on what can be seen).

This inspection of the sediments will be used by CP, JB and CW to make a final decision on which areas are vulnerable and need to be excavated.

The excavation on Section C will be carried out by CP, JB and CW to the minimum extent necessary to achieve aim (c) above, to stabilise the face and leave no exposed bones. The sediment will be examined during excavation to characterise its major properties including colour, texture, particle size distribution, and particle angularity and lithology. All bones, archaeological material and larger clasts will be measured in using the EDM, with 2 or more points measured depending on the object to establish its 3 dimensional position. All bones will be extracted with minimal handling and double bagged for possible ^{14}C dating.

(1.4.2.c) Excavation (Floor Trench)

The floor trench for the placing of the grille will be excavated by using the previously placed datum points as references. As this is a horizontal excavation it will be recorded by more traditional methods, establishing a datum line and using a tape, laser rangefinder and spirit level to measure distances and horizontal and vertical offsets from the datum. Otherwise the method will be the same. About 1/3 the length of this trench is known to be in disturbed ground in the location of the 1962-63 Simons excavation trench. This material will be examined but not fully processed unless anything unusual turns up. The east side is expected to be in-situ sediment and this will be excavated and processed as for material from Section C.

(1.4.2.d) Palaeoenvironmental Sampling / Analysis.

As the amounts of sediment are expected to be small, separate specialist samples will not be recovered, but consideration will be given to sampling in spits if the context is over 10cm thickness (or less if advised by specialists). However, due to the archaeological/geological significance of Palaeolithic sediments, all excavated in-situ sediment will be retained and flotated/wet sieved by CW and JP through 4mm; 2mm; 500 micron and 250 micron sieves. The >25mm lithological fraction will be removed by hand and examined by CP for analysis of clast lithology and roundness. The fine fractions will be sorted to recover microfauna and any archaeological material (small flint chips, etc). After recovery of fauna and archaeology the fine fractions will be examined by CP to make a qualitative description of the lithologies present. Pollen sampling will be undertaken in small tins or columns of samples or spot samples as appropriate to the stratigraphy and on advice from the pollen specialist. Animal bone and molluscs will be recovered from the samples and sent to relevant environmental specialists for analysis and reporting. If charred ecofact remains (e.g.charcoal or charred plant macrofossils) are recovered during processing, these will also be sent to the relevant environmental specialist. All Environmental work will be undertaken in accordance with Historic England's Environmental Archaeology Guidelines (English Heritage 2011). The specialists attached to the project and their areas of expertise are listed in Section 6 below.

1.4.3. Health and Safety

Health and Safety requirements will be observed at all times by any archaeological staff working on site. A cave-specific risk assessment will be prepared by John Boulton listing the hazards and risks associated with the cave excavation and access to the site, including any recommended mitigation measures. As a minimum high-visibility jackets; safety helmets and protective footwear will be worn.

1.4.4. Reporting

Reporting requirements are listed below and will be confirmed with Historic England at the close of site work and will include the following elements as necessary. In Year 1 an Interim Excavation Report will be written and submitted (Dr C. Proctor) by 11th March 2016 and a Final Excavation Report (Dr C. Proctor) will be submitted by the end of Year 2 (10th March 2017), following the completion of specialist reports which will be produced within six months of the end of excavation in February 2016.

(1.4.4.a) A report number, date and the OASIS record number;

(1.4.4.b) A copy of this Method Statement;

(1.4.4.c) A summary of the project's background;

(1.4.4.d) A description and illustration of the site location;

(1.4.4.e) A methodology of the works undertaken, and an evaluation of that methodology;

(1.4.4.f) Plans and reports of all documentary and other research undertaken;

(1.4.4.g) A summary of the project's results;

(1.4.4.h) An interpretation of the results in an appropriate Palaeolithic research context.

(1.4.4.i) A summary of the contents of the project archive and its location (including summary catalogues of finds and samples);

(1.4.4.j) A location plan and overall site plan including the location of areas subject to archaeological recording. Also, any relevant photos, plans and sections at an appropriate scale.

(1.4.4.k) Detailed plans of areas of the site in which archaeological features are recognised along with adequate OD spot height information. These will be at an appropriate scale to allow the nature of the features exposed to be shown and understood. Plans will show the site and features/deposits in relation to north.

(1.4.4.l) Section drawings of deposits and features, with OD heights, at scales appropriate to the stratigraphic detail to be shown and must show the orientation of the drawing in relation to north/south/east/west.

(1.4.4.m) Analysis, as appropriate, of significant artefacts, environmental and scientific samples;

(1.4.4.n) A description of any remains and deposits identified including an interpretation of their character and significance and a consideration of the evidence within its wider context;

(1.4.4.o) Site matrices where appropriate;

(1.4.4.p) Photographs showing the general site layout and exposed significant features and deposits referred to in the text. A photographic record of the works will be made. All photographs will contain appropriate scales, the size of which will be noted in the illustration's caption;

(1.4.4.q) A summary table and descriptive text showing the features, classes and numbers of artefacts recovered and sediment profiles with interpretation;

(1.4.4.r) Copies of any relevant historic maps and plans (of the site as a whole that provide context and interpretation).

(1.4.4.s) Copies of the reports above detailing the results of these investigations will be submitted to the OASIS (Online Access to the Index of Archaeological Investigations) database under reference *.

1.4.5 Archive

The archive is important as the primary record for posterity of the work, and of any remains that have had to be destroyed. On completion of the project an ordered and integrated site archive will be prepared in accordance with the Management of Research Projects in the Historic Environment (MoRPHE)

http://www.english-heritage.org.uk/publications/morphe-project-managers-guide/

The digital element of the archive will be transferred to the Archaeology Data Service (ADS) for long-term curation. The material (finds) element of the archive, if suitable, will be deposited at Torquay Museum.

(1.4.5.a) The archive will consist of two elements, the digital archive and the material archive.

(1.4.5.b) The digital archive, including digital copies of all relevant written and drawn records and photographs, will be deposited with the Archaeology Data Service (ADS) and in compliance with their standards and requirements.

(1.4.5.c) The material archive, comprising the retained artefacts/samples and the related records (if requested) will be cleaned (or otherwise treated), ordered, recorded, packed and boxed in accordance with the deposition standards of the MBND, and in a timely fashion.

1.4.6 Excavation Team and Specialists

Chris Proctor, BSc, PhD (Bristol) – Excavation Director

Chris Proctor is a self-employed geologist and researcher based in Torquay. A principal focus of his research has been on cave geomorphology and cave sedimentology, particularly as applied to Quaternary archaeological and bone caves in Devon and elsewhere in SW Britain. He has worked at numerous Quaternary cave sites including several major excavations, and is a co-director of the current excavation at Kent's Cavern, Torquay. He is currently collaborating with JB on a landscape scale survey of the caves of Chudleigh Glen.

John Boulton – Excavation Assistant

John Boulton is an experienced field archaeologist specialising in Quaternary archaeological and bone caves and has excavated at caves including Cresswell Crags, Kents Cavern and a number of smaller sites. He is currently collaborating with CP on a landscape scale survey of the caves of Chudleigh Glen. In addition he has technical expertise in excavation and stabilisation work in non-archaeological caves and abandoned mines. He was formerly a member of Devon cave Rescue organisation and has cave rescue experience.

Janet Proctor, BA – Excavation Assistant

Janet Proctor has worked with CP as a surveying and archaeological field assistant since 1989. She has also worked on several cave excavations on sample processing, and has considerable experience of wet and dry sieving techniques and of sample retrieval from sieving residues. She is a qualified first aider.

Cressida Whitton, BA, MA, MSc MCiFA – Project Manager and Excavation Assistant

Cressida Whitton works part time in Devon County Council's Historic Environment Team (DCHET), covering agri-environment issues across Devon. She is an experienced field archaeologist and took part as a student in a number of

Palaeolithic cave excavation projects including at Torbryan Caves; King Arthur's Cave (Wye Valley) and in 2004 at Kent's Cavern running a developer-funded project for Exeter Archaeology. She also works part time for AC Archaeology as an Environmental Archaeology Technician, and is experienced in environmental sampling; processing and sorting.

Hazel Riley, BA (Hons), ACIFA, FSA - Surveyor

Hazel Riley is a consultant in the historic environment, specialising in the survey and analysis of archaeological sites and landscapes. She has worked on archaeological survey and research projects on Exmoor and the Quantock Hills and is currently engaged on survey projects for the Exmoor Mire Project and Exmoor National Park. She also runs a beef and sheep farm on the Blackdown Hills in Devon.

2. Methods

2.1 Methodology of works undertaken.

Recording and excavation methodology were laid out in advance of the excavation in the Project Brief and Method Statement (summarised in sections 1.3, 1.4). The field recording and excavation part of the project was carried out between 5/2/2016 to 19/2/2016. This followed the proposal and method statement in broad scope but had to be modified in places. While the project broadly confirmed the stratigraphy proposed by Simons (2010) it was found to be significantly more complex than that recorded by him and Lundberg *et al*, (2008). Extensive, previously unrecorded sediment remnants were found against the north and south walls and the roof of the inner chamber of the cave. These remnants are thin and potentially vulnerable to erosion so obtaining a record of them was considered important. They include the previously unrecorded uppermost part of the Reindeer Stratum which is present as a high level remnant on the south wall of the inner chamber, above the south end of Section C. This remnant is potentially at risk of erosion or collapse and it was considered important that it be sampled in detail, in order to obtain a record of the sediment in case of possible loss of the remnant in future. In addition Section C needed to be recorded in greater detail than originally anticipated. The sediments were found to be significantly affected by later piping and burrowing; and the Broken Stalagmite Layer was found to be a breccia with complex internal stratigraphy. The greater complexity recognised suggests this unit may be more significant than formerly proposed. During recording and excavation it became apparent that many parts of Section C are still actively eroding, increasing the importance of obtaining a detailed record of the face in its current state.

(a) **Survey and recording methodology**

A differential GPS survey of the area around the cave was carried out on 5/2/2016 by Hazel Riley to set up fixed survey stations tied into the National Grid. Two differential GPS stations were set up in the field below the cave and an EDM survey traverse was used to establish fixed stations at the cave. The EDM survey of the site used National Grid coordinates and Ordnance Datum altitudes. Two main survey stations were established at the cave, one just outside the entrance, and the second in the inner chamber. The second station was sited so that all the main sediment exposures could be surveyed from it and was used to position the EDM for surveying during the recording and excavation. Several further fixed stations were also established around the cave walls although they were not used on a daily basis. These may however be important in future as the main station outside the cave entrance was destroyed by vandals shortly after completion of the excavation.

For recording of Section C the planned recording methodology was adhered to with the following modifications. The section was cleaned prior to recording. Originally a planar cut section, Section C now has a complex 3 dimensional shape due to excavation by Simons in1962-3, and collapse over the years since then. This necessitated a modification of normal section drawing methods, with a laser line level used to facilitate plotting the section. This was used to project horizontal and vertical laser lines onto the section face, with the both lines set to local coordinates of the section plane. The section was plotted at a scale of 1:10 onto a plane parallel with the original plane of the 1962 section (still visible in sediment baulks at either end). The shape of the section necessitated the preparation of two section drawings, one in the front plane of the original Simons cut section, and a second of the irregular back face some 1 - 1.2 metres behind. A series of points were EDM surveyed across the section to provide 3-dimensional control, with survey point locations being recorded on the drawn sections. This was followed by a detailed lithological examination and description all parts of Section C.

The Stream Deposit section in the Alcove (a floor-level niche on the south side of the inner chamber) was cleaned, recorded and exposed bone recovered, as per the Project Brief and Method statement. Excavation of the trench created a further exposure of Stream Deposit. This section was drawn at 1:10 scale and lithological examination carried out, as with Section C.

While it had been originally envisaged that drawings of the other sections would also be prepared at lesser scale, the large number of previously unidentified sediment remnants located made this impossible in the time available. In addition, Sections A and B were found to be very dirty as both are exposed to daylight and the sediment surface is covered with algal growth. While it was possible to confirm the main details of Simon's (2010) drawn section, no more could be seen than shown by him. Instead all sediment faces in the cave (including Sections A, B and C, and other sediment remnants on the cave walls) were photographed, and their 3-dimensional locations determined by surveying a series of EDM surveyed points on each section/remnant, with the survey point locations being recorded on the photographs. One series of small remnants could not be surveyed using the EDM as they lay out of sight of the EDM station. These lie on the east side of the entrance passage, between the grille and the entrance. Their position was measured after the excavation with a fibron survey tape, taking the grille as the zero point. Following photography and survey, the lithological examination of the sections/remnants was carried out, with details being recorded on copies of the photographs. Due to lack of time this was not as detailed as had been carried out for Section C and the Alcove and trench Stream Deposit section, but it provides a first record of the distribution of sediment remnants through the whole cave.

(b) **Excavation**

The sampling undertaken is described in detail in section 4.1.; sampling sites are further described in section 3. Three sample columns (B, C and D) were excavated in the Reindeer Stratum at locations on the south side of section C considered to be at greatest risk of sediment collapse. These were areas where the face was overhanging and collapse had occurred in the past, with bones eroding out of the collapsing face. A further column (A) was excavated in the high level remnant above the south end of section C as this was considered to be also at risk of collapse. All sample columns were excavated in 5cm spits.

Individual finds from the sample columns, including megafaunal bone and charcoal, were recovered individually and surveyed in during excavation. Pollen samples were taken from two of the columns (A and C), at 2.5cm resolution (tied in with the spit samples). Pollen samples were also taken from the sediment immediately surrounding bones. Additional sampling of Section C and adjacent sediments was carried out, as agreed with Vanessa Straker (HE scientific advisor): for a full list of these samples and further details see section 4.1. The stratigraphic complexity identified in the Broken Stalagmite Layer posed problems that necessitated sampling of this part of the sequence for U-Th dating and pollen analysis. Additional bulk and pollen spot samples were taken elsewhere in areas identified by specialists (Chris Hunt, Chris Gleed-Owen) as being of particular interest (section 4.1). These included samples of loose dark earth from a pipe/burrow in the middle of Section C, and from a microfauna rich patch of the high level remnant on the south wall of the inner chamber, both for microfaunal recovery; and pollen samples from roof remnants above the middle of section C.

The Stream deposit in the Alcove was cleaned for lithological description. One bone was recovered from here but it was not otherwise sampled. Excavation of the Stream Deposit in the trench in preparation for placing of the grille produced almost no palaeontological material (a single small bone fragment). Bulk samples were taken of the two main sedimentary units identified in the trench.

All the above samples were taken for flotation/sieving, clast lithological analysis and recovery of fauna and archaeological material, or for kept for pollen analysis or dating as appropriate.

2.2 Assessment of the methodology

Most of the work carried out at the site was in the back of the cave, where there is almost no daylight. Work was carried out using helmet mounted LED caving lamps. These are useful in directing light where required but do not provide good overall illumination of the sediment face. They were supplemented by a portable floodlight which was found to be invaluable in providing good even illumination of the entire face.

Survey work in and around cave sites presents a number of problems. Differential GPS could not be used close to the Chudleigh Rocks cliff due to a poor GPS signal.

However this was easily solved by placing the differential GPS stations in the field below, and laying an EDM traverse up from there. Two EDM base stations were placed at the cave, marked by steel floor pegs, one just outside the cave, one in the inner chamber. The peg outside the cave was removed by vandals shortly after completion of the excavation. Had this happened during the excavation it might have caused significant problems. Two chiselled crosses on the cave wall (from a previous survey) were also surveyed in. These provided a more permanent and less obvious method of establishing fixed survey stations in the long term. Where risk of vandalism is high, chiselled crosses can easily be camouflaged by rubbing mud over them immediately after marking, which had been done in this case. The complex 3D nature of the sections and other sediment remnants needed to be surveyed in detail to establish their shape and position. The use of a reflectorless EDM unit was very useful in plotting these surfaces as it allowed rapid plotting of numerous survey points across the sections.

Section drawing of Section C was found to be difficult due to its 3D nature. It was found necessary to prepare two drawings, one of the front face of the section following Simons' (2010) original section plane, the second of the more irregular back face of the section. The latter drawing was necessary to record parts of the section which would have been obscured by projecting parts of the front section. Due to the use of National Grid coordinates for the EDM survey, it was not possible to transfer EDM coordinates directly for plotting as the plane of the section followed the original section plane of Simons (2010), and this deviated by several degrees from the grid N-S direction. Use of a laser line level was found to be useful in providing horizontal and vertical laser lines onto the section face, with the both lines set to local coordinates of the section plane, and it was relatively simple to measure from these datum lines to find the position of any feature. However this method was in practice found to be quite slow. Recording of complex sections such as this might possibly be better achieved by new methods of 3D plotting by photogrammetry. However, use of photogrammetry in a cave environment might require some experimentation due to the need for good, even lighting of the sediment face.

The widespread sediment remnants located elsewhere in the cave necessitated the adoption of an effective technique of rapid recording. Use of photographs followed by EDM survey and lithological examination, with survey points and details of the sediments recorded directly onto copies of the photographs was found to be a quick and efficient recording method. This allowed the large scale geometry of the sediments throughout the cave to be recorded for the first time. Time constraints and the dirty nature of some remnants meant that the recording exercise carried out during this investigation was certainly not complete; it would be worth examining these remnants in more detail in future.

The sampling undertaken was significantly more extensive than originally envisaged. Inclusion of an additional sample column in particular placed a considerable extra workload on the excavators and all workers were needed in the cave in order to complete sampling within the time allotted, significantly putting back post excavation processing and analysis. The sample columns (columns B and C) on the south side of Section C achieved the aim of removing the actively collapsing overhanging deposits, which were cut back to a more stable vertical face. Column A was excavated in the high level sediment remnant above the south end of Section C. This was excavated because it was considered that this entire remnant might be at risk of collapse and should be sampled before any such event. The excavation of a sample column here has arguably left the remaining sediment to either side less stable than before. However a low slot was found that extends in at roof level from the top of column A for over 2 metres: rather than being a thin skim of sediment adhering to the wall, the column A remnant might be part of a much larger sediment body flooring this cavity.

On the HE/specialist's site visit during the excavation, pollen samples were requested by the specialist (Chris Hunt) at 2.5 cm intervals on Columns A and C, as well as further spot samples. This led to a large number (67) of pollen samples being taken. In the light of this the decision was subsequently taken to bulk them up to 5cm interval for analysis. It would have been better once it had been realised in the field that the originally requested resolution would generate so many samples, had this been communicated to the specialist; a decision to sample at 5cm resolution during the excavation would have saved valuable time.

2.3 Installation of the grille.

Several factors were important in determining the design of the grille. It had to be effective in securing the site against entry by people, but also had to satisfy recommendations for design of bat grilles. The adjacent Pixie's Hole is occupied by a significant colony of greater horseshoe bats, which breed and hibernate in the cave. Smaller numbers of other species are also present. Cow Cave is primarily used by greater horseshoe bats from the Pixie's Hole colony as a swarming and mating site in late spring (David Wills, pers. comm.). There is little evidence of use of the cave by bats at other times, but this could be due to almost constant disturbance by visitors, which would discourage bats from roosting through the day and might change after grille installation.

Design of bat grilles is discussed by Mitchell-Jones (2004). The basic design for the grille was taken from this source, with modifications suggested by David Wills (pers. Comm.). The agreed specifications were: Spacing between horizontal bars (gap width) 15cm, with two gaps done at a wider spacing of 18cm between 1.5 and 2 metres from the ground; Vertical bars to be included in the design for strength; spacing between vertical bars (gap width) 75cm; small gate, as Pixie's Hole grille, to fit between two of the vertical bars and of similar height. A 15cm spacing between horizontal bars is standard in bat grille designs; the inclusion of two gaps of 18cm was incorporated based on observations that greater horseshoe bats the Pixie's Hole prefer to use gaps with a slightly larger spacing when exiting the cave. Given that Cow Cave is used as a swarming site with much flight activity at these times, this was considered particularly important. It was also specified that the grille be galvanised to make it more durable. The final grille design is shown in figure 2.3.1.

The contractor selected for fabrication of the gate was Terry Shears of Chudleigh. The grille installation trench was excavated as part of the archaeological investigation on 19/2/2016, and Mr Shears visited the cave to measure the passage dimensions at the installation site. The trench was then temporarily backfilled for safety. The grille was fabricated in two sections from 20mm steel bar and galvanised. A consideration for installation of the grille was timing the installation work to minimise disturbance to bats in Cow Cave or neighbouring caves. Even if no bats were visibly present in Cow Cave, small fissures connect upwards from here to Chudleigh Rift with the possibility of an onward connection to Pixie's Hole. These could cause the possibility of dust or fumes from the installation works affecting neighbouring caves, as well as considerable noise disturbance, to which bats are known to be intolerant. The gate was installed on 28th April 2016 following the end of the bat hibernation season. Installation was carried out by Mr Shears with John and Bruce Boulton, using resin anchors fixed in holes drilled in the cave walls and roof. The finished grille is shown in figure 2.3.2.

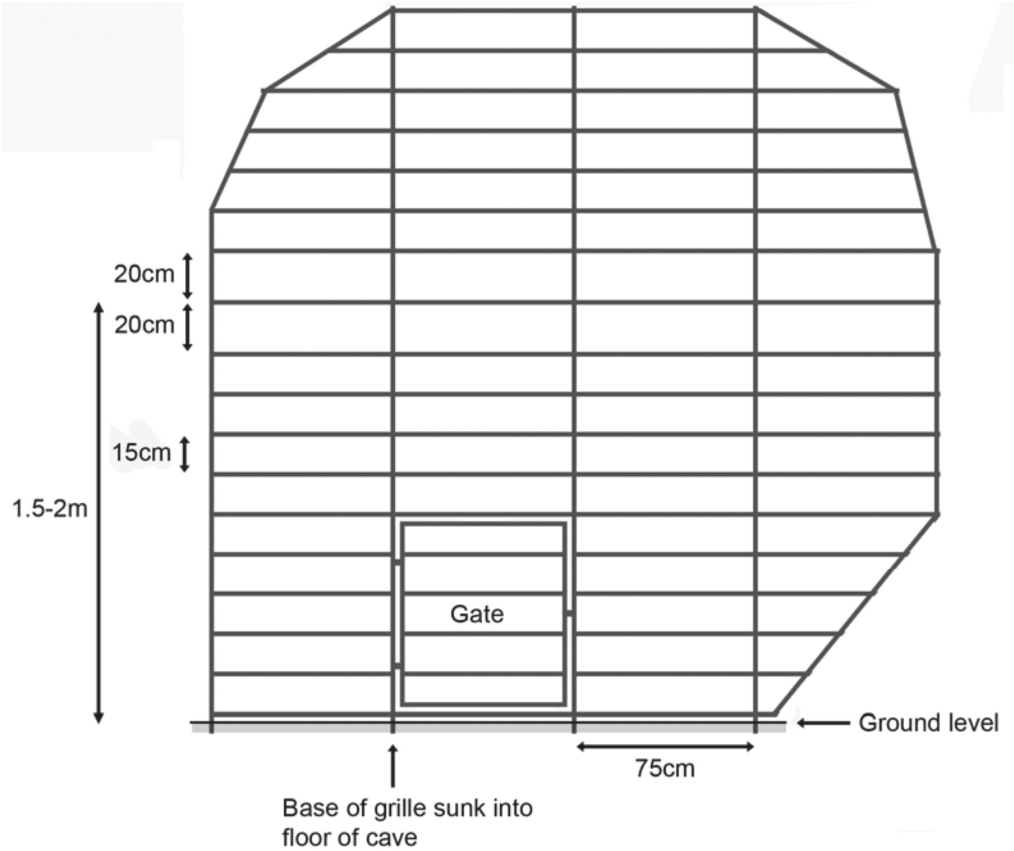

Figure 2.3.1. the grille design.

Figure 2.3.2. The grille after installation.

3. Field results

3.1 Sections recorded

Sediment remnants were found to be widespread in the cave, in addition to the three sections recorded by Simons (2010) and the floor trench. The distribution of sections and sediment remnants is shown on figure 3.1.1. (see also Appendix 2). Section C and the associated high level remnant excavated in column A were recorded in detail, as were the Alcove, and the sediments exposed in the floor trench. Other sediment remnants, and the very dirty sections A and B were recorded by a combination of photography and placement of EDM points to locate their positions.

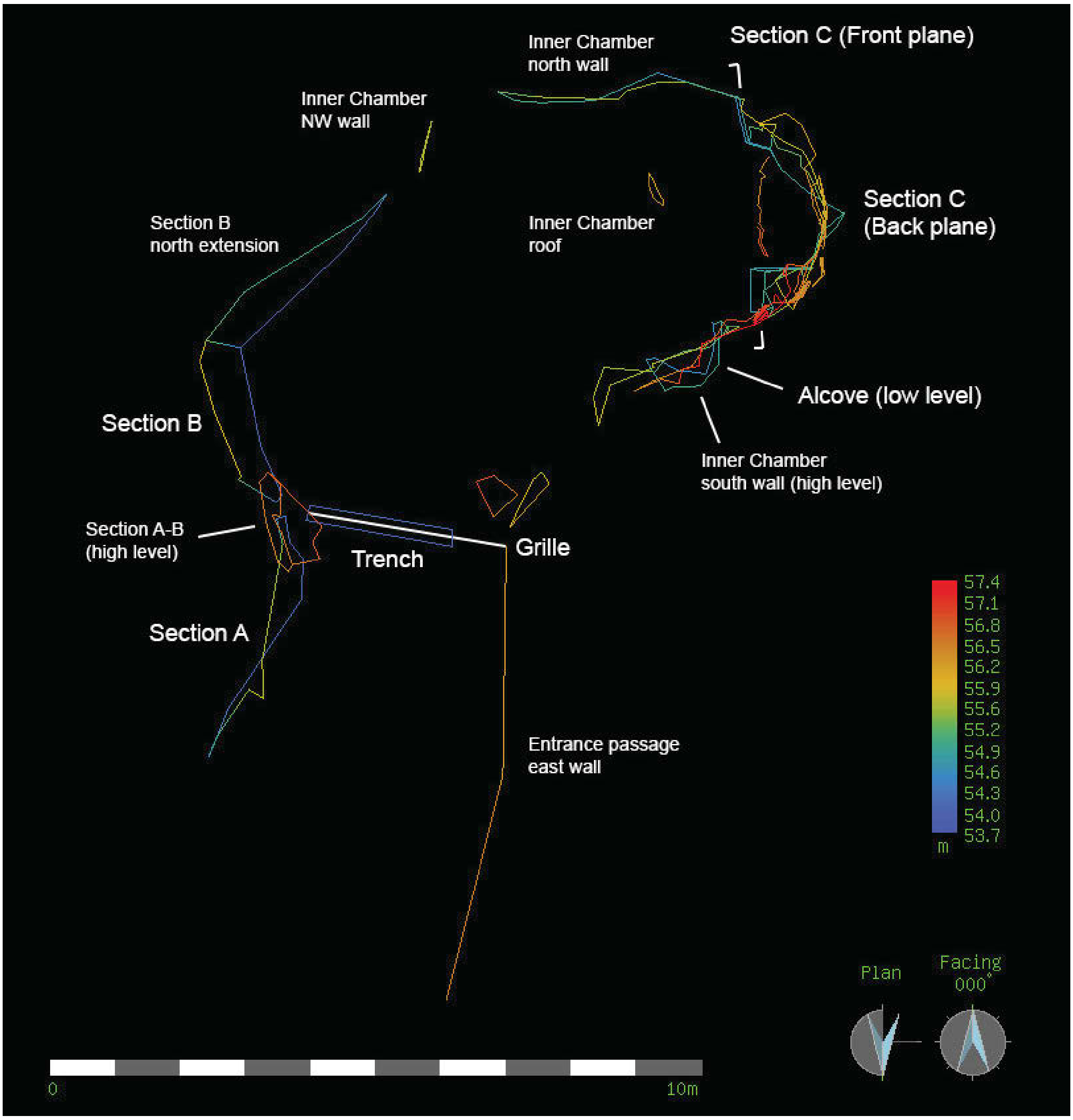

Figure 3.1.1. Positions of sections and sediment remnants in the cave. Plan from the EDM data Survex model (Appendix 2). Heights in metres O.D.

3.2 Section C

This is the main sediment face at the rear of the cave, comprising the blockage which prevents further progress up the cave passage (figure 3.2.3). A complex stratigraphy is exposed in this section, with almost all the known stratigraphic units exposed here. Originally a reasonably planar section (Simons, 2010, figure 2; see this report figure 1.2.1), Simons excavated most of the face back by 1 metre. It has also suffered some later erosion, creating a complex three dimensional section. The original section plane is still visible in sediment baulks at either side of the section, with the main central face about a metre behind (figure 3.1.1). The section was plotted at a scale of 1:10 onto a plane parallel with the original plane of the 1962 section using two section drawings, one in the original plane of the Simons cut section, and a second of the irregular modern face some 1 - 1.2 metres behind (figures 3.2.1, 3.2.2, Appendices 1, 2). These are referred to as the **Front plane** and the **Back plane** respectively in the account below. A series of points were EDM surveyed across the section to provide 3-dimensional control in addition to surveying in locations of sample columns and other sample points (figures 3.2.1, 3.2.2 Appendix 2). The following stratigraphy is visible in Section C (from the base up).

(a) **Stream Deposit**

This is the lowest unit exposed in the cave. In Section C it is best exposed on the front plane on the south side, where it comprises a clast supported deposit of rounded to subangular flint cobbles to 5cm in size. No clear fabric is visible. The matrix is a wet, quite dense brown clay/silt/sand. At the top of the deposit is a 3-6cm layer of very soft, malleable, compact brown clay/silt. This has a sharp but convoluted contact with the calcite sand that marks the base of the overlying Broken Stalagmite Layer.

The Stream deposit is poorly exposed in the back plane of the section although a bone was recovered from the cemented top of the deposit just north of the lower pipe (find 0012). On the north side of the front plane the Stream Deposit is again visible in a dirty exposure which has been badly affected by a fire set against the wall in this location. It comprises subangular flints to 9cm, clast supported in a clay/silt/sand matrix and with no clear fabric visible. At the base of the exposure the matrix has been fire altered to a bright red colour. On this side it is directly overlain by a partially cemented breccia (the lowest unit of the Broken Stalagmite Layer), with stalagmite cement extending down into the uppermost ~10cm of the Stream deposit to create an irregular contact.

(b) **Broken Stalagmite Layer**

The Stream Deposit is overlain by a thick layer of broken stalagmite fragments which extends right the way across Section C. On the south side of the section, the base of the unit comprises a 4-18cm thick layer of gritty calcite sand. Under magnification the individual particles can be seen to be crystallline, suggesting this material is disaggregated stalagmite. This was confirmed by testing with hydrochloric acid which showed it to be calcite. At one place the sand is still lightly cemented, providing further evidence that it is disaggregating stalagmite. As already noted this material has a convoluted contact with a clay layer at the top of the underlying Stream Deposit. In the front plane, a detached block of stalagmite is present within the convoluted calcite sand and clay layer. The calcite sand thins out to the north, extending across the back plane as far as the lower pipe.

On the south and central side of the section, the calcite sand is overlain by a massive stalagmite floor. This floor has been broken up into large slabs, but remains essentially *in-situ* with the fragments still fitting together. One block was sampled for U-Th dating (sample 0037) and was found to be cream coloured, vuggy sugary textured stalagmite, with a 10mm basal layer of massive clean laminated stalagmite. This block was itself underlain by a 15cm thick lower layer. Wet muddy sediment is present infiltrated into the cracks between the blocks.

Overlying the broken massive floor with a sharp contact, is a breccia of smaller stalagmite fragments up to 28cm in size, in a matrix of stalagmite gravel and brown earth, cemented in places. The breccia is quite chaotic but a weak fabric is present, dipping gently down to the north: this becomes stronger towards the south wall. One megafaunal bone was observed in the section; it was deeply embedded and cemented firmly in place so was left unsampled. A few fragments of clean crystalline stalagmite are present. One such was sampled by Lundberg *et al* (2008) in the south central part of the back plane for U-Th dating. Part of this fragment remains in place. Another very similar fragment is located immediately to its north, which was sampled by us for dating and pollen analysis (sample 0038). Both these clean stalagmite fragments represent part of a thin clean growth layer, not typical of the main mass of stalagmite fragments which are dirtier and more porous. A further more typical sample of the breccia was taken from just beneath sample 0038 for pollen analysis (sample 0160). Over the central and south side of the back plane the top of the breccia is cemented, forming a smooth top surface with a very sharp contact with the overlying Reindeer Stratum. This cementation horizon incorporates too much sediment and fragments of brecciated stalagmite to be described as a stalagmite floor, but it represents a significant phase of stalagmite growth. This horizon was sampled at a point where it looked like it might be clean enough to attempt to date (sample 0039), but on close inspection after sampling the clean area proved to be a detrital stalagmite block embedded in the cementation horizon.

Towards the north side of the back plane the massive basal floor is absent and the Broken Stalagmite layer is represented by a cemented breccia. This continues to the north wall, where a further massive stalagmite block is present, cemented to the north wall. This block has breccia above and below, and a few limestone fragments are present in addition to stalagmite within the breccia. On this side of the section no cementation of the top of the breccia is present and the contact with the overlying Reindeer Stratum is gradational, with material of that unit infiltrated into the upper part of the breccia. Lundberg *et al* (2008) took another stalagmite sample for dating from this side of the section. Close inspection of their recorded sampling point revealed no trace of the stalagmite, so the whole fragment must have been removed in sampling.

(c) **Reindeer Stratum**

The Reindeer Stratum forms a thick layer overlying the Broken Stalagmite layer, and extending across the back plane. It is thickest on the south side at ~1 metre thick, although even here piping or burrowing has removed a significant amount of sediment, producing a series of tunnels within the deposit. Sediment remnants on the wall suggest that on this side of section C the Reindeer Stratum was originally nearly 1.6 metre thick, thinning to around 0.4 metre at the opposite (north) side.

Where thickest on the south side of the back plane (figure 3.2.4), the Reindeer Stratum is a typical, fairly structureless cave earth. It is very poorly sorted with a matrix of crumbly brown clay/silt/sand. The bottom ~25cm of the deposit is very stony, less so above this level. Clasts include abundant matrix to clast-supported fragments of angular-subangular limestone to 17cm in size, and a few fragments of stalagmite. One 3cm sized gritstone clast was recorded in the section, and some bone is present. A weak subhorizontal clast orientation is present, with many planar clasts sloping at angles up to 20-25^{o}. Although the colour of the matrix is generally a uniform brown a very diffuse, slightly redder layer 10-20cm thick is present halfway down the section. Two sample columns were excavated on this side of the section; columns B and C. They were excavated primarily to remove overhangs in the sediment face, but column C was continued down to the base of the Reindeer Stratum to sample the full depth of the deposit. A further column (D) was excavated below column B, in an area where the sediment was found to be stony and very crumbly, and contained abundant poorly preserved megafaunal bone (figure 3.2.7). This might represent an area of pipe or burrow development, so was excavated as a separate column. Excavation showed that the loose sediment does not extend far back into the face.

In the middle of the section the Reindeer Stratum is similar to the stony basal sediment on the south side. The red layer seen on the south side can be traced into the central section where it lies just below a tunnel within the sediment on the central face. Towards the north side of the section, the upper part of the Reindeer Stratum has been removed by later piping or burrowing (see below). Cemented sediment remnants on the roofs of the tunnels show that the sediment originally extended up to the cave roof. The upper part of the Reindeer Stratum here comprises a cave earth like that on the south side of the section, with angular limestone and a few stalagmite clasts in a clay/silt/sand matrix. Clasts dip gently down to the north, at 15-20^{o} in some places. The red layer is more distinct but thinner (~5cm) on the north side of the section, and here it is underlain by a 2-10cm thick yellow layer. Both these coloured layers are clast supported, with abundant small stones and gravel fragments and a subhorizontal fabric. This fabric was thought on first inspection to be lamination and a block was sampled for SEM analysis with adjacent pollen samples also taken, but during excavation was found to be due to the presence of abundant small gravel flakes. Further more subtle colour bands can be traced under the yellow layer. The basal Reindeer Stratum on the north side is a stony unit, with stalagmite and some limestone blocks to 15cm, clast supported and showing a clear fabric with clasts dipping to the left and out of the face (NW). The matrix is brown clay/silt/sand, cemented in a few places. It rests with a fairly sharp contact on the Broken Stalagmite Layer below. This unit grades laterally over ~50cm into typical Reindeer Stratum in the central part of the section.

On the sediment baulk on the north side of the front plane, the Reindeer Stratum is represented by ~20cm of fine clay/silt with a little sand. The main unit here is bright orange brown with a thinner (~4cm) buff brown unit above. This buff unit is even finer, clay/silt with a little very fine sand. These two colour variants have quite a sharp contact and are finely interbedded in places, otherwise both are soft, compact and look completely structureless in field section. This sediment rests on the top of the broken Stalagmite Layer, the uppermost clasts of which are enclosed by the fine sediment; This suggests that the fine sediment has infiltrated into the top of the Broken Stalagmite Layer, producing a zone of contact about 12cm thick.

A high level remnant on the south side above the sediment baulk in the front plane marks the highest preserved remnant of Reindeer Stratum. Its position near the roof and lack of any sign of higher sediments suggests the top of this remnant probably represents the true top of the Reindeer Stratum. This body of sediment was sampled as Column A. The lower part of this column (spits 9-13) are a typical cave earth, very poorly sorted with many clast-matrix supported angular limestone fragments to 7cm in size in a clay/silt/sand matrix. A fairly well developed subhorizontal clast orientation is present. As such it resembles the Reindeer Stratum on the south side of the back plane below. Spit 8 has much less fine matrix and there is considerable void space (~50%). Above this level the sediment is a clast-supported cave earth with angular limestone fragments to 14cm, in a crumbly brown matrix. There are numerous small voids (around 5-10% of the sediment volume). Spit 1 is a darker earth, suggesting some admixture of Dark Earth. The occurrence of numerous voids in the upper part of the sediment may be primary porosity; an alternative explanation would be that it has been eluviated, with a significant eluviation horizon at the level of spit 8.

(d) **Pipes and burrows**

The Stream Deposit, Broken Stalagmite Layer and Reindeer Stratum have all been affected by post-depositional piping or burrowing on Section C to create a series of tunnels within the sediment. At the base of the section is a tunnel lying on the boundary of the Stream Deposit and the overlying Broken Stalagmite Layer. At this point the stalagmite consists of a massive, cracked *in-situ* floor, and the roof of the tunnel has been cut up into it to create an arched profile. It is floored by loose stones and broken glass, which appears at least in part to be to be recent tipped debris.

The largest structure is a complex, branching series of tunnels that can be traced right the way across the top of the section. At its south end a shaft feature connects up to the top of the sediment at a point below the highest part of the roof (figure 3.2.4). At roof level here, a small (too tight for human entry) passage continues sloping gently uphill, the end of which is very close to Chudleigh Rift which lies 2.5 metres almost directly above it (figures 1.1.3, 1.1.4). The shaft feature directly overlies sample columns B and C, and spit 1 of those columns sampled late stage fills (e and f, below) within the shaft. The Reindeer Stratum immediately beneath this shaft shows orange-brown mottling, suggesting it might have been disturbed (figure 3.2.4). The late stage fills and mottled sediment comprising the upper parts of the columns contained significant quantities of animal bone, particularly microfauna. One further tunnel structure is visible about halfway down the Reindeer Stratum in the central part of the section (figure 3.2.5), and again is associated with complex later fills containing bone (e and f, below).

Sediment remnants in the roof in the front plane of the section show that there was a gap between the top of the Reindeer Stratum and the cave ceiling. This might represent the true top of the Reindeer Stratum or could be related to later piping or compaction.

(e) **Tufaceous Stalagmite**

The tunnels in the upper part and middle of the Reindeer Stratum on Section C, are floored by soft tufaceous stalagmite. A stalagmite boss has grown in the shaft feature at the end of the tunnel on the south side of the section (figure 3.2.4). Its base has a sharp contact with the underlying Reindeer Stratum. This boss directly overlies column B, and it was designated as representing spit 1 of column B, with spits 2 and below being in the underlying Reindeer Stratum. The stalagmite itself was not excavated, but removal of the Reindeer Stratum beneath revealed 2 large charcoal fragments embedded in the base of the stalagmite boss, and these were sampled (figure 3.2.8). On the right hand side of the shaft feature the base of the boss pinches out between a layer of Dark Earth (f) and the underlying Reindeer Stratum. The stratigraphic position of the charcoal shows that it is older than both the stalagmite boss and the Dark Earth in this shaft.

In the central part of the section, the tunnel halfway up the Reindeer Stratum is floored by a very soft Tufaceous Stalagmite, which grades up over ~6cm into Dark Earth which part fills the tunnel (figure 3.2.5). The stalagmite encloses an 8cm long angular lump of red clay, which may be a clod kicked up by animal activity. The walls and ceiling of the tunnel are lined by a 1mm thick layer of stalagmite. Other tunnel remnants in the upper part of the central and north side of the section have small stalagmite remnants, but none as well developed as those described above.

Tufaceous Stalagmite floors are also present in the roof remnants in the front plane of the section. In the central part of the section here, Simons (2010) recorded a sequence of Reindeer Stratum, overlain by stalagmite, Dark Earth (called by him the Frog Stratum) and topped by another stalagmite. We were able to confirm this basic sequence, though the relevant section has been cut back by excavation and erosion and now lies 0.55 metre further back towards the rear face (figure 3.2.6). Simons reported further complexity here, suggesting that two floors were present between the Reindeer Stratum and his Frog Stratum. This could not be confirmed: numerous small limestone blocks are present here, some of which are completely encased in stalagmite, and it is possible that without the benefit of modern electric floodlighting, one of these might have been mistaken for a thick stalagmite.

(f) **Dark Earth**

Dark Earth is present in a number of places on Section C, either infilling tunnels within the Reindeer Stratum, or overlying the Reindeer Stratum in the roof remnants visible in the front plane. Pockets at roof level were designated as Frog Stratum by Simons (2010) but he did not apply this name to all dark earths. In the shaft feature on the south side of the section (figure 3.2.4), Dark Earth is present on the right hand (SW) side of the feature, overlying the basal edge of the Tufaceous Stalagmite boss, and lying directly on Reindeer Stratum towards the wall. Column C was excavated at this point and spit 1 excavated the Dark Earth, with lower spits (2 and below) in Reindeer Stratum. Here the Dark Earth is a crumbly dark brown earth with matrix-supported limestone and stalagmite fragments to 5mm. It has a sharp contact with the Reindeer Stratum, and with the Tufaceous Stalagmite boss.

In the tunnel in the Reindeer Stratum of the central part of Section C (figure 3.2.5), Dark Earth overlies Tufaceous Stalagmite in the tunnel with a much more gradational contact. Here the Dark Earth is very loose with traces of pellets, and matrix supported limestone clasts to 2 cm. Small bones (mostly microfauna but some larger) are abundant. This was sampled for microfaunal recovery as the Section C Dark Burrow Fill (DBF) sample and an adjacent pollen sample taken (0157).

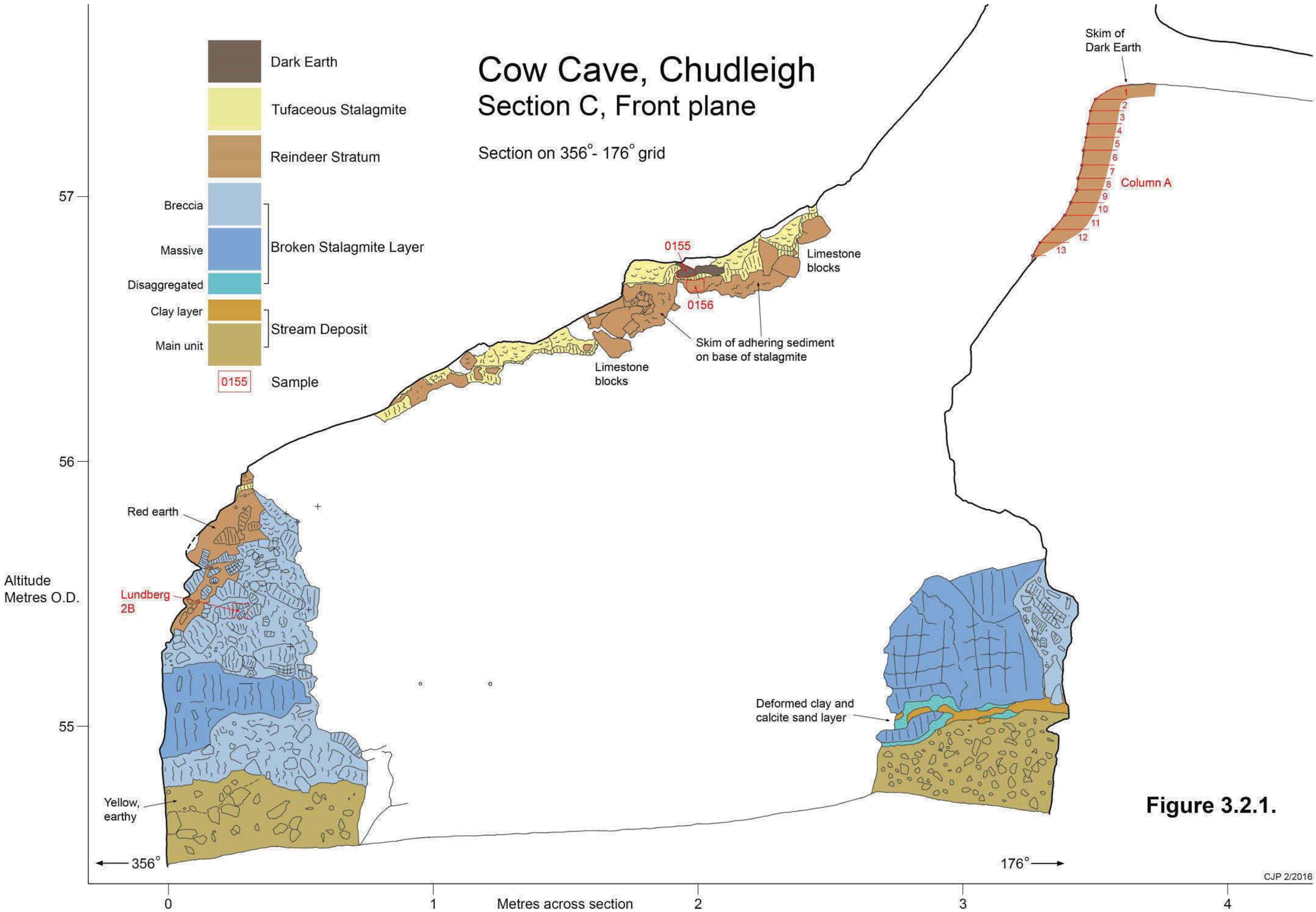
Cow Cave, Chudleigh
Section C, Front plane
Section on 356° - 176° grid
Dark Earth
Tufaceous Stalagmite
Reindeer Stratum
Breccia
Massive
Disaggregated
Broken Stalagmite Layer
Clay layer
Main unit
Stream Deposit
0155
Sample
Altitude
Metres O.D.
57
56
55
Red earth
Lundberg 2B
Yellow, earthy
Limestone blocks
Skim of adhering sediment on base of stalagmite
0155
0156
Limestone blocks
Skim of Dark Earth
Column A
1
2
3
4
5
6
7
8
9
10
11
12
13
Deformed clay and calcite sand layer
356°
176°
0
1
2
3
4
Metres across section
CJP 2/2016

Figure 3.2.1.

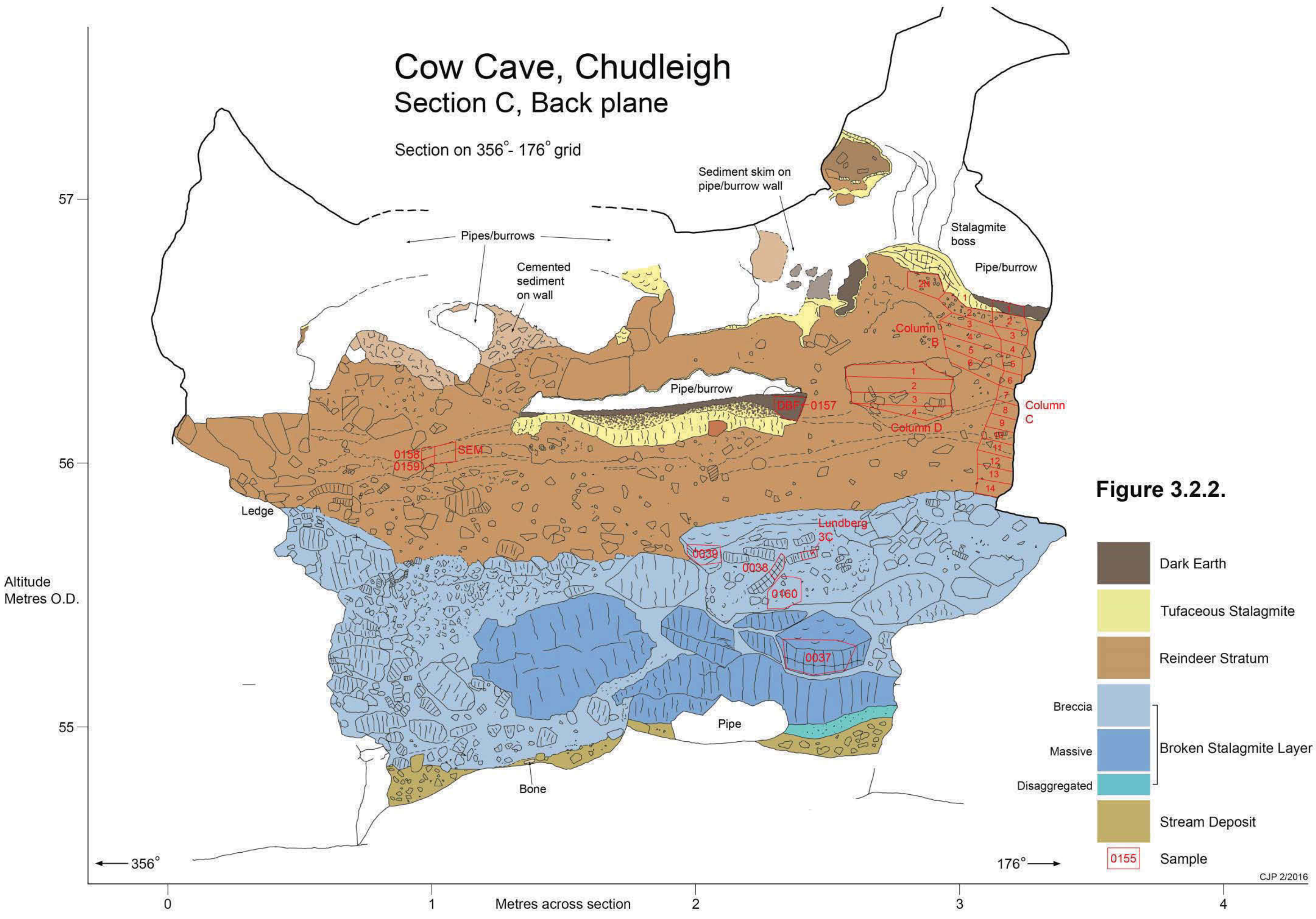
Cow Cave, Chudleigh
Section C, Back plane
Section on 356°- 176° grid
Sediment skim on pipe/burrow wall
Pipes/burrows
Cemented sediment on wall
Stalagmite boss
Pipe/burrow
Pipe/burrow
Column B
Column C
Column D
DBF
0157
0158
0159
SEM
Ledge
Lundberg 3C
0039
0038
0160
0037
Pipe
Bone
Altitude Metres O.D.
57
56
55
356°
176°
0
1
2
3
4
Metres across section
Dark Earth
Tufaceous Stalagmite
Reindeer Stratum
Breccia
Massive
Disaggregated
Broken Stalagmite Layer
Stream Deposit
0155
Sample
CJP 2/2016

Figure 3.2.2.

Figure 3.2.3. Section C, view looking east. 0.5 metre scale.

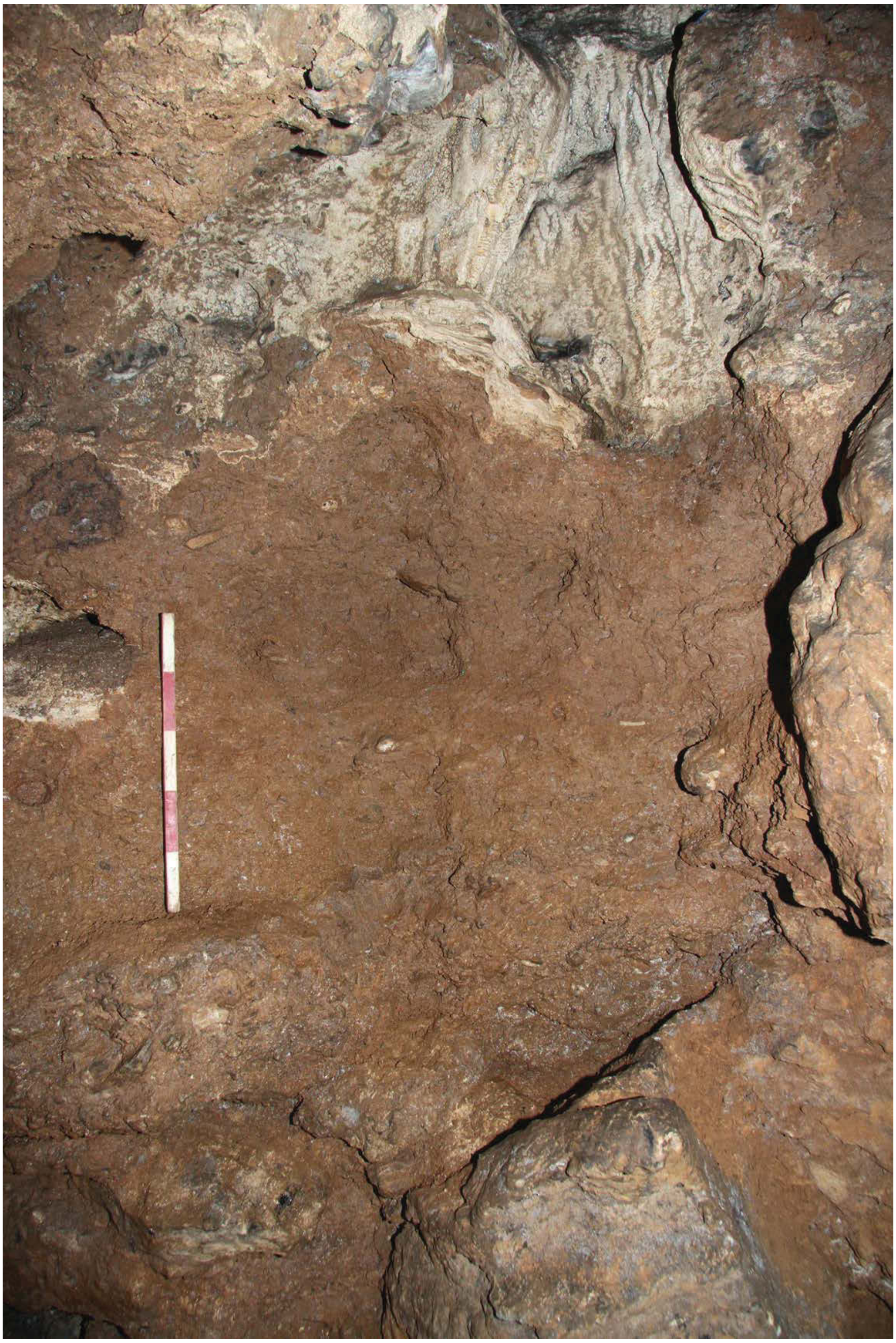

Figure 3.2.4. The south side of Section C, showing overhanging Reindeer Stratum prior to the excavation of columns B-D. The base of the scale bar is resting on the top of the Broken Stalagmite Layer. View looking southeast, 0.5 metre scale.

Figure 3.2.5. Pipe/burrow in the central back plane of Section C, showing partial infill with Tufaceous Stalagmite and Dark Earth. View looking east, 0.5 metre scale.

Figure 3.2.6. Roof remnant of Reindeer Stratum, Dark Earth and Tufaceous Stalagmite 55cm behind the front plane of Section C. View looking east, 10cm scale.

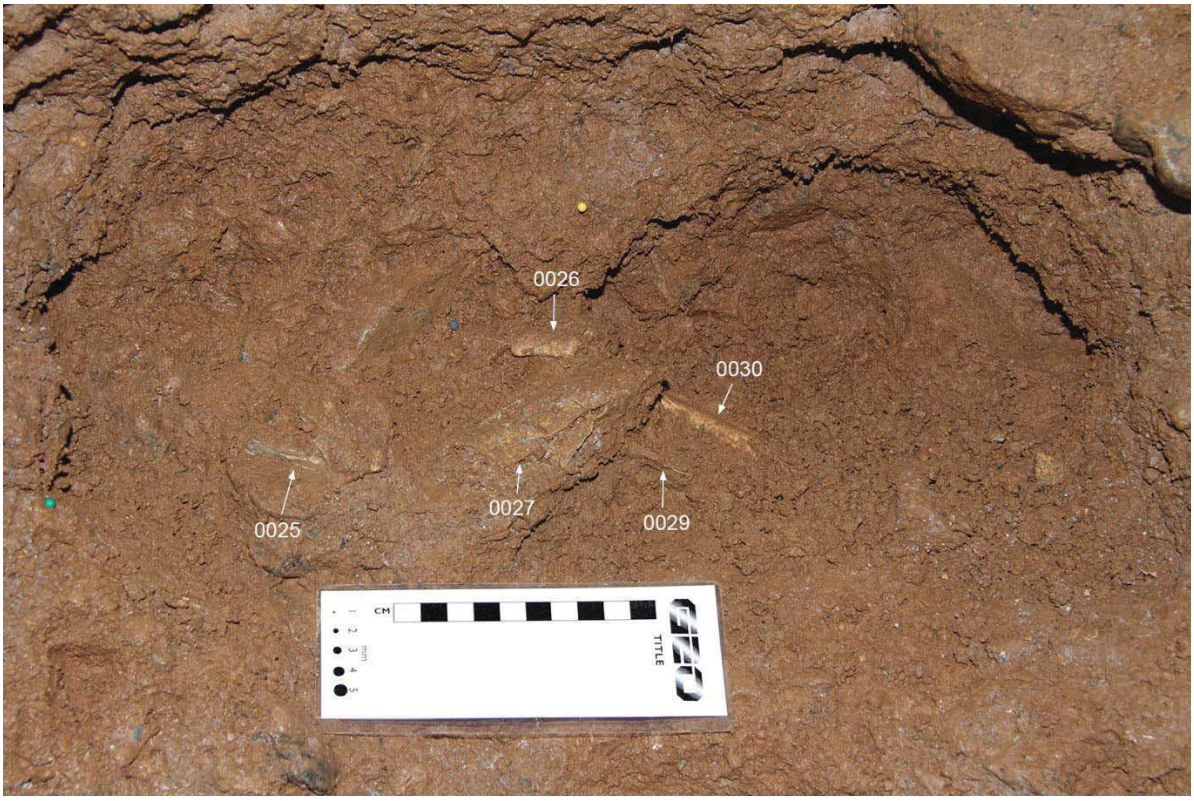

Figure 3.2.7. Bone fragments during excavation of column D spit 3. 10cm scale.

Figure 3.2.8. Base of stalagmite boss in column B spit 1, showing cavity left after excavation of embedded charcoal fragments 003 and 004. 10cm scale.

3.3. The Trench

The trench was excavated across the whole width of the cave passage, at a point between sections A and B. The location was determined by the requirement to locate the grille at the narrowest point of the entrance passage, and to avoid damage to standing sediment sections in installation. Its width and depth were likewise determined by the requirements for fitting the grille, at approximately 25cm deep and wide. The following stratigraphy was recorded.

(a) **Stream Deposit, lower gravel**

This is a very poorly sorted deposit of angular to rounded flint cobbles to 15cm in size, clast to matrix supported in a finer matrix of fine slate gravel to clay. The sediment is orange brown in colour. This unit is quite like the Stream Deposit sediment exposed in the Alcove (section 3.4) but differs from it in having a more gravelly matrix. There is a steep, sharp contact with the overlying upper gravel, which may infill a channel. At the west end of the trench, beneath an earlier trench cut (see (c) Spoil, below) this unit may have been disturbed by earlier excavation.

A small bone fragment was found in this unit at the base of the trench, but no other fauna were recorded.

(b) **Stream Deposit, upper gravel**

This is a yellowish slate gravel with some matrix-supported clasts of angular to rounded flint to 6cm. Some areas of concretion are present. The slate gravel matrix shows a strong horizontal fabric, with larger clasts showing the same orientation. Some weak flint cobble beds are present. No limestone was observed in field section in either the upper or lower gravel. No bone was recovered in field excavation of the upper gravel.

(c) **Spoil**

The uppermost layers recorded in the trench comprise recent spoil dating from the 1927-35 TNHS and 1962-3 Simons excavations. A trench cut along the west wall may be that cut by Simons during 1962-3. This cuts spoil layers extending to the east side of the trench, which can therefore be dated to the earlier excavation. Most of this spoil is brown earth with stones: a broken moulded glass bottleneck in it confirms it dates from a 20th century excavation and not from earlier disturbance. On the east side at the base of the spoil is a hard trample layer of flint and limestone fragments, clast supported in a hard compacted earthy matrix.

Cow Cave, Chudleigh
The Trench

Section on 279°- 099° grid

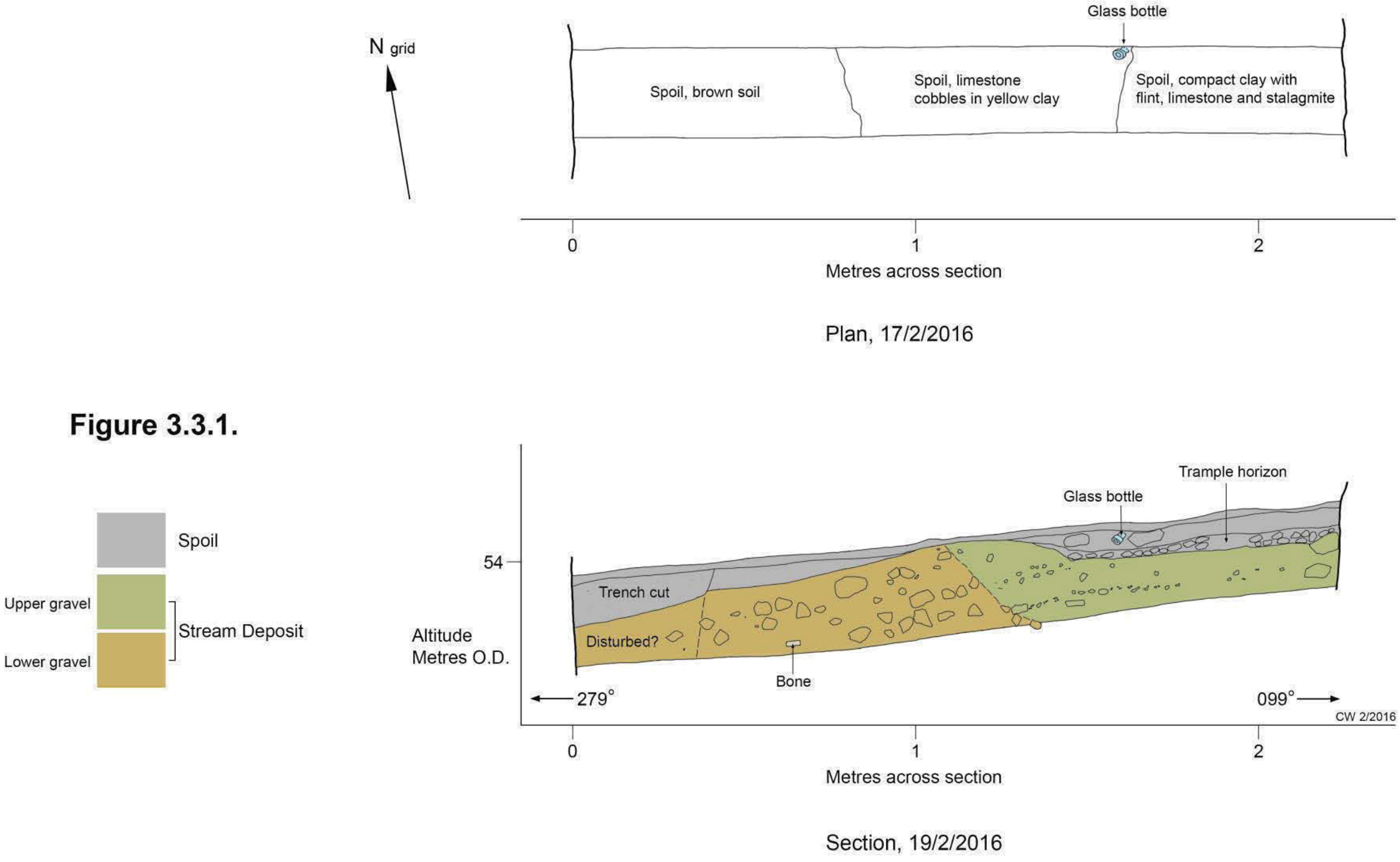

Figure 3.3.1.

Figure 3.3.2. (above) The Trench, view from south. Metre scale.

Figure 3.3.3. (left). East end of the Trench, looking east during excavation. 10cm scale. Stream Deposit, Upper Gravel showing bedding revealed by colour differences and stone lines.

3.4. The south and east walls of the cave.

A series of sediment remnants can be seen on the south side of the cave, running from the south end of Section C, along the south wall of the inner chamber of the cave, and from there along the east wall of the entrance passage. For locations of these sections see figure 3.1.1.

(a) **The Alcove**

The Alcove is a floor level depression on the south wall of the inner chamber of the cave, ~1 metre west of the south end of Section C. A 0.8 metre thick sequence of Stream Deposit sediments is exposed here: this is the best exposure of these sediments normally visible in the cave. The following sequence can be recognised (figure 3.4.1).

Four distinct layers could be distinguished, and are most clearly visible on the left hand (east) side. The basal exposed layer is a bed at least 45cm thick. It is a clast supported deposit of angular to rounded flint cobbles up to 16cm in size; 1 angular limestone slab is also present. The matrix is stiff yellow-brown sand/silt/clay. There are signs of contact imbrication with clasts dipping to the east, implying a westward current flow. A long bone was recovered from this layer. The next bed up is 17cm thick, and is chaotic with perhaps a higher proportion of fine orange-brown matrix. This unit has a strongly bimodal clast size distribution: the fine matrix, and large flint clasts. One 19cm long angular limestone block is present. The next overlying layer, 14cm thick, is similar to the layer immediately below but has a smaller maximum clast size, to ~3.5cm. No limestone was noted. This is overlain by the topmost layer, 12 cm thick. This is a chaotic deposit of subangular to subrounded flint cobbles to 10cm. The layer is clast supported and has a crumbly earth matrix. It is part cemented at the left hand end.

The topmost layer is directly overlain by a massive stalagmite floor which is preserved as an *in situ* remnant spanning the top of the Alcove. This floor lies at the same level as, and can be correlated with, the stalagmite floor which forms the lower part of the Broken Stalagmite Layer in Section C just to the east. It thins and pinches out 1.4 metres to the west of the alcove, marking the furthest point that this floor extends to the west across the cave.

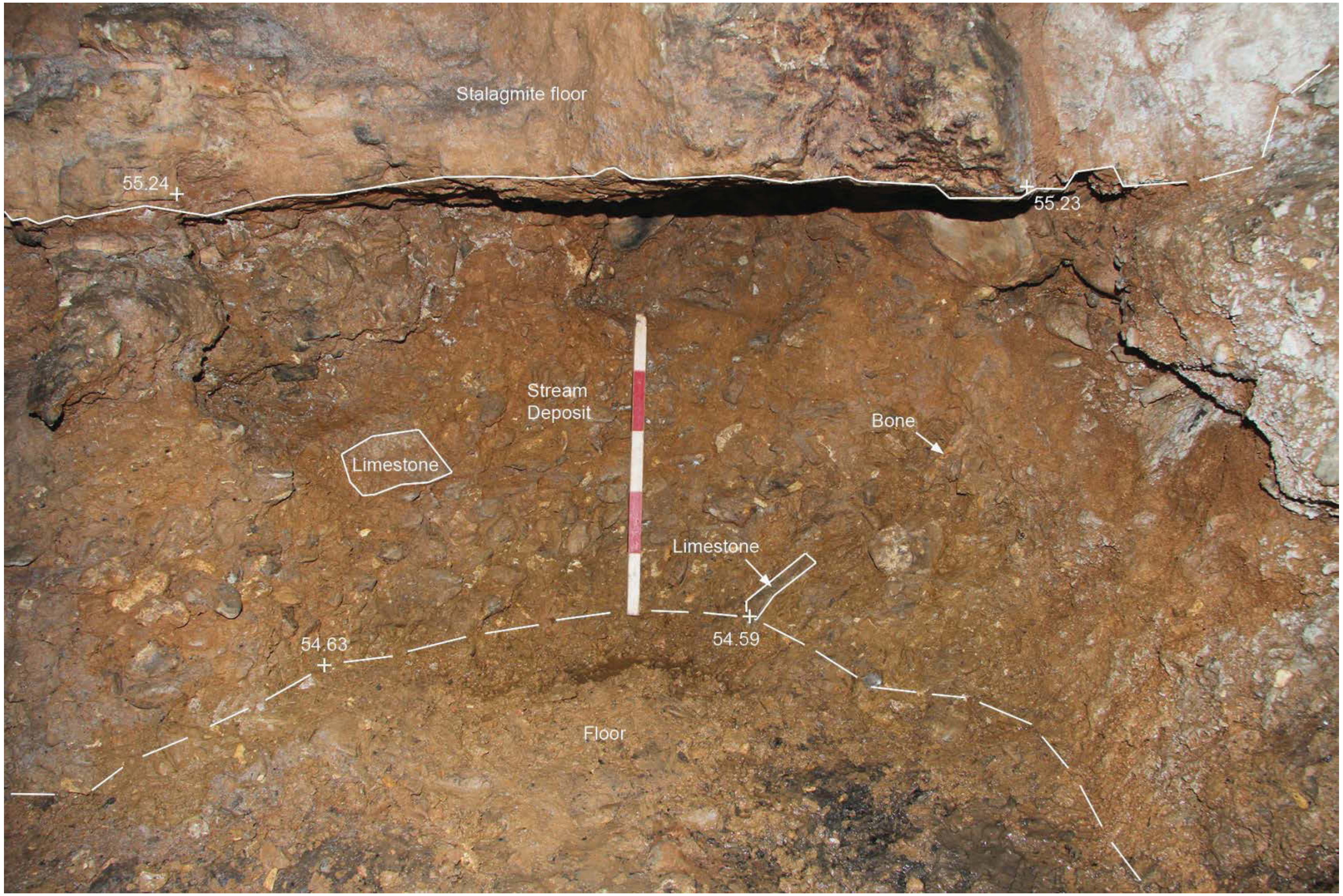

Figure 3.4.1. The Alcove, view looking south. 0.5 metre scale; spot heights in metres O.D.

(b) **The inner chamber south wall**

The full sequence of deposits originally present on this side of the cave is still visible as a series of sediment remnants adhering to the wall. The lower part of the sequence is the Stream Deposit and overlying massive stalagmite floor exposed in the Alcove, and is described in detail above.

Above the stalagmite floor, wall remnants consist of orange-brown Reindeer Stratum cave earth, which represent the extension of the column A remnant to the west (figure 3.4.2). From column A the highest sediment remnants slope down to the west, probably marking the slope of the original top of the deposit. In one place it is capped by a thin stalagmite floor. Elsewhere, remnants of Dark Earth are present. These are less dark than in Section C, and may represent a mixture of Dark Earth and Reindeer Stratum sediment. Where it lies directly on Reindeer Stratum a transition zone of mixed sediment is present. A patch of this material was found to be very rich in microfauna and was sampled as the south wall Microfaunal Bone Cluster (MBC) sample.

(c) **The ledge**

At the western end of the south wall is a wide ledge about 1.6 metres above the floor (figure 3.4.3). Lying on the ledge is a very dirty remnant of stalagmite (possibly marking a further extension of the floor spanning the Alcove), overlain by a breccia of limestone blocks in an orange brown earthy matrix. On the overhanging wall above is another remnant of cemented breccia, again consisting of limestone blocks in an orange brown matrix. This has been partly covered by a fake cave painting. Both the upper and lower remnants can be correlated with the Reindeer Stratum.

(d) **The entrance passage east wall**

The same ledge can be traced along the east wall of the entrance passage as a much narrower feature, extending most of the way to the cave entrance (figure 3.4.4). From the grille, sediment remnants can be traced for 7 metres towards the entrance. These consist of very dirty Reindeer Stratum type cemented breccia with limestone clasts in an orange brown earthy matrix. On the wall above is a stalagmite remnant; it is unclear whether this marks the original top of the breccia or is a much older relic feature.

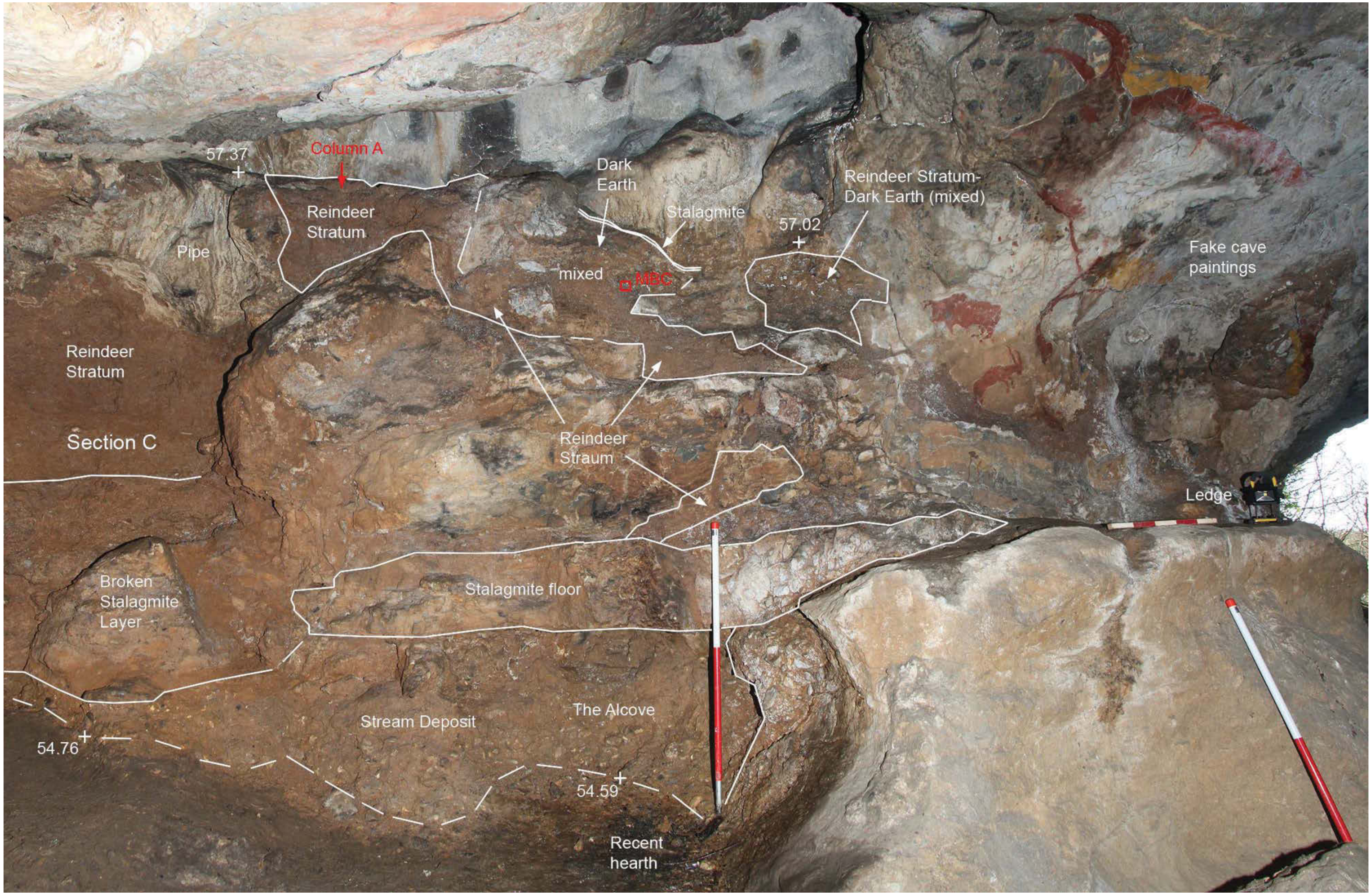

Figure 3.4.2. The inner chamber south wall, view looking south. 1 metre scale; spot heights in metres O.D. MBC = Microfaunal Bone Cluster sample.

Figure 3.4.3. The Ledge sediment remnants, view looking southeast. 0.5 metre scale; spot heights in metres O.D.

Figure 3.4.4. The entrance passage east wall remnants, view looking east. Scale bars 0.5 metre; spot height in metres O.D.

3.5. The north and west walls of the cave

From the north end of Section C, a sediment remnant extends most of the way along the north wall of the inner chamber of the cave. Another small remnant lies in the NW corner. There is a standing sediment face on the west side of the inner chamber (Section B of Simons, 2010), and from that point, another standing section (Simons' Section A) extends along the west side of the entrance passage to within 8 metres of the entrance. For locations of these sections see figure 3.1.1.

(a) **The north wall**

The north wall remnant forms an extension from the north side of Section C, extending for 3.7 metres along the north wall. At its eastern end the Stream Deposit is visible at the base of the section, but to the west it is obscured by heaped spoil on the floor. Close to roof level are a series of crystalline stalagmite remnants which are probably correlative with the Broken Stalagmite Layer in Section C. On the wall above the Stream Deposit is a dirty cemented breccia with limestone and stalagmite clasts and brown matrix. This covers broken faces of the stalagmite floor in places, and together with the presence of abundant stalagmite clasts in the breccia, suggest that it postdates the stalagmite floor. Just below the roof is a soft red brown earth which clearly correlates with similar soft earths in the Reindeer Stratum on the north side of Section C. The breccia is also probably correlative with the Reindeer Stratum.

(b) **The NW corner**

In the NW corner of the inner chamber, between the north wall remnant and Section B, is a small remnant of cemented breccia, comprising limestone clasts in a yellow-brown matrix. It is overlain by a thin stalagmite.

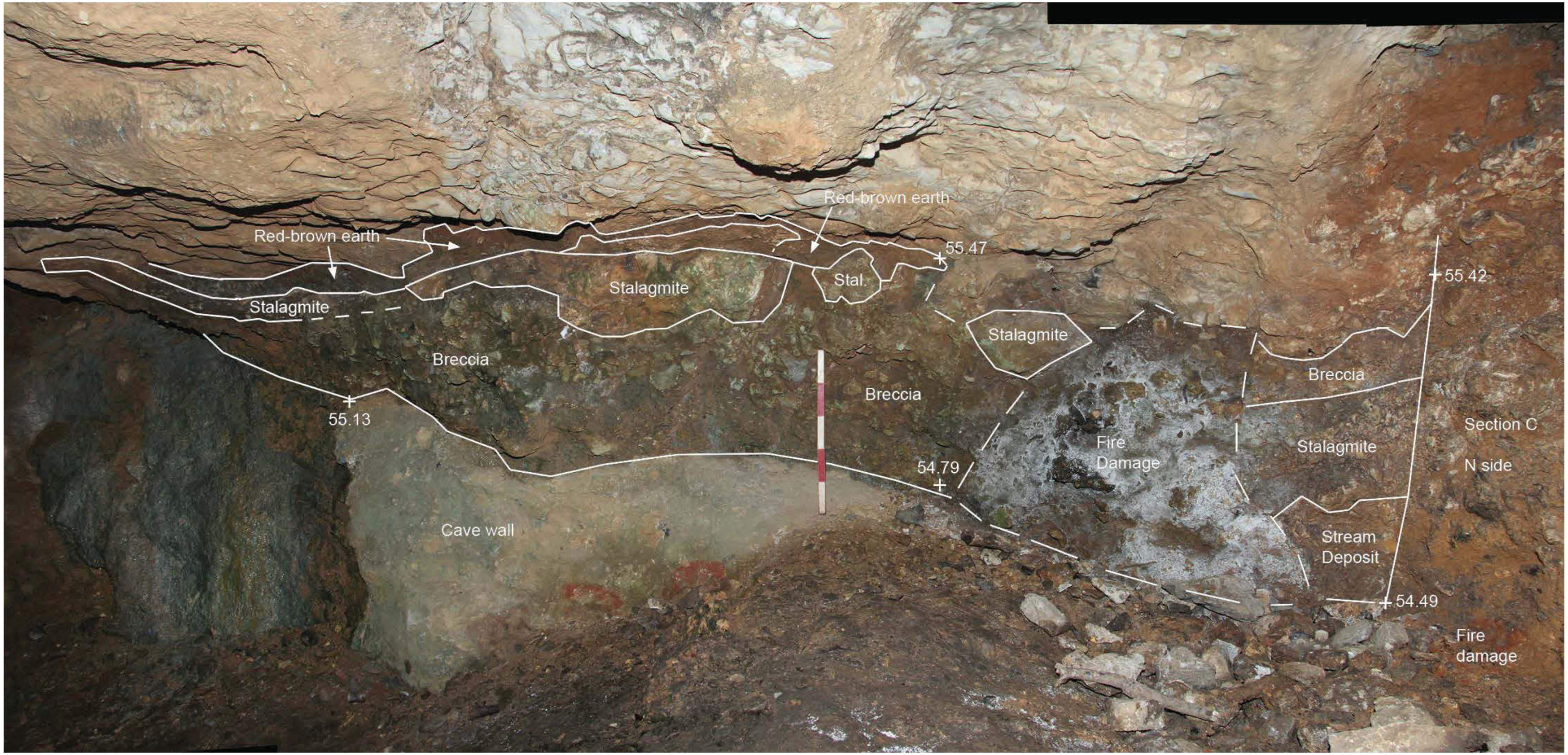

Figure 3.5.1. The north wall sediment remnant, view looking north. 0.5 metre scale; spot heights in metres O.D.

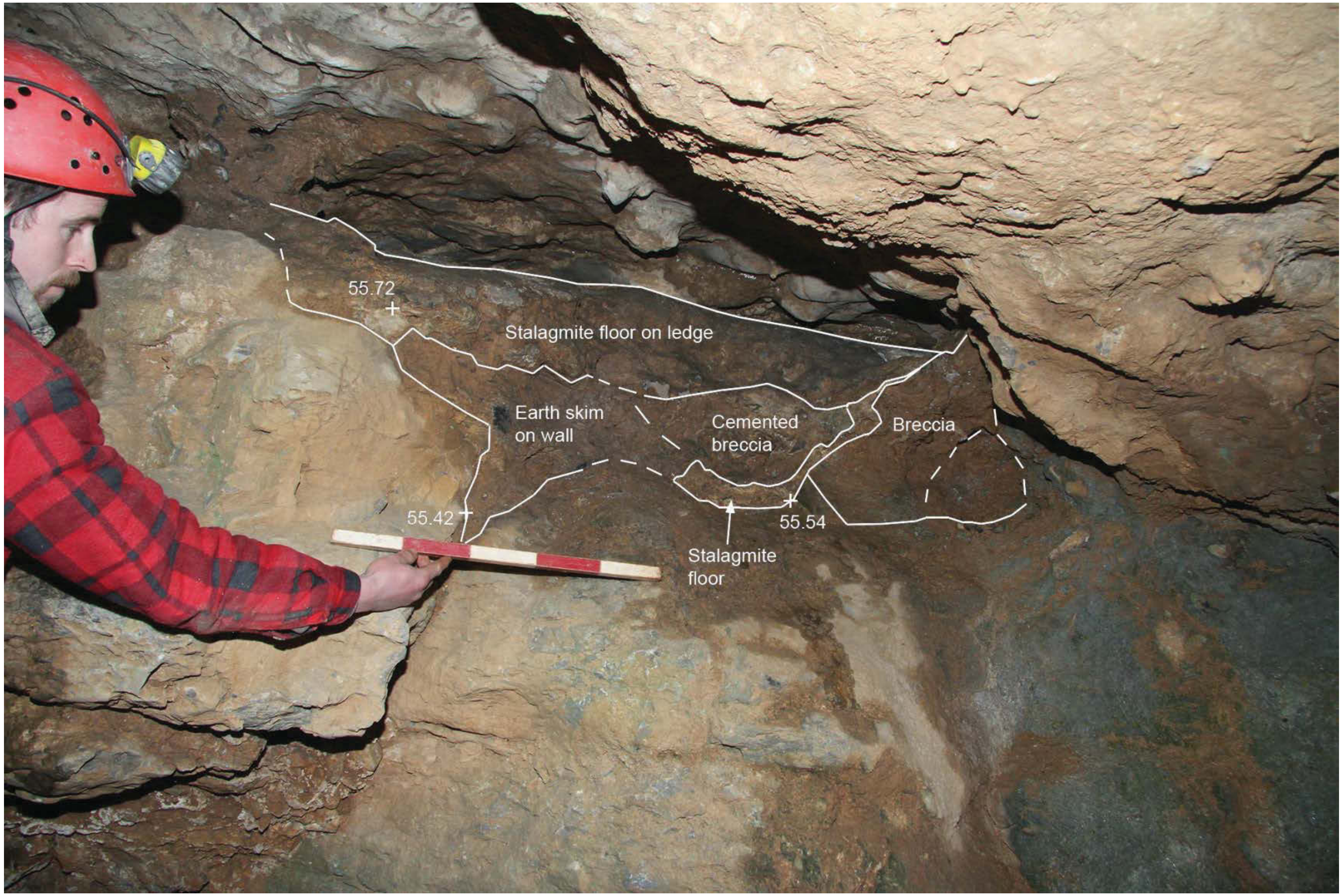

Figure 3.5.2. The NW corner sediment remnant, view looking west. 0.5 metre scale; spot heights in metres O.D.

(c) **Section B**

This is one of the main sections excavated by Jim Simons in1962-3. He made a section drawing then which is reproduced in Simons (2010), figure 4. The section is within reach of daylight and is now heavily encrusted by algae. Without cleaning it was impossible to distinguish any further details beyond those already recorded by Simons although it is clear that the section recorded by him remains intact (figure 3.5.3).

The lower part of the section comprises Stream Deposit flint gravels. These are overlain by Reindeer Stratum, here represented by a breccia with limestone and occasional stalagmite clasts in an orange brown earth matrix. On the south (left) side of the section the contact with the Stream Deposit below is sharp. To the north, this contact becomes more diffuse, in what Simons terms the “Transition Zone”. He suggested this might be the local correlative of the Broken Stalagmite Layer of Section C. The section is currently too dirty to adequately address this question without cleaning. From the north side of Simon’s section B, the standing face extends a further 3.3 metres to the NE. This section is also dirty, but shows a similar stratigraphy, with Stream Deposit flint gravels overlain by Reindeer Stratum breccia with limestone and some flint clasts in an orange brown matrix.

At the north end of Simon’s excavated Section B face a fire has been set against the standing face. The sediment here has been baked and strongly reddened.

(d) **The Section A-B high level remnant**

This small sediment remnant lies just below roof level and spanning the short gap between Sections B and A. It consists of a cemented breccia, with limestone clasts in a brown earthy matrix (figure 3.5.4). The breccia is capped by a dirty tufaceous stalagmite floor. Against the wall and running around the base of the breccia remnant is a pipe or burrow lined with a thin layer of tufaceous stalagmite.

(e) **Section A**

Like Section B, this was excavated and recorded by Simons (2010, figure 4). It is well within reach of daylight and is very dirty and encrusted with algae now (figure 3.5.5). This section has also remained largely intact though some recent damage has occurred (see below).

The section is broadly similar to Section B with a basic stratigraphy of Stream Deposit flint gravels, overlain by Reindeer Stratum earthy breccia with limestone clasts. Simons also recognised a stalagmite floor overlain by further breccia. It is unclear whether the floor is part of the breccia sequence or whether it might represent an ancient relic feature predating the breccia above and below.

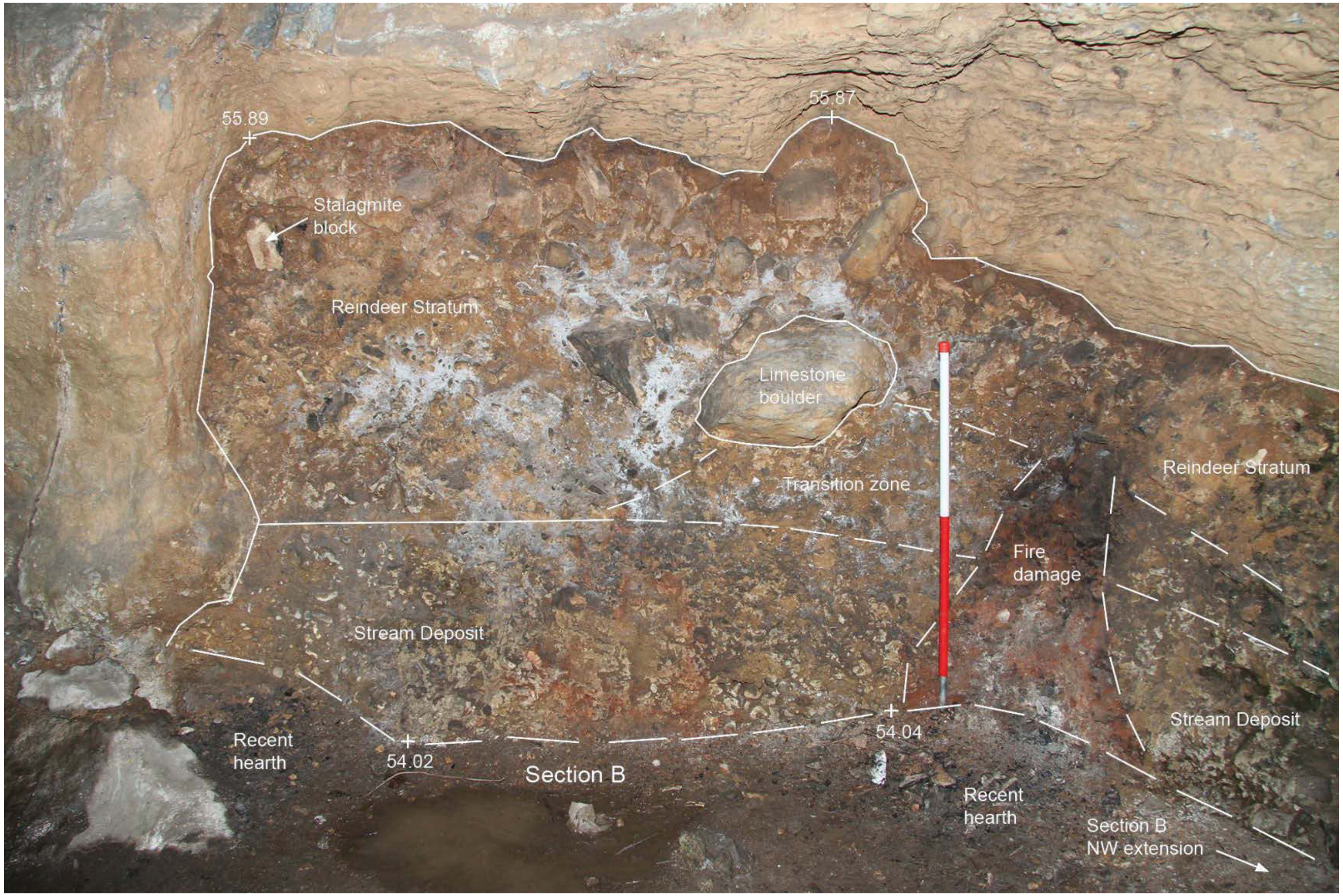

Figure 3.5.3. Section B, view looking west. 1 metre scale; spot heights in metres O.D.

Figure 3.5.4. The Section A-B high level sediment remnant, view looking west. 0.5 metre scale; spot heights in metres O.D.

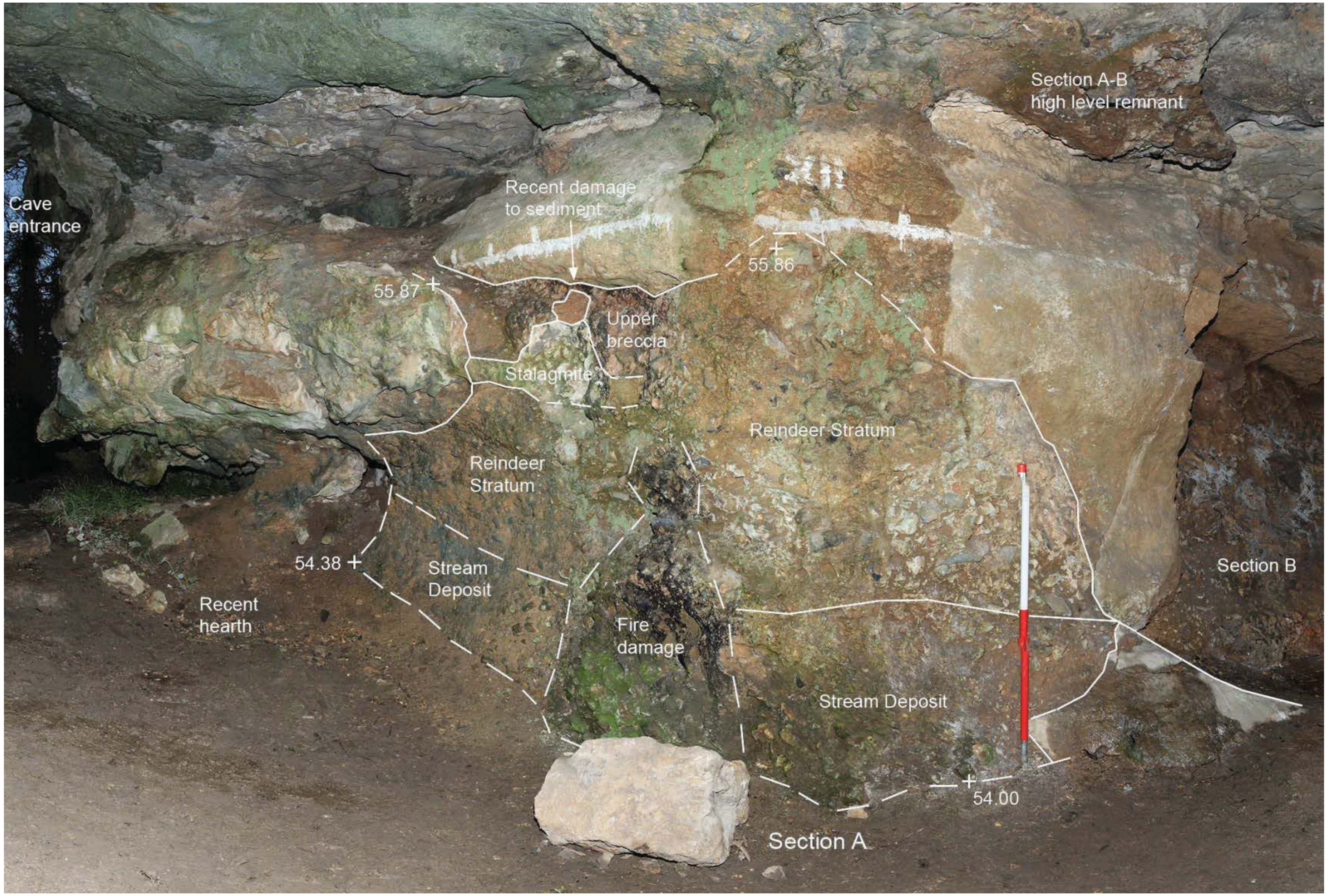

Figure 3.5.5. Section A, view looking west. 1 metre scale; spot heights in metres O.D.

Damage was noted to the breccia above the stalagmite floor. At first sight this looked possibly natural but close inspection revealed a chisel mark, and there is no doubt that it is the result of deliberate vandalism. The section lies outside the grille and a fire was set close to the section shortly after completion of the excavation in spring 2016, fortunately without damage.

3.6. The cave roof

The first four metres of the cave roof inward from the entrance has suffered massive collapse. However no sign of any collapse blocks survive on the floor here, probably because of later quarrying. Over most of the length of the cave, the roof is a solutionally rounded surface with phreatic roof pockets. This indicates that it has been stable with no roof collapse since the cave's formation.

Sediment remnants are absent on the roof in most places, except from within the inner chamber close to Section C. At section C, the top of the Reindeer Stratum and overlying Tufaceous Stalagmite and Dark Earth come into contact with the roof: these have been described above (section 3.2). One further roof remnant is present 2 metres to the west of Section C. It consists of orange brown Reindeer Stratum earth with limestone fragments, overlain by a thin layer of tufaceous stalagmite (figure 3.6.1).

Figure 3.6.1. The inner chamber roof remnant, view looking east. 0.5 metre scale; spot heights in metres O.D.

3.7 Interpretation of the field sections.

The cave and its deposits preserves a record that implies a long history of deposition and significant environmental change.

The form of the exposed cave walls and roof, with rounded surfaces and phreatic roof pockets, implies that when the cave originally formed it was below the water table, and filled to the roof with water. The Stream Deposit shows characteristics including well defined bedding, good sorting of some beds, clast support and imbrication that suggest it was deposited by a stream. The clast lithology, dominated by flint and slate, is consistent with deposition by a stream which brought in sediment from outside the cave. The texture of the deposit varies substantially between beds with most units dominated by flint gravel, but the upper unit in the Trench containing larger amounts of slate. This might result from variations in proportions of these different materials entering the cave, but is as likely to result from variations in stream depth and flow velocity depositing larger and smaller clasts on different sides of the passage. In the alcove the Stream Deposit has a clearly bimodal clast size distribution, which can be attributed to deposition of coarse flint gravel by the stream, followed by later infiltration of fine sediment as the stream dried out, or by later colluvial processes. The top of the Stream Deposit lies well below the roof, suggesting that by the time it was deposited, the water table may have fallen with air space in the upper part of the passage. In the alcove, contact imbrication suggests flow towards the west, suggesting it flowed out from the back of the cave.

The massive stalagmite floor that forms the lower part of the Broken Stalagmite Layer in Section C, and the correlative floor remnant spanning the Alcove, represents a significant change of conditions. The cave must have been dry for the stalagmite to accumulate, and growth of a massive floor implies a warm, interglacial climate (Ford & Williams, 1989, page 362). The upper part of the Broken Stalagmite Layer in Section C consists mostly of fragments of much thinner stalagmite floors which might have grown in shorter, interstadial periods. The brecciation of this entire layer may have been caused by freezing during a period of cold climate; although it has been brecciated it shows no evidence of having moved very far and the underlying Stream Deposit and the massive lower part of the stalagmite floor remain *in situ*, suggesting that collapse was not the cause of the break-up. Finally, following brecciation, the top surface of the Broken Stalagmite Layer was recemented, suggesting the return of warmer conditions.

The Reindeer Stratum has features including very poor sorting, loose earthy matrix, and angular clasts dominated by local materials including limestone and stalagmite, that indicate that it is a typical cave earth deposited by colluvial processes including collapse, soil creep, minor debris flows and wash. Although the deposit contains a high proportion of limestone blocks these cannot have come from the cave roof in the passage now accessible, which shows no sign of collapse. These blocks must be derived from elsewhere in the cave system, probably the high level gull fissures which intersect the roof of the main cave passage just beyond the present choked end on the cave (figures 1.1.3, 1.1.4). The top of the Reindeer Stratum seen in Section C and nearby sediment remnants slopes up to the back of the cave on the south side of Section C. Here a roof level fissure has been surveyed to within 2.5 metres of a gull fissure in Chudleigh Rift above. This provides strong evidence that the Reindeer Stratum of Section C entered the cave through these gull fissures. The slope of the top of the deposit down to the west from the south side of Section C across the inner chamber, suggests that in the inner part of the cave this was the main source of sediment. In Section C itself, the sequence is thickest on the south side where it is quite loose and disordered with some layers clast supported, typical of colluvial sediment deposited by soil creep, collapse and minor wash. To the north it thins and more organised, coloured layers appear which suggest that on the downslope parts of the Reindeer Stratum debris pile, wash may have been a more significant sedimentary process. The deposit is not climatically diagnostic; cold climate cave earths are known in many British caves, but apparently similar deposits are still accumulating today in some Devon caves.

The tunnels and possible evidence of eluviation within the sediments show that they have been considerably affected by post-depositional erosive processes. The lowest of these tunnels lies at the base of Section C on the boundary of the Stream Deposit and the overlying Broken Stalagmite Layer. At this point the stalagmite consists of a massive, cracked *in-situ* floor, and the roof of the tunnel has been cut up into it to create an arched profile. This strongly suggests that this low level structure is a pipe eroded by percolating water which dissolved the stalagmite roof to create a typical arched solutional tube. Higher in the Section C sequence are the tunnels within the Reindeer Stratum, which are connected via a shaft feature to the same roof level fissure that leads up into the gulls and has already been discussed in relation to the source of the Reindeer Stratum. This fissure would have been a likely entry point for water draining down from Chudleigh Rift during rainstorms; the position of the shaft feature directly below suggests that these upper tunnels might also have been formed at least in part by piping. However they also contain a lot of bone, and an angular clay clast observed in the tunnel in the in the middle of Section C appears to be a kick-up clast left by an animal (it is difficult to explain by any purely physical process). These features point to significant animal activity in the tunnels and they could in part or largely be burrows excavated by animals.

During the excavation, it was noted that heavy rain caused considerable amounts of water to drip through into the cave within a day after rainfall. A seep occurred from the Stream Deposit in the Alcove after rain, and this might be related to an active pipe.

The Tufaceous Stalagmite and Dark Earth can be seen to infill the tunnels in several places and thus postdate them. Both the stalagmite and the dark, organic rich sediment suggest deposition in a warm climate regime. Simons (2010) treated them as chronostratigraphic units in the roof level exposure in Section C. In any small area they can be treated as such, but in different exposures the precise sequence of Tufaceous Stalagmite and Dark Earth varies in a complex fashion. These relationships are most easily explained by assuming that the two units are contemporaneous, with local factors determining whether one or the other was deposited at any one place and time.

Previous workers (Beynon, 1932; Simons, 2010) have noted that the bulk of the deposits had been removed from the cave before any archaeological excavation commenced. Both concluded, doubtless correctly that this was related to quarrying activity in historical times (possibly dated by a coin of William and Mary reported by Beynon, 1932); there is no evidence in the cave of any natural process which could so thoroughly have cleared out the sediments. As already noted, collapse at the entrance should have produced a boulder pile there which has probably been removed by quarrymen. A limestone quarry lies only 40 metres to the west and any loose limestone boulders would have made tempting material for the limekiln. The name of the cave may provide a further clue to the reasons for this clearing out, implying as it does the use of the cave to shelter animals.

4. Analysis

4.1 Sample columns and other samples taken.

Bulk samples are listed in table 4.1.1. Four sample columns were excavated in the Reindeer Stratum of Section C (section 3.2; Figures 3.2.1, 3.2.2, 4.1.1). All sample columns were excavated in 5cm spits. These were:

Column A: the uppermost part of the Reindeer Stratum in the high level sediment remnant on the south wall of the inner chamber, above the south side of Section C. 13 spits.

Column B: the overhanging, uppermost remaining part (in this location) of the Reindeer Stratum on the south side of Section C, directly under a shaft feature within the Reindeer Stratum. This column was immediately adjacent to Column C and the (unexcavated) stalagmite boss partially filling the shaft at the top of the column was designated Spit 1, to maintain as nearly as possible stratigraphic equivalence with Column C. 6 spits.

Column C: overhanging to vertical Reindeer Stratum on the south side of Section C, immediately adjacent to Column B. The top spit of this column was a dark earth flooring the same shaft structure seen above column B, and is stratigraphically younger than the stalagmite boss at the top of Column B. 14 spits.

Column D: a column of 4 spits excavating a loose patch of Reindeer Stratum, immediately below Column B. This area had been a major source of collapse over recent years and is rich in bone, but its stratigraphic relationship to the intact Reindeer Stratum around it was considered to be unclear as it might represent a pipe/burrow fill, hence it was sampled separately.

Further samples were taken of the Stream Deposit gravels exposed in the Trench, and for recovery of microfauna. The latter included the Dark Burrow Fill (DBF) sample from the central pipe/burrow on Section C; and the Microfaunal Bone Cluster (MBC) sample from the south wall of the inner chamber. Lastly, a sample was taken of the red and yellow banded Reindeer Stratum sediment on the back plane of Section C for SEM analysis. Apart from the SEM block, the bulk samples were flotated/wet sieved through 4mm; 2mm; 500 micron and 250 micron sieves. The residues were then picked for recovery of artefacts, vertebrate bone, molluscs, and other archaeologically significant material. Flint and chert, bone fragments and microfauna and molluscs were recovered and retained for examination by the relevant specialists (Sections 4.3 – 4.8). The only other material recovered was organic material in the form of small plant rootlet fragments, and a dead beetle. All were considered to be of probable recent origin and were not examined further: the beetle in particular came from spit 2 of column A, a location very likely to be affected by intrusion of recent material. Following picking for archaeological materials the residues were examined for lithological analysis (section 4.2).

Individual finds including bone, charcoal and stalagmite samples are listed in table 4.1.2. These include bone and charcoal excavated in the sample columns and the Trench. Two further bone fragments were collected from Section C and the Alcove. The stratigraphic complexity identified in the Broken Stalagmite Layer posed problems that necessitated sampling of this part of the sequence for U-Th dating and pollen analysis: these are also listed on table 4.1.2.

Pollen samples are listed in table 4.1.3. Samples were taken from Columns A and C, at 2.5cm resolution (tied in with the spit samples). Pollen samples were also taken from the sediment immediately surrounding bones, and from roof remnants above the middle of section C. Further spot samples were taken at locations inside and outside the cave for taphonomic study.

Materials selected for dating included charcoal, and bones from the Reindeer Stratum and Dark Earth which were submitted to the University of Oxford Radiocarbon Accelerator Unit for ^{14}C dating. For details of the samples selected see sections 4.4, 4.5 and 4.7; dating results are given in section 4.9. Stalagmite samples were submitted to the Bristol Isotope Group, University of Bristol for U-Th dating. For details of the samples selected see section 3.2 and table 4.1.2; dating results are given in section 4.10.

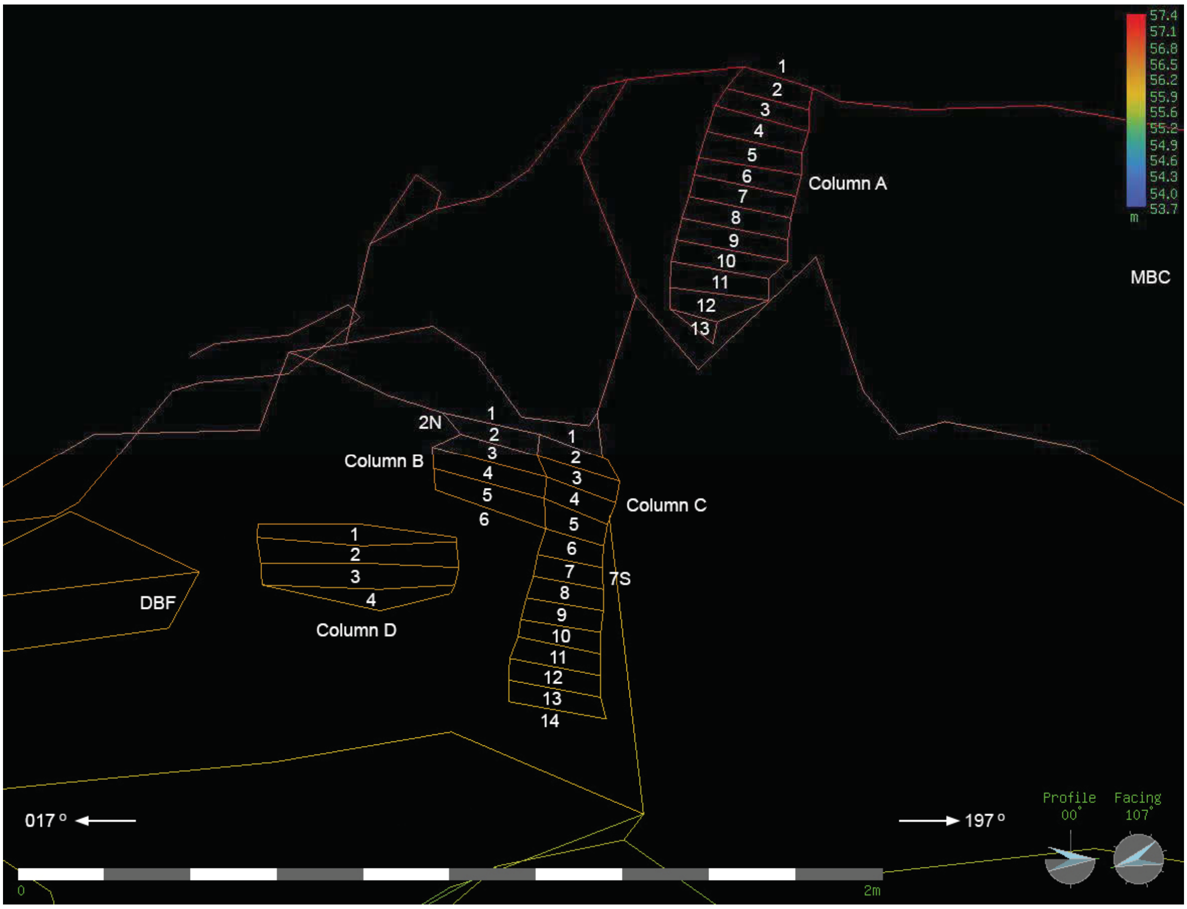

Figure 4.1.1. Section C sample columns, elevation from the EDM data Survex model (Appendix 2). Heights in metres O.D.

Name	Description	EDM nos	Date
Column A spit 1	Lithological/faunal sample	217, 218	18/02/16
Column A spit 2	Lithological/faunal sample	217, 218, 219, 220	18/02/16
Column A spit 3	Lithological/faunal sample	219, 220, 221, 222	18/02/16
Column A spit 4	Lithological/faunal sample	221, 222, 223, 224	18/02/16
Column A spit 5	Lithological/faunal sample	223, 224, 225, 226	18/02/16
Column A spit 6	Lithological/faunal sample	225, 226, 227, 228	18/02/16
Column A spit 7	Lithological/faunal sample	227, 228, 229, 231	18/02/16
Column A spit 8	Lithological/faunal sample	229, 230, 231, 232	18/02/16
Column A spit 9	Lithological/faunal sample	230, 232, 233	18/02/16
Column A spit 10	Lithological/faunal sample	233, 234, 235	18/02/16
Column A spit 11	Lithological/faunal sample	234, 235, 238	18/02/16
Column A spit 12	Lithological/faunal sample	236, 238, 239	18/02/16
Column A spit 13	Lithological/faunal sample	236, 237, 239	18/02/16
Column B spit 1	Stalagmite, not sampled	241, 246	15/02/16
Column B spit 2	Lithological/faunal sample	241, 242, 246, 247	15/02/16
Column B spit 3	Lithological/faunal sample	242, 243, 247, 248	15/02/16
Column B spit 4	Lithological/faunal sample	243, 244, 248, 249	15/02/16
Column B spit 5	Lithological/faunal sample	244, 245, 249, 250	15/02/16
Column B spit 6	Lithological/faunal sample	245, 250	15/02/16
Column B spit 1 north	Stalagmite, charcoal sampled	345-352	16/02/16
Column B spit 2 north	Lithological/faunal sample	240, 241	15/02/16
Column C spit 1	Lithological/faunal sample	246, 259	15/02/16
Column C spit 2	Lithological/faunal sample	246, 247, 259, 260	15/02/16
Column C spit 3	Lithological/faunal sample	247, 248, 260, 261	15/02/16
Column C spit 4	Lithological/faunal sample	248, 249, 261, 262	15/02/16
Column C spit 5	Lithological/faunal sample	249, 250, 262, 263	15/02/16
Column C spit 6	Lithological/faunal sample	250, 251, 263, 264	16/02/16
Column C spit 7	Lithological/faunal sample	251, 252, 264, 265	16/02/16
Column C spit 8	Lithological/faunal sample	252, 253, 265	16/02/16
Column C spit 9	Lithological/faunal sample	253, 254, 266	16/02/16
Column C spit 10	Lithological/faunal sample	254, 255, 266	16/02/16
Column C spit 11	Lithological/faunal sample	255, 256	16/02/16
Column C spit 12	Lithological/faunal sample	256, 257, 268	16/02/16
Column C spit 13	Lithological/faunal sample	257, 258, 267, 268	16/02/16
Column C spit 14	Lithological/faunal sample	258, 267	16/02/16
Column C spit 7 south	Lithological/faunal sample	264, 265	16/02/16
Column D spit 1	Lithological/faunal sample	269, 272, 275	17/02/16
Column D spit 2	Lithological/faunal sample	269, 270, 272, 273, 275, 276	17/02/16
Column D spit 3	Lithological/faunal sample	270, 271, 273, 274, 276, 277	17/02/16
Column D spit 4	Lithological/faunal sample	271, 274, 277	17/02/16
Section C, SEM block	SEM block	Plotted on section	19/02/16

		drawing	
Section C, Dark Burrow Fill	Lithological/faunal sample	Plotted on section drawing	19/02/16
Inner chamber S. wall, Microfaunal Bone Cluster	Lithological/faunal sample	Plotted on section photo	19/02/16
Trench, Upper gravel	Lithological/faunal sample	Plotted on section drawing	19/02/16
Trench, Lower gravel	Lithological/faunal sample	Plotted on section drawing	19/02/16

Table 4.1.1. List of bulk samples (including sample columns). Samples were sieved through a standard sieve stack, for clast lithological analysis and recovery of vertebrate microfauna, molluscs, artefacts and other archaeologically significant material. 1 further sample block was taken for SEM analysis.

Number	Description	Location	EDM no.	Date
0001	Small piece of charcoal	Column B spit 5	278	15/02/16
0002	Small fragment of bone	Column B spit 4	279	15/02/16
0003	Large charcoal fragment, cemented into base of stal boss, touching 0004	Column B spit 2N	345-348	16/02/16
0004	Large charcoal fragment, cemented into base of stal boss, touching 0003	Column B spit 2N	349-352	16/02/16
0005	Bone, possibly tooth enamel fragment	Column B spit 2N	369	15/02/16
0006	Bone fragment	Column C spit 4	438	15/02/16
0007	Bone fragment, 5cm long	Column C spit 4	439, 440	15/02/16
0008	Bone fragment	Column C top of spit 5	441	15/02/16
0009	Bone fragment	Column C spit 4	466	15/02/16
0010	Bone fragment	Column C spit 5	487, 488	15/02/16
0011	Bone fragment	Column C spit 5	489	15/02/16
0012	Bone fragment cemented into breccia, Stream deposit/Stal breccia junction	Section C Stream Deposit top	491-2, 494-5	16/02/16
0013	Small bone, microfauna, Stream Deposit	Alcove	497	16/02/16
0014	Bone epiphysis	Column C spit 6	498	16/02/16
0015	Bone fragment	Column C spit 6	499	16/02/16
0016	Large bone fragment, end of long bone	Column C spit 6	500, 501	16/02/16
0017	Bone fragment	Column C spit 7	502	16/02/16
0018	Bone fragment	Column C spit 7	503	16/02/16

0019	Bone fragment	Column C spit 13	505	16/02/16
0020	Bone fragment	Column D spit 1	624	17/02/16
0021	Bone fragment	Column D spit 1	625	17/02/16
0022	Bone fragment	Column D spit 1	649	17/02/16
0023	Rib bone	Column D spit 2 (-3)	650, 651	17/02/16
0024	Bone fragment	Column D spit 3	669	17/02/16
0025	Bone fragment	Column D spit 3	670. 671	17/02/16
0026	Bone fragment	Column D spit 3	672, 673	17/02/16
0027	Large shattered bone fragment	Column D spit 3	674, 675	17/02/16
0028	Bone fragment	Column D spit 3	706, 707	17/02/16
0029	Bone	Column D spit 3	708, 709	17/02/16
0030	Rib-like bone	Column D, spit 3	710, 733	17/02/16
0031	Rib bone	Column A spit 11	near 235	17/02/16
0032	Charcoal, 2-3mm fragment	Column A spit 9	none	18/02/16
0033	Charcoal, 4-5mm fragment	Column A spit 10	none	18/02/16
0034	Bone fragment	Column A spit 10	none	18/02/16
0035	Tiny bone fragment, Stream Deposit gravel	Trench	none	19/02/16
0036	Long bone, Stream Deposit	Alcove	723, 724	19/02/16
0037a	Massive Stalagmite sample, basal part of Stalagmite breccia	Section C	557-663	19/02/16
0037b	Subsample of above	Section C	557-663	19/02/16
0037c	Subsample of above	Section C	557-663	19/02/16
0038a	Fragment of clean stalagmite floor, upper part of Stalagmite breccia	Section C	550, 551	19/02/16
0038b	Subsample of above	Section C	550, 551	19/02/16
0038c	Subsample of above	Section C	550, 551	19/02/16
0039	Stalagmite from top of stalagmite breccia	Section C	544, 545	19/02/16
0040a	Cemented sediment, upper gravel	Trench	none	19/02/16
0040b	Cemented sediment, upper gravel	Trench	none	19/02/16

Table 4.1.2. List of individually recorded finds, including bone, charcoal and stalagmite fragments.

Number	Description	Location	Date
0100	Column sample (= modern pollen sample)	Column A black skim from top	19/02/16
0101	Column sample	Column A spit 1 upper	19/02/16
0102	Column sample	Column A spit 1 lower	19/02/16
0103	Column sample	Column A spit 2 upper	19/02/16
0104	Column sample	Column A spit 2 lower	19/02/16
0105	Column sample	Column A spit 3 upper	19/02/16
0106	Column sample	Column A spit 3 lower	19/02/16
0107	Column sample	Column A spit 4 upper	19/02/16
0108	Column sample	Column A spit 4 lower	19/02/16
0109	Column sample	Column A spit 5 upper	19/02/16
0110	Column sample	Column A spit 5 lower	19/02/16
0111	Column sample	Column A spit 6 upper	19/02/16
0112	Column sample	Column A spit 6 lower	19/02/16
0113	Column sample	Column A spit 7 upper	19/02/16
0114	Column sample	Column A spit 7 lower	19/02/16
0115	Column sample	Column A spit 8 upper	19/02/16
0116	Column sample	Column A spit 8 lower	19/02/16
0117	Column sample	Column A spit 9 upper	19/02/16
0118	Column sample	Column A spit 9 lower	19/02/16
0119	Column sample	Column A spit 10 upper	19/02/16
0120	Column sample	Column A spit 10 lower	19/02/16
0121	Column sample	Column A spit 11 upper	19/02/16
0122	Column sample	Column A spit 11 lower	19/02/16
0123	Column sample	Column A spit 12 upper	19/02/16
0124	Column sample	Column A spit 12 lower	19/02/16
0125	Column sample	Column A spit 13 upper	19/02/16
0126	Column sample	Column C spit 1 upper	19/02/16
0127	Column sample	Column C spit 1 lower	19/02/16
0128	Column sample	Column C spit 2 upper	19/02/16
0129	Column sample	Column C spit 2 lower	19/02/16
0130	Column sample	Column C spit 3 upper	19/02/16
0131	Column sample	Column C spit 3 lower	19/02/16
0132	Column sample	Column C spit 4 upper	19/02/16
0133	Column sample	Column C spit 4 lower	19/02/16
0134	Column sample	Column C spit 5 upper	19/02/16
0135	Column sample	Column C spit 5 lower	19/02/16
0136	Column sample	Column C spit 6 upper	19/02/16
0137	Column sample	Column C spit 6 lower	19/02/16
0138	Column sample	Column C spit 7 upper	19/02/16
0139	Column sample	Column C spit 7 lower	19/02/16
0140	Column sample	Column C spit 8 upper	19/02/16

0141	Column sample	Column C spit 8 lower	19/02/16
0142	Column sample	Column C spit 9 upper	19/02/16
0143	Column sample	Column C spit 9 lower	19/02/16
0144	Column sample	Column C spit 10 upper & lower	19/02/16
0145	Column sample	Column C spit 11 upper & lower	19/02/16
0146	Column sample	Column C spit 12 upper & lower	19/02/16
0147	Column sample	Column C spit 13 upper & lower	19/02/16
0148	Column sample	Column C spit 14 upper & lower	19/02/16
0149	Sample around bone	Column C around bone 0007	15/02/16
0150	Sample around bone	Column C around bone 0008	15/02/16
0151	Sample around bone	Column C around bone 0016	16/02/16
0152	Sample around bone	Column D around bone 0023	17/02/16
0153	Sample around bone	Column D around bone 0027	17/02/16
0154	Sample around bone	Column D around 0028/29/30	17/02/16
0155	Spot sample, Dark Earth	Roof remnant	19/02/16
0156	Spot sample, brown earth Reindeer Stratum	Roof remnant	19/02/16
0157	Spot sample, Dark Earth	S. end of central pipe/burrow, Section C	19/02/16
0158	Spot sample, red sediment, Reindeer Stratum	Section C, by SEM block	19/02/16
0159	Spot sample, yellow sediment, Reindeer Stratum	Section C, by SEM block	19/02/16
0160	Spot sample, Stalagmite breccia	Stalagmite Breccia, Section C	19/02/16
0161	Sample around bone, Stream Deposit	Alcove around bone 0036	19/02/16
0162	Spot sample	Subsample of upper gravel, Trench	19/02/16
0163	Modern pollen sample, surface sediment	SE corner of trench in cave	19/02/16
0164	Modern pollen sample, surface sediment	Dump outside cave, by EDM station peg	19/02/16
0165	Modern pollen sample	Halfway between 0164 & 0166, not taken yet	19/02/16
0166	Modern pollen sample, soil sample	GPS station in field	19/02/16

Table 4.1.3. Pollen samples.

4.2. Clast lithology

Chris Proctor

Clast lithology within the sediments was investigated by examining the 4mm and 2mm sieve residues from the sediment samples. These included the bulk samples of the Stream Deposit from the trench, columns A, B, C and D and two microfaunal spot samples, taken from the Section C central pipe/burrow and the inner chamber south wall respectively.

Due to the large number of samples, lithological composition was determined using a semi-quantitative method. Accurate clast counts were not undertaken but abundances of each lithology were estimated using the abundance scale shown in table 4.2.1.

The geology of the surrounding area is shown on the 1:50,000 geological map sheet 339 (BGS, 1997) and described in the accompanying geological memoir (Selwood et al, 1984). The position of Cow Cave on a ridge between the Teign valley to the west, and Kate Brook valley to the southeast, means that as well as local material from the ridge itself, material derived from one or both stream catchments could have been emplaced in the cave. The following lithologies were recognised, listed in order of autochthonous sediments, then allochthonous sediments, then igneous and associated rocks in order of age.

Limestone: grey Chercombe Bridge Limestone, of Middle Devonian age. Limestone of this lithology comprises Chudleigh Rocks. Their angular unweathered state implies that the vast majority of the clasts within the cave sediments are derived from the roof and walls of the cave. Some clasts show some weathering and may be derived from the surface immediately above or from Chercombe Bridge Limestone outcrops further up the Kate Brook valley. Rare clasts of pink limestone occur, which may represent material from thin beds within the predominantly grey limestone of the rocks, or limestone from a more distant outcrop.

Calcite: angular white coarsely crystalline calcite, derived from veins within the limestone. Such calcite veins (of Variscan age) are common in the Chercombe Bridge Limestone and this material is also undoubtedly derived from the same local source.

Stalagmite: stalagmitic calcite deposited by dripwater within the cave. The climate must be at least reasonably warm for stalagmite growth to occur. The occurrence of stalagmite clasts within the sediment shows that growth has occurred followed by breakup of the stalagmite and incorporation into accumulating sediment. Several different types of stalagmite clast were found. Crystalline stalagmite is typical of deep-cave environments, far from any entrance. Massive stalagmite is not environmentally diagnostic. Tufaceous stalagmite is present in quantity in some samples. Tufaceous stalagmite growth occurs close to cave entrances and is thus a good indicator that the cave was open at the time of deposition.

Concretion: stalagmitic material deposited within the sediment, to form masses of sediment cemented together by calcite. Concretions were found to vary according to the nature of the cemented sediment. Within the Stream Deposit, masses of cemented slate fragments occur. Within the Reindeer Stratum of Columns A, B and C, hard, very angular concretions of clasts cemented together are abundant. Softer, subangular to subrounded earthy concretions also occur. The roundness of the earthy concretions may be original but could be an artefact of rounding during the sieving process.

Slate: slate occurs as extensive outcrops upstream of the cave in both the Kate Brook and Teign valleys. These include the Kate Brook Slate (Kate Brook valley, upper Devonian), the Trusham Shale and Combe Shale (Teign valley, Lower Carboniferous) and the Crackington Formation (Teign and Kate Brook valleys, Upper Carboniferous). Slates also occur in the basal part of the Ugbrooke Sandstone (Upper Carboniferous) in the Kate Brook valley. Slate fragments are generally greenish-grey but no attempt was made to distinguish different slate lithologies as this is not practical in hand specimen.

Siltstone: siltstone of Upper Devonian and Carboniferous age occurs within the same outcrop areas as the slate. Most is probably derived from the Crackington Formation and Ugbrooke Sandstone, of Upper Carboniferous age. Siltstones also occur rarely in the Kate Brook Slate. Clasts are generally brown to grey, with rare weathered material of a yellowish colour. As with the slate, no attempt was made to match clasts to any of the possible source rocks.

Sandstone: sandstone beds are common in the Crackington Formation and form much of the Ugbrooke Sandstone. Most sandstone clasts are brown to grey, and not diagnostic of either of the possible sources.

Gritstone: a few clasts comprise a coarse gritstone. This material is characteristic of the Ugbrooke Sandstone, and indicates a Kate Brook origin.

Chert: rare fragments of angular grey chert were found. These are derived from the Teign Chert (Lower Carboniferous) which occurs in the Teign and Kate Brook valleys.

Red sandstone: bright red sandstone, of Permian age. Clasts of this material are rare, probably due to its soft, easily eroded nature. Sandstones occur interbedded within the Permian Breccias on Haldon at the head of the Kate Brook valley.

Greensand: the Greensand outcrops on Haldon and includes glauconitic sands and speckled cherts of Cretaceous age. Greensand clasts are rare, and include sandstone, chert and silicified fossils.

Flint: cryptocrystalline silica, occurring as nodules in the Chalk, of Upper Cretaceous age. No chalk outcrops occur nearby but extensive derived flint gravel deposits of Eocene age occur on Haldon. The possibility of importation by early Man also needs to be considered.

Quartz: crystalline quartz grains form a rare but constant component of most samples. Quartz veins occur widely in the Palaeozoic slates and sandstones of the area. Some crystalline quartz might also be derived from coarse-grained igneous rocks such as granite and quartz porphyry. Due to its very widespread occurrence quartz is not diagnostic of any source area.

Haematite: clasts of red iron oxide from mineral veins in the Palaeozoic rocks or granite. These mineral veins are not well-described in the geological literature as most are not of economic size, but occur in many rock types.

Limonite/geothite: clasts of brown iron hydroxide, usually the amorphous mineral limonite, though hard crystalline goethite was also found.

Granite: granite derived from the Dartmoor batholith to the west, of Permian (late Variscan) age (Scrivener, 2006). This material could have reached the cave via the River Teign. Dartmoor derived materials (Quartz-schorl and hornfels) occur in the Eocene flint gravels on Haldon, suggesting that this might also have been a source of this material. Granite clasts are very rare, but include biotite, muscovite and schorl (tourmaline) granites.

Quartz/schorl: rare clasts of quartz-schorl (black iron tourmaline) veinstone from veins in the Dartmoor granite. This material is highly resistant to erosion and quartz-schorl veinstone of Dartmoor origin occurs in the Eocene flint gravels on Haldon.

Schorl: black mineral grains are rare but widespread. Their colour, lack of cleavage and the striated texture preserved on the surface of some of these grains identify them as schorl tourmaline. They are Dartmoor derived, either from tourmaline granite or quartz-schorl veins, and they also occur in the Eocene flint gravels on Haldon.

Hornfels: dark grey, very hard clasts of fine grained, structureless hornfels. This contact metamorphic rock is characteristic of the metamorphic aureole of the Dartmoor granite and also occurs in the Eocene flint gravels on Haldon.

Quartz porphyry: fine grained pink acid igneous rock with quartz and feldspar megacrysts. Bedrock exposures of this rock type do not occur closer than Kingsand in east Cornwall but quartz porphyry clasts are common in the Teignmouth Breccia, of Permian age, which occurs on Haldon.

Acid igneous rock: a few clasts of fine grained pink igneous rock were found. Due to the small clast size it was not possible to determine whether these represented fine grained aplitic rock associated with the Dartmoor granite, or fragments of the groundmass of Permian quartz porphyry.

Feldspar: a single cleavage rhomb of pink feldspar was found. This is probably a fragment of murchisonite feldspar derived from the Permian Teignmouth Breccia on Haldon, although the possibility that it is a fragment from disaggregated granite cannot be ruled out.

Other crystalline clasts: a few grains of indeterminate crystalline mineralisation were found. Possible sources are mineral veins in the Palaeozoic rocks or granite (which are highly diverse in the area), or mineralisation within the metamorphic aureole of the Dartmoor granite.

Results of the clast lithological analysis are given in Tables 4.2.2 - 4.2.7. For each sample, the abundance of each lithology uses the scale given in table 1, and is given as the abundance in the 4mm/2mm residues.

Results for the Stream Deposit samples are given in table 4.2.2. Both were bulk samples taken from the floor trench, and sampled the 2 major units identified there. Both units are dominated by allocthonous lithologies, principally slate and flint. A wide variety of other allochthonous lithologies occur more rarely. The presence of abundant angular to rounded flint in both samples shows that the sediment includes a major input from Haldon, at the head of the Kate Brook valley. The weathered nature of this flint is consistent with a natural source. Apart from two small flakes, none showed any sign of possible human modification. Other Haldon derived material includes Greensand, and red sandstone and quartz porphyry derived from the Permian breccia. Most of the others occur in the Kate Brook catchment, including hornfels and quartz-schorl which are known to occur in the Eocene gravels on Haldon. Only the granite clasts cannot certainly be traced to a Haldon/Kate Brook source; this is discussed in more detail below. Authochonous clasts within the Stream Deposit are limited to limestone, calcite and concretion. Angular limestone and calcite probably represents material derived from the cave walls or roof; a single rounded limestone clast found in the Upper Unit might be derived from limestone outcrops further up the valley. Concretions occur within the Stream Deposit as calcite cementation of the gravel sediment. These preserve the sedimentary structure and are clearly post-depositional.

Results for the Reindeer Stratum sampled in columns A, B and C are shown in tables 4.2.3 – 4.2.5 respectively. Almost the entire thickness of the Reindeer Stratum was sampled by the three columns (with a small gap between the base of column A and the top of column B). All the samples are dominated by autochonous lithologies. Very large quantities of limestone and smaller amounts of calcite veinstone are present in all samples. Almost all of it is angular and shows little sign of any significant weathering. This suggests that it is derived from the cave walls and roof. The walls of the solution passage in Cow Hole (and in the adjacent Pixie’s Hole) show little signs of collapse, implying that this material is derived from the gull fissures which intersect the solution passage above the current end of the cave at Section C. A few subangular limestone clasts show significantly weathered surfaces and may represent fragments which were exposed on the surface prior to their transport into the cave. Stalagmite is also frequent to abundant, occurring as broken fragments. These have clearly been reworked from floors which grew at various times in the cave's history. The texture of the stalagmite varies from hard crystalline to tufaceous. Crystalline stalagmite fragments are particularly abundant towards the base of the deposit (the bottom of column C) and probably represent material reworked from the Broken Stalagmite Layer immediately beneath. Tufaceous stalagmite fragments become increasingly common towards the top of the deposit. Some of this tufaceous stalagmite might predate the Reindeer Stratum; however the presence of pipes/burrows within the Reindeer Stratum suggests much of it may represent later intrusive material. Concretion is abundant: as with the Stream Deposit, this represents calcite concretions that have formed within the sediment since its deposition. Many of these concretions are very angular stony aggregates. However more rounded earthy concretions were also found. These latter are quite soft and their shape may be an artefact of abrasion during sieving.

All the Reindeer Stratum samples also contain small amounts of allochthonous lithologies. The lithologies seen in the Stream Deposit samples are again represented here. However allochthonous lithologies within the Reindeer Stratum show a strong bias away from friable lithologies such as slate. Quartz, a hard mineral which is very resistant to erosion is the only allochthonous clast type widely represented. Flint is also widespread although rare. Many of the flint clasts are rough weathered grains, and clearly natural. However a proportion comprise angular fragments of white flint, which apart from the colour showed little sign of weathering. This material closely resembles the later prehistoric flint debitage which is quite abundant in the Chudleigh Rocks area, and could represent small fragments of that material. However none shows any definite signs of human workmanship (see section 4.3), nor should its presence within the Reindeer Stratum be taken as indicating a possible coeval human presence as it is only represented by tiny fragments which could very easily have been intruded by late stage piping or burrowing processes. Palaeozoic sandstone, siltstone and slate are present in the lower columns of the Reindeer Stratum (B and C). Compared to the Stream Deposit, slate is less abundant than the siltstone and sandstone, probably because slate is less resistant to weathering. Sandstone, siltstone and slate are almost absent from column A, which sampled the upper part of the Reindeer Stratum. This suggests that the source of this material may have been exhausted before the upper part of the Reindeer Stratum was deposited.

Column D (table 4.2.6) sampled a loose, stony patch of Reindeer Stratum which might possibly represent an infilled pipe or burrow within the deposit. It does not lithologically differ from the Reindeer Stratum sampled in the adjacent columns B and C. The Dark Earth was sampled in pipe/burrow fills in column C spit 1 (table 4.2.5), and the Section C Dark Burrow Fill (DBF) sample from the central stalagmite-lined pipe/burrow (table 4.2.7). A further sample, the south wall Microfaunal Bone Cluster (MBC) sample (table 4.2.7), was from the boundary between the Reindeer Stratum and the Dark Earth, which here is gradational. All were relatively small samples, and do not differ lithologically from the Reindeer Stratum. It is likely that the clastic sediment in these units is derived from the same source as the Reindeer Stratum. The clear colour difference between the Reindeer Stratum and the Dark Earth can be attributed to a greater organic content in the latter unit.

The clast lithological differences between the Stream Deposit on the one hand, and the Reindeer Stratum on the other, reflect the sedimentological differences between these sediment bodies. Its sedimentary structure (Sections 3.2, 3.3, 3.4) suggests that the Stream Deposit is an alluvial sediment deposited by a stream which flowed through the solutional passage of Cow Cave. This stream would be expected to have introduced a wide variety of lithologies from the stream's catchment. As noted above, the lithologies present in the Stream Deposit are almost all known to occur in the Kate Brook catchment. The only exception is granite, which occurs as rare grains. This might be derived from the Eocene gravels on Haldon which are known to contain granite-associated lithologies including quartz-schorl and hornfels, suggesting that some granite might be present there. An alternative source would be an input from the River Teign, either direct or reworked from ancient high level terrace remnants. However, a number of lithologies have extensive outcrops in the lower Teign valley only a few kilometres upstream from Chudleigh Rocks which are conspicuously rare or absent from the Stream Deposit. These include Carboniferous dolerite and Teign Chert, both of which are hard, weathering resistant rocks which should be present in some quantity if there was a significant contribution from a Teign valley source. Thus it seems most likely that the Stream Deposit was either directly deposited by an ancient precursor of the Kate Brook, or represents sediment reworked from a source originally deposited by the Kate Brook. This problem is best explored by further examination of possible source areas, but lies outside the scope of this project.

The Reindeer Stratum and Dark Earth, by contrast are cave earths deposited by a combination of colluvial and collapse processes. As such their clast lithology is dominated by autochthonous limestone, calcite and stalagmite. The rare allochthonous fraction cannot be reworked from the Stream Deposit as these sediments lie well above the level of that deposit. The overall form of the sediment body suggests that the Reindeer Stratum of Section C has entered the cave from high level gull fissures. The most likely source of the allochthonous fraction is a residual deposit of allochthonous sediment which may have existed on the plateau above the cave. Lithologically it is similar to that in the Stream Deposit although the range of lithologies is more restricted due to the much smaller quantity of allochthonous material present. The general rarity of these allochthonous lithologies in the Reindeer Stratum suggests that by the time it was deposited, the plateau surface above had become almost entirely denuded of whatever ancient allochthonous sediments may originally have covered it. Such deposits are certainly absent at the present day.

Abundance	Abbreviation on tables	Approx. %
Dominant	D	>50%
Abundant	A	50-20%
Common	C	20-10%
Frequent	f	10-5%
Occasional	o	5-1%
Rare	r	<1%
Absent	-	0

Table 4.2.1: Clast abundance scale used in lithological analysis.

Sample	Unit	Limestone	Calcite	Stalagmite	Concretion	Slate	Siltstone	Sandstone	Gritstone	Chert	Red sandstone	Greensand	Flint	Quartz	Haematite	Limonite/Goethite	Granite	Quartz-schorl	Schorl	Hornfels	Quartz porphyry	Acid igneous rock
Upper gravel	**SD**	o/-	r/-	-/-	A/C	A/D	f/f	o/o	r/-	r/f	-/r	o/r	A/C	o/C	-/-	-/-	r/r	r/r	-/o	r/o	r/r	-/-
Lower gravel	**SD**	-/-	-/-	-/-	o/o	A/D	f/f	f/r	r/	-/-	-/-	-/?	D/f	o/f	-/-	r/r	-/r	r/	-/f	o/r	r/	-/-

Table 4.2.2: Stream Deposit clast lithology. Clast abundances are listed for the 4mm/2mm sieve residues. For abundance scale see Table 4.2.1.

Spit	Unit	Limestone	Calcite	Stalagmite	Concretion	Slate	Siltstone	Sandstone	Gritstone	Chert	Red sandstone	Greensand	Flint	Quartz	Haematite	Limonite/Goethite	Granite	Quartz-schorl	Schorl	Hornfels	Quartz porphyry	Acid igneous rock
1	**RS**	A/A	-/o	C/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	r/o	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-
2	**RS**	D/A	r/o	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r
3	**RS**	D/A	o/o	C/C	C/C	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	r/r	-/-	-/-	-/-	-/r	-/r	-/-	-/-	-/-
4	**RS**	D/A	r/o	C/f	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
5	**RS**	D/A	o/o	C/C	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	r/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
6	**RS**	A/A	o/o	C/C	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	o/o	-/-	-/-	-/-	-/r	-/-	r/-	-/-	-/?
7	**RS**	A/A	r/o	C/f	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	o/o	r/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
8	**RS**	D/A	o/r	C/C	A/A	r/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	r/o	-/r	-/-	-/-	-/r	-/-	-/-	-/-	-/-
9	**RS**	D/A	o/o	f/f	A/A	r/-	-/-	-/-	-/-	r/-	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/-	-/r	-/-	-/-	-/-
10	**RS**	D/A	o/o	f/f	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	r/r	-/-	-/r	-/-	r/-	-/r	-/-	-/-	-/-
11	**RS**	A/A	o/o	C/f	C/A	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/r	r/r	-/r	-/-	-/-	-/-	-/r	-/-	-/-	-/r
12	**RS**	D/A	o/o	C/C	C/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/?	r/r	-/-	-/-	-/r	r/-	-/r	-/-	r/?	-/-
13	**RS**	D/A	o/o	f/f	C/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	r/o	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/-

Table 4.2.3: Column A clast lithology. RS denotes Reindeer Stratum. Clast abundances are listed for the 4mm/2mm sieve residues. For abundance scale see Table 4.2.1.

Spit	**Unit**	Limestone	Calcite	Stalagmite	Concretion	Slate	Siltstone	Sandstone	Gritstone	Chert	Red sandstone	Greensand	Flint	Quartz	Haematite	Limonite/Goethite	Granite	Quartz-schorl	Schorl	Hornfels	Quartz porphyry	Acid igneous rock	Indet. crystal
1	**Stalagmite**	-	-	**D**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	**RS**	A/A	o/o	A/A	C/C	-/-	-/-	-/r	-/-	-/-	-/-	-/-	-/-	r/o	-/r	-/r	-/-	-/-	-/r	-/-	-/-	-/-	-/-
3	**RS**	A/A	o/-	A/A	C/A	-/-	-/r	-/r	-/-	-/-	-/-	-/-	-/-	r/o	-/r	r/r	-/-	-/-	-/r	-/-	-/-	-/-	-/-
4	**RS**	A/A	o/o	A/A	A/A	r/-	r/-	-/-	-/-	-/-	-/r	-/-	r/r	-/r	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-
5	**RS**	D/A	o/o	C/C	A/A	-/r	?/-	-/r	-/-	-/-	-/-	-/-	-/-	r/o	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/r
6	**RS**	D/A	o/o	f/f	A/A	-/-	-/r	-/r	-/-	-/-	-/-	-/-	-/r	r/r	-/-	-/-	-/-	-/r	-/r	-/-	-/-	-/-	-/-

Table 4.2.4: Column B clast lithology. Column A clast lithology. Spit 1 is the (unexcavated) stalagmite layer at the top of the column. RS denotes Reindeer Stratum. Clast abundances are listed for the 4mm/2mm sieve residues. For abundance scale see Table 4.2.1.

Spit	**Unit**	Limestone	Calcite	Stalagmite	Concretion	Slate	Siltstone	Sandstone	Gritstone	Chert	Red sandstone	Greensand	Flint	Quartz	Haematite	Limonite/Goethite	Granite	Quartz-schorl	Schorl	Hornfels	Quartz porphyry	Acid igneous rock	Feldspar
1	**DE**	A/A	o/o	A/A	C/A	-/-	r/r	-/-	-/-	-/-	-/-	-/-	-/-	r/r	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/-	-/-
2	**RS**	A/A	r/o	A/A	C/A	-/-	-/r	-/-	r/-	r/?	-/-	-/-	-/?	r/r	-/-	r/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-
3	**RS**	A/A	o/o	A/A	A/A	-/-	r/r	-/-	-/-	-/-	-/-	-/-	r/-	-/r	-/-	-/-	-/-	r/-	-/-	-/-	-/-	-/-	-/-
4	**RS**	A/A	o/o	A/C	A/A	-/r	r/r	-/-	-/-	-/-	-/-	-/-	-/-	r/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
5	**RS**	A/A	o/o	o/f	A/A	-/-	-/r	-/-	-/-	-/r	-/-	-/-	-/r	r/r	-/-	-/-	-/r	-/-	-/r	-/-	-/-	-/-	-/-
6	**RS**	A/A	o/o	f/f	A/A	-/r	?/r	-/-	-/-	-/-	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/-	-/-	r/-	-/-	-/-	-/-
7	**RS**	A/A	o/f	C/f	A/A	-/r	r/-	-/-	-/-	-/-	-/-	-/-	-/r	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r
8	**RS**	D/A	o/-	C/o	A/A	-/-	r/r	-/-	-/-	-/-	-/-	-/-	-/-	-/o	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	-/-
9	**RS**	A/A	o/o	C/f	A/A	-/-	-/r	-/-	r/-	-/-	-/-	-/-	-/-	r/o	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-
10	**RS**	A/A	f/f	C/C	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/r	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
11	**RS**	A/C	r/r	A/A	A/D	-/r	?/r	-/-	-/-	-/-	-/-	-/-	r/r	r/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
12	**RS**	C/f	r/r	D/D	C/A	-/-	-/-	-/-	-/-	-/?	-/-	-/-	r/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
13	**RS**	C/C	?/o	D/D	A/A	-/-	r/-	-/?	-/-	-/-	-/-	-/-	-/r	-/r	-/-	-/-	-/r	-/-	-/-	-/r	-/-	-/?	-/-
14	**RS**	C/C	-/r	D/A	C/A	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/r	-/r	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-

Table 4.2.5: Column C clast lithology. **DE** denotes dark Earth, **RS** denotes Reindeer Stratum. Clast abundances are listed for the 4mm/2mm sieve residues. For abundance scale see Table 4.2.1.

Spit	**Unit**	Limestone	Calcite	Stalagmite	Concretion	Slate	Siltstone	Sandstone	Gritstone	Chert	Red sandstone	Greensand	Flint	Quartz	Haematite	Limonite/Goethite	Granite	Quartz-schorl	Schorl	Hornfels	Quartz porphyry	Acid igneous rock	Mineral veinstone
1	**RS**	D/A	f/o	f/f	A/A	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	r/r	-/-	-/-	-/-	-/-	-/-	r/?	-/-	-/-	-/-
2	**RS**	D/A	o/o	C/A	A/A	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/r	-/r	-/-	r/-	-/r	-/r	-/r	-/-	-/-	-/-	-/-
3	**RS**	D/A	o/f	C/C	A/A	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/r	r/r	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-
4	**RS**	D/A	o/o	C/C	A/A	-/-	-/-	r/r	-/-	-/-	-/-	-/-	-/r	r/o	-/-	r/r	-/-	-/-	-/-	-/-	-/-	-/r	-/r

Table 4.2.6: Column D clast lithology. **RS** denotes Reindeer Stratum. Clast abundances are listed for the 4mm/2mm sieve residues. For abundance scale see Table 4.2.1.

Sample	**Unit**	Limestone	Calcite	Stalagmite	Concretion	Slate	Siltstone	Sandstone	Gritstone	Chert	Red sandstone	Greensand	Flint	Quartz	Haematite	Limonite/Goethite	Granite	Quartz-schorl	Schorl	Hornfels	Quartz porphyry	Acid igneous rock
DBF	**DE**	A/C	-/-	A/D	C/A	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	r/r	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-
MBC	**DE/RS**	A/f	-/-	A/A	A/A	-/r	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/r	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-

Table 4.2.7: Dark Earth clast lithology. **DBF**: Dark Burrow Fill sample, Section C central stalagmite-lined pipe/burrow. **MBC**: Microfaunal Bone Cluster sample, inner chamber south wall. **DE** denotes dark Earth, **RS** denotes Reindeer Stratum. Clast abundances are listed for the 4mm/2mm sieve residues. For abundance scale see Table 4.2.1.

4.3. Artefacts

Rob Dinnis

Flint and chert were recovered from several locations. These included all the sample columns (A-D) in the Reindeer Stratum. Flint and chert are rare in the Reindeer Stratum (section 4.2), and all flint and chert fragments found were retained for examination. The Stream Deposit excavated in the floor trench contains very large quantities of flint in both the upper and lower units (section 4.2). Here, only flints showing possible signs of human modification were retained for examination. Four further flints were found on paths close to the cave. As these were found during the excavation they are dealt with here, although as they do not come from the cave itself they strictly do not fall within the remit of this investigation.

Only two of the flints can be said with confidence to be anthropogenic. These are two of the four found outside the cave (table 4.3.1) – one a nice fragment of a bifacially worked piece (an arrowhead?), the other a blade fragment. None of the flints found inside the cave show the characteristics necessary to conclude that they are archaeological – obvious platforms, features associated with deliberate fracture (e.g. bulb of percussion), "clean" ventral surface and structured dorsal scar pattern. The pieces were checked with a hand lens and none bear any form of retouch, therefore none is a small fragment of a larger artefact. Given the absence of any clearly anthropogenic piece the Section C assemblage should be presumed natural.

However, this conclusion should come with a note of caution. In most cases it cannot be stated with confidence that the pieces are *not* anthropogenic (and they have therefore been listed with a "?" in table 4.3.1). During knapping many small pieces of (unintentional) shatter debitage are created, and in most cases these do not bear the features characteristic of knapping. This is particularly true of pieces c.3mm or less, which tend to be small fragments of larger pieces of shatter. With this in mind, the anthropogenic origin of only a few pieces can be confidently ruled out (see table 4.3.1). In these cases they are either obviously from tiny pebbles, are completely rolled, or have dorsal/ventral surfaces that are incompatible with debitage shatter.

Regarding the Section C material, it is notable that only very small pieces are present. (We can note that if a random proportion of a knapping event was selected one may expect an identifiable flake, but also larger pieces of debitage/shatter). Therefore, whether natural or deriving from an archaeological assemblage, it seems likely that they have been sorted geologically before being deposited in Section C. The small size of all pieces is clearly important for understanding the depositional circumstances of the flint fragments. Also noteworthy, the condition of the dorsal arêtes/edges on the Section C flints is not consistent. In some cases the arêtes/edges are fresher/more pronounced than on others, perhaps indicating that some have been "rolled" more than others? Similarly, the difference in condition between the two pieces from "cave floor trench, Stream Deposit" is notable.

In future it may prove useful to compare the patina of the Section C pieces with that of known LUP material from the site. It would be also be useful to compare the assemblage with surface flint debitage from on and around Chudleigh Rocks, and with possible natural flint sources. The latter includes the flint in the Stream Deposit, and any residual natural flint that may survive on the surface.

Section	Column	Spit	Mesh size (mm)	Material	Anthropogenic?	Notes
C	A	3	2	Flint	?	
C	A	4	2	Flint	?	
C	A	4	2	Flint	?	
C	A	5	2	Flint	?	
C	A	5	2	Flint	?	
C	A	5	2	Flint	?	
C	A	5	2	Flint	?	
C	A	7	2	Flint	?	
C	A	7	2	Flint	?	
C	A	9	4	Chert	?	
C	A	10	2	Flint	?	
C	A	10	2	Flint	?	Broken into two pieces?
C	A	10	2	Flint	?	
C	A	10	2	?	N	
C	A	11	2	Flint	?	
C	A	12	2	?	?	
C	A	13	2	Flint	N	
C	B	4	4	Flint	N	
C	B	4	2	Flint	?	
C	B	4	2	Flint	?	
C	B	6	2	Flint	?	
C	C	2	4	Chert	N	
C	C	2	2	Flint?	N	
C	C	2	2	Chert?	N	
C	C	3	4	Flint	?	
C	C	5	2	Flint	?	

C	C	5	2	Flint	?	
C	C	5	2	Flint	?	
C	C	7	2	Flint	?	
C	C	10	2	Flint	?	
C	C	10	2	Flint	?	
C	C	10	2	Flint	?	
C	C	10	2	Flint	N	
C	C	11	4	Flint	?	
C	C	11	2	Flint	N	
C	C	11	2	Flint	N	
C	C	11	2	Flint	?	
C	C	12	4	Flint	N	
C	C	12	4	Flint?	N	
C	C	12	2	Chert?	?	
C	C	12	2	Flint	?	
C	C	13	2	Flint	?	
C	C	14	2	Flint	N	
C	D	2	2	Flint	?	
C	D	2	2	Flint	?	
C	D	2	2	Flint	?	
C	D	2	2	Flint	?	
C	D	2	2	Flint	N	
C	D	3	2	Flint	N	
C	D	3	2	Flint	?	
C	D	3	2	Flint	?	
C	D	3	2	Flint	?	
C	D	4	2	Flint	N	
C	D	4	2	Flint	N	
C	D	4	2	Flint	?	

C	D	4	2	Flint	?	
C	D	4	2	Flint	?	
Trench Stream Dep.	Upper unit	-	4	Flint	?	Heavily rolled
Trench Stream Dep.	Upper unit	-	4	Flint	?Y	
Surface finds	(site 1)	-	-	Flint	?	
Surface finds	(site 1)	-	-	Flint	Y	Bifacially worked
Surface finds	(site 2)	-	-	Flint	Y	Blade
Surface finds	(site 3)	-	-	Flint	?Y	

Table 4.3.1. Flint fragments from Cow Cave. Note that pieces were marked “?” in the “Anthropogenic?” column if they displayed no features that allowed a confident yes/no allocation – taken overall, the section C material should be presumed of natural origin (see text). Locations for surface finds are: **site 1**, E path up to Cow Cave, SX 8648 7866; **site 2**, path between Cow Cave and Jacob's Ladder, SX 8648 7866; **site3**, path up to Cow Cave from field , SX 8646 7866.

4.4. Cow Cave Vertebrate Remains (except herpetofauna)

John Stewart and Monika Knul

Vertebrate remains were recovered during the 2016 excavations of Cow Cave. These remains were found during the excavation itself and from sample columns that were later sieved at various mesh sizes. What follows is a description of the significant remains found during those different procedures with a discussion of their palaeoecological significance in relation to the likely age of the various deposits at Cow Cave. Herpetofauna are described separately by Chris Gleed-Owen (section 4.5).

4.4.1. Larger Vertebrate Remains

The large vertebrate remains collected from Cow Cave in 2016 during the excavation are listed in Table 4.4.1. These are made up in the most part by fragments that are not identifiable beyond the level of large mammal. In addition to these unidentified fragments there are medium sized mammal and smaller vertebrate bone fragments. None of these exhibit any features that allow identification beyond these taxonomic categories. The exceptions to this are the following:

Bovidae / Cervidae

Three specimens belonging or probably belonging to a large cervid or bovid were recovered. They include a partial right calcaneum (0016) from Column C, Spit 6, another possible partial calcaneum (0008) of a cervid from Column C Spit 5 and distal right radius fragment (0036) of an immature cervid from the stream deposit in the Alcove.

Ursus sp.

A distal metapodial of a bear was retrieved from unstratified cleaning of the Stream Deposit section in the Alcove. Further work should establish whether it belongs to that of a brown bear (*U. arctos*) or cave bear (*U. spelaeus*). If the latter it would likely date to MIS 3 (ca. 57 to 29 KYrs) or older based on youngest reliable dates available for this species (Pacher and Stuart, 2009). If it belongs to brown bear the age is not easy to refine as they have been dated to MIS 3, the LGM and the Late Glacial (Pettitt *et al*., 2012) and it is believed that large individuals of brown bear were in the UK during MIS 4 (Currant and Jacobi, 2001).

Turdus and *Turdus* sized passerine

A distal right humerus (0021) of a large member of the thrush genus *Turdus* was found in Column C, Spit 1. The bones of *Turdus* species cannot be distinguished on the basis of morphology (Stewart and Jacobi, 2015). Based on size, albeit not on actual measurements, and compared to that of the British members of *Turdus* today, the specimen would appear to belong to one of the two, or possibly three, larger species of the genus *Turdus* i.e. fieldfare (*T. pilaris*) or mistle thrush (*T. viscivorus*). There is a chance that the specimen belongs to a ring ouzel (*T. torquatus*) but there are not many specimens available with which to adequately compare the specimen. It is tempting, given the possible last glacial age of the specimen and the northern breeding distribution of the species, to consider fieldfare as the most likely but there is evidence for mixing in this sequence (Simons, 2010). The tarsometatarsus shaft (no sample number) from Section C during cleaning of the stream deposit hollow may be further evidence of *Turdus* but the incompleteness of the specimen causes a need for caution. The occurrence of *Turdus* of a large size i.e. fieldfare or mistle thrush would indicate the presence of trees or shrubs for nesting if the specimens represent breeding individuals (Harrison, 1982). If on migration a greater variety of habitats could be implicated.

4.4.2. The Smaller Vertebrate Remains

The smaller vertebrate material from the 2016 Cow Cave excavation was recovered by sieving sediment samples from a number (4) of sampling columns. The latter were divided into a series of vertical 'Spits' which were 5 cm in depth. The sediment samples were flotated/wet sieved through 4mm; 2mm; 500 micron and 250 micron sieves. The residues were then picked for recovery of artefacts, vertebrate remains, molluscs, and other archaeologically significant material.

The samples all yielded vertebrate material although most consisted of bone fragments that could not be identified beyond the levels of undetermined vertebrate, undetermined small vertebrate, undetermined large mammal, undetermined small mammal, undetermined rodent. The material described here in detail is all that that was determined to genus or species with the exception of the avian eggshell that nevertheless merited further mention (Tables 4.4.2 and 4.4.3).

Microtus agrestis / arvalis

Three M_1s were identified as belonging to *Microtus agrestis / arvalis*. The two species *M. arvalis* and *M. agrestis* cannot easily be distinguished on the morphology of their M_1 although their identity as this species pair is based on having five closed enamel triangles on the occlusal surface, and with well-developed 6th and 7th triangles (van Kolfschoten, 1985). Both species are characteristic of temperate grassland habitats (Macdonald & Barrett 1993). The species pair is common in Late Pleistocene and Holocene deposits (Sutcliffe and Kowalski, 1976) and so cannot be used to refine the age of the deposits at Cow Cave.

Microtus oeconomus

Three specimens of northern vole *M. oeconomus* have been found in Column D, Spits 1 and 4 and Column C, Spit 4. The northern vole is identified on the basis of

M_1s and has four closed triangles of enamel on the occlusal surface and a 5th triangle that is confluent with the anterior part of the tooth. Triangle 6 is poorly developed compared to triangle 7 (van Kolfschoten, 1985). The species has never been identified in deposits dating to the Holocene and is very common in the Late Pleistocene as well as the Middle Pleistocene. It has been claimed that they were not present in the UK during the last interglacial MIS 5e (Currant and Jacobi, 2011) but this would seem to be a result of a general lack of sieving of deposits of that age as one of the authors found several specimens of the species in Joint Mitnor which is the type site for the MIS 5e Mammal Assemblage Zone (pers. obs.). So while the species could indicate that they do not date to MIS 5e or the early Holocene they cannot be used to date the deposits as very little in the way of sediments in Britain have been sieved from these times. The preferred habitat of *M. oeconomus* today is grassland although wetter grassland than would be occupied by the field vole *M. agrestis* (Macdonald & Barrett 1993).

Undet. small Microtine */ Microtus* sp.

The species in the genus *Microtus* in NW Europe are all characteristic of relatively open habitats with grasslands. The precise identity has not been possible to establish with the specimens put in this category because they are either very fragmentary or are not M_1s where the identity is most easily established. The specimens described as undet. microtines (Appendix B and C) are probably mostly represented by members of the genus *Microtus* although they were not identified as such due to their fragmentary nature hence requiring caution.

Clethrionomys sp.

The rooted microtine molar in Column C, Spit 1 is clearly that of a member of the genus *Clethrionomys* with its open, rounded enamel triangles with continuous cementum in occlusal view (van Kolfschoten, 1985). There are 3 species in the genus *Clethrionomys* in Europe today (*C. glareolus*, *C. rufocanus* and *C. rutilus*) which could all be represented here. However, it may be likely that it represents the bank vole *C. glareolus,* the species found in the UK today, especially because it comes from the uppermost spit of Column C which is likely to be Holocene in age and the bank vole is usually taken to indicate temperate woodland environments. This cannot easily be proved as the possibility that the specimen represents either *C. rufocanus* or *C. rutilus* exists and would in such cases indicate tundra and Boreal forests respectively (Macdonald & Barrett 1993).

Dicrostonys torquatus

The single molar identified as that of *Dicrostonyx torquatus* has the characteristic acutely angled enamel triangles seen on the occlusal surfaces. These triangles do not have enamel along their continuous surface in *Dicrostonyx* further confirming their identification. The species was found in Column A, Spit 6. The ecology of this species today is continental tundra and is found in the treeless north of Siberia. *Dicrostonyx torquatus* is often very common in Late Pleistocene deposits of North West Europe being found in sediments dating to before, during and after the LGM (Brace *et al*. 2012).

Apodemus sp.

The lower M1 of the murid recovered from Column B, Spit 2 would appear to be that of *Apodemus* due to having three cusps on the anterior part of the M_1 (Lawrence and Brown 1967). The species represented has not been established as yet and would require measurements (Stewart and Parfitt, 2006) although the sizes of both species are thought to vary during the Quaternary (van Kolfschoten, 1985). However, the two likely candidate species are *A. sylvaticus* and *A. flavicollis*, which are both characteristic of temperate forests in North West Europe today, so the precise identity is not necessary for a palaeoecological inference (Macdonald & Barrett 1993).

Lepus sp.

The molar definitively identified as that of *Lepus* is from Column A, Spit 6. The distinction of the two NW European species of hare would refine the palaeoecological interpretation that could be made from the specimen as arctic hare *L. timidus* is the dominant Late Pleistocene species and is generally associated with colder habitats than *L. europaeus* (Smith et al., In press). However, in the recent study of aDNA of hares from the region a number of specimens turned out to belong to *L. europaeus* the brown hare (Smith et al., In press). So further identification of this solitary molar would seem unreliable. Hares in general live in open grassland habitats today (Macdonald & Barrett 1993).

Sorex. sp.

There are a number of specimens, mostly teeth, that represent the shrew genus *Sorex* although some may strictly need to be described as Soricid (and so could potentially belong to water shrew *Neomys* or even other taxa) as they are fragmentary or represent post cranial elements such as the distal humerus from the south wall Microfaunal Bone Cluster sample. There are in addition some very fragmentary specimens of mostly teeth that are clearly those of insectivorous small mammals but that may not be shrews and could belong to bats Chiroptera (Table 4.4.2 and 4.4.3). The problem with distinguishing the different species of the genus *Sorex* is that it has recently been shown that the characteristics often used for identifying them, which is often size, are likely to be unreliable as this varies through time (Prost *et al*., 2013). Therefore the material will not be identified further. The habitats used by members of the genus *Sorex* are broad and can include temperate forests to tundra as the presence of the cold adapted tundra shrew (*S. tundrensis*) has been confirmed in Germany (Prost *et al.* 2013). *S. tundrensis* is today is restricted to Siberia and the specimens that were identified as belonging to it by aDNA analysis had been identified as belonging to the common shrew group *S. araneus*/*coronatus* on the basis of size. The material that was identified as a larger species turned out to belong to modern common shrew (Prost et al. 2013). The latter is why the *Sorex* material cannot be reliably used to infer habitat although the presence of insectivores has been seen to increase during interstadials of the Late Pleistocene of North West Europe (Stewart and Parfitt 2011).

cf. Talpa sp.

The tooth tentatively referred to the mole genus *Talpa* is fragmentary and needs further examining with more reference material. However, if it can be confirmed to represent that of *Talpa* it would suggest that milder conditions may have been present at that time although they are known from the Late Pleistocene in North West Europe (Stewart and Parfitt 2011). Moles also avoid wet ground suggesting well drained areas in the vicinity.

Avian Eggshell

Eggshell belonging to that of one or more large birds was found in a number of samples (see Tables 4.4.2, 4.4.3). It has not been possible to determine the type of bird that produced this eggshell although the thickness suggests that it represents a large bird. It is tempting to think that it belongs to that of a domestic fowl as this is the most commonly found eggshell on archaeological sites (Stewart *et al*., 2013). The reason for mentioning the latter is that it would then be indicative of an Iron Age or post-Iron Age origin (post *ca*. 3200 years BP – the timing of arrival of the chicken in Britain – Best et al., 2016) and maybe suggesting some mixing of material in the sediments containing it. The latter is by no means certain although a note of caution is needed because of the possible concern it raises.

Undet Passeriforme

In addition to the *Turdus* material described above, a number of specimens cannot be securely assigned to species or even family within the Passeriformes (see Table 4.4.2). Passeriformes are notoriously difficult to identify and little interpretation of such undetermined material can be made as there are many species in the group occurring in a great variety of habitats including deciduous and coniferous woodland as well as open habitats such as marshland, tundra, grasslands, moorland etc.

Anguilla anguilla Eel

The eel was represented by a vertebra in the sample from Column A, Spit 12. Eel vertebrae are very distinct among fish vertebrae. The eel is a catadromous fish (lives in fresh water but spawns in the sea) and is therefore ambiguous as to its indications regarding the nature of the waterbody that it may represent palaeoecologically. The present specimen could be indicative of a local standing or flowing freshwater body or alternatively have an estuarine or even fully marine origin.

4.4.3. Conclusion

The Cow Cave vertebrate assemblage (including fish, birds and small and large mammals) is not particularly rich in material identifiable to species or genus. However, the assemblage does have some notable and relatively clear suggestions of distinctive palaeoecologies. The most distinct being the collared lemming which is only found today in Northern Siberia and represents continental tundra conditions. The northern vole which is considered a humid continental species by Cordy (Cordy, 1991) while the *M. agrestis / arvalis* he considers to be indicative of temperate grasslands. The wood mouse/yellow-necked mouse *Apodemus sylvaticus*/*flavicolis* is suggestive of temperate closed habitats and the *Clethrionomys* sp. may also be if it belongs to *C. glareolus*. The other taxa are mostly identified to a level that is too imprecise for interpretation and/or they are broadly adapted and cannot be reliably used to interpret the sediments at Cow Cave.

Column	Spit	Undetermined Large Mammal	Small Vertebrate	Med. Mam/bird	Bovid/Cervid	*Ursus* sp.	Anuran	*Turdus* sp.	Passerine *Turdus* size
A	10	1	-	-	-	-	-	-	-
A	11	1	-	-	-	-	-	-	-
B	4	1	-	-	-	-	-	-	-
BN	2	1	-	-	-	-	-	-	-
C	1	2	-	-	-	-	-	1	-
C	2-3	1	-	-	-	-	-	-	-
C	3	7	-	-	-	-	-	-	-
C	4	2	-	-	-	-	-	-	-
C	5	2	1		1?	-	2	-	-
C	6	3	-	-	1	-	-	-	-
C	7	2	-	-	-	-	-	-	-
C	13		-	2	-	-	-	-	-
Section C	Central Pipe/Burrow	1	-	-	-	-	-	-	-
Section C	Stalagmite Breccia	1	-	-	-	-	-	-	-
Section C	Stream Deposit	-	-	-	-	-	-	-	1
Alcove	Stream Deposit	-	-	-	1	1	-	-	-
Cave Floor Trench		-	-	-	-	-	-	-	-

Table 4.4.1. Larger Bone – Hand collected.

Column	Spit	Size Fraction	*Cf. Talpa*	Soricid / Chiroptera	*Sorex* sp.	Small carnivore	*M. oeconomus*	*M. arvalis* / *agrestis*	*Undet.* small *Microtine* / *Microtus* sp.	*Clethrionomys* sp.	*Lepus* sp.	Bird Eggshell	Passerine *Turdus* size	Passerine *Passer* size	*Anguilla anguilla*	Fish	Total Vertebrate remains
A	1	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46
A	2	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
A	3	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
A	4	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
A	5	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
A	6	4mm	-	-	-	-	-	-	-	-	1	-	-	-	-	-	7
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17
A	7	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		2mm	-	-	-	-	-	-	-	-	-	4	-	-	-	-	14
A	8	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
A	9	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	53
A	10	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	16
A	11	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
		2mm	-		-	-	-	-	1	-	-	-	-	-	-	-	17
A	12	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		2mm	-	-	-	-	-	-	2	-	-	-	-	-	1	-	39
A	13	4mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	8
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	18
B	2*	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29

		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	>50
B	3	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38
		2mm	-	1	-	1	-	-	6	-	-	-	-	-	-	-	>100
B	4	4mm	-	-	-	-	-	-	-	-	1?	-	-	-	-	-	43
		2mm	-	-	-	1	-	-	1	-	-	-	-	-	-	-	>100
B	5	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	>50
B	6	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	80
BN	2*	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40
		2mm	-	-	-	-	-	1	4	-	-	-	-	-	-	-	>100
C	1	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
		2mm	-	-	-	1	-	-	-	1	-	-	-	3	-	-	>100
C	2	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14
		2mm	-	-	1	-	-	-	-	-	-	-	-	-	-	-	>100
C	3	4mm	-	-	1	-	-	-	-	-	-	-	-	-	-	-	29
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	>100
C	4	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47
		2mm	-	-	-	-	1	-	-	-	-	-	1	-	-	-	>100
C	5	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	>50
C	6	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22
C	7	4mm	-	-	-	-	-	-	-	-	1?	-	-	-	-	-	6
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
C	8	4mm	-	-	-	-	-	-	-	-	-	-	1	-	-	-	9
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	9
C	9	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		2mm	-	-	-	-	-	-	1	-	-	-	-	-	-	-	14
C	10	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
C	11	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8

C	14	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
CS	7**	4mm		-	-	-	-	-	-	-	-	-	-	-	-	-	11
		2mm		-	-	-	-	-	-	-	-	-	-	-	-	-	47
D	1	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	1	-	-	1	-	-	-	-	-	-	-	-	-	27
D	2	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		2mm	-	-	-	-	-	-	3	-	-	-	-	-	-	-	149
D	3	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	1	23
		2mm	-	-	-	-	-	1	-	-	-	-	-	-	-	5?	>100
D	4	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19
		2mm	1	-	-	-	-	-	-	-	-	-	-	-	-	1	69
Section C	DBF ***	4mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20
		2mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	103
South Face	MBC ****	4mm	-	-	-	-	-	1	-	-	-	-	-	-	-	-	23
		2mm	-	1	1	-	-	-	1	-	-	-	-	-	-	-	>100

Notes: * - from 2 separate bags; ** Column C spit 7 south; *** - Dark Burrow Fill; **** - Microfaunal Bone Cluster.

Table 4.4.2. Small Bone – Sieved to 4 and 2 mm.

Column	Spit	Soricid / Chiroptera	*Sorex* sp.	*Undet.* small *Microtine* / *Microtus* sp.	*Dicrostonyx* sp.	Murid (*Apodemus* sp.)	Bird Eggshell	Fish	Presence of Vertebrates
A	1	2	2	2	-	-	-	1?	Yes
A	2	-	-	1	-	-	-	-	Yes
A	3	-	-	5	-	-	-	1?	Yes
A	4	-	-	3	-	-	-	-	Yes
A	6	-	-	3	1	-	-	-	Yes
A	7	-	-	-	-	-	1	-	Yes
A	8	-	-	-	-	-	+	-	Yes
A	9	-	-	6	-	-	+	-	Yes
A	10	-	-	2	-	-	+	-	Yes
A	11	-	-	2	-	-	-	-	Yes
A	12	-		-	-	-	-	-	-
A	13	-	-	5	-	-	-	-	Yes
B	2*	1	-	12	-	1	-	-	Yes
B	3	-	-	5	-	-	2	-	Yes
B	4	-	-	6	-	-	-	-	Yes
B	5	-	-	9	-	-	-	-	Yes
B	6	-	-	7	-	-	-	-	Yes
C	1	-	-	4	-	-	-	-	Yes
C	2	-	-	-	-	-	+	-	-
C	3	-	-	3	-	-	+	-	Yes
C	4	-	-	2	-	-	+	-	Yes
C	5	-	-	5	-	-	-	-	Yes
C	6	1	-	1	-	-	-	-	Yes
C	7	-	-	2	-	-	-	-	Yes
C	8	-	-	5	-	-	+?	-	Yes
C	9	-	-	3	-	-	-	-	Yes
C	10	-	-	2	-	-	-	-	Yes
C	11	-	-	1	-	-	-	-	Yes
C	12	-	-	6	-	-	-	-	Yes
C	13	1		2	-	-	-	-	Yes
C	14	-	-	3	-	-	-	-	Yes
D	1	-	-	2	-	-	-	-	Yes
D	2	-	-	4	-	-	+	-	Yes
D	3	-	-	2	-	-	-	-	Yes
D	4	-	-	2	-	-	-	-	Yes

Notes: * - from 4 separate bags.

Table 4.4.3. Small Bone – Sieved to 0.5 mm.

4.4.4. Previously recovered mammals.

Chris Proctor.

A small assemblage of large mammal remains were recovered from the cave in the early 2000's by John and Bruce Boulton, following collapse of the overhanging Reindeer Stratum face which exposed a significant quantity of bone and led to some of it falling onto the floor. This material was collected up and passed on to English Heritage, where identification by Danielle Schreve was arranged before the bones were returned to the Boultons. Due to the very limited recovery during the 2016 investigation of identifiable megafauna from the Reindeer Stratum worth ^{14}C dating, the decision was made to utilise the material collected earlier to provide a larger sample for dating.

The 2000's material was collected from two areas, the "lower area of recovery", and the "upper area of recovery". The upper area of recovery is the more important: it was an area of the Reindeer Stratum sediment face on the south side of Section C. It corresponds to the loose patch of sediment that was later excavated in this investigation as Column D; and an area extending up and to the right from column D at about the same stratigraphic level towards column C. As such this material can be referred to the same bone rich level sampled in column B spits 5 and 6, column C spits 3-7, and column D. All this material was collected from the crumbling, but *in situ* Reindeer Stratum face.

The lower area of recovery consisted of a scatter of material lying on the floor below. Most of this was certainly loose material from the Reindeer Stratum which had fallen from the unstable sediment face above. However one, a bear femoral head, no. 0202, was recovered from an *in situ* context in the Stream Deposit.

Table 4.4.4 lists the bones recovered. As only the upper area of recovery included Reindeer Stratum material from an *in situ* context, material from this area was selected for ^{14}C dating. Details of the samples used and results obtained are given in the radiocarbon dating report (section 4.9). As this material had been drawn into this project its proper curation was treated as part of the remit of this investigation and it has been added to the material archive.

	Description	Area of recovery	Stratum	Comments
0201	1 complete and 1 fragmentary vertebra of Frog or Toad (Anura sp.)	Lower area	Reindeer Stratum?	Prob. not in situ
0202	?Left femoral head of adult bear, probably Brown Bear (*Ursus* cf. *arctos*)	Lower area	Stream Deposit	
0203	Fragment of vertebral centrum of *Ursus* sp.	Lower area	Reindeer Stratum?	Prob. not in situ
0204	Proximal 3rd phalanx of *Ursus* sp.	Lower area	Reindeer Stratum?	Prob. not in situ
0205	Tine tip fragment of cf. Reindeer (*Rangifer tarandus*)	Lower area	Reindeer Stratum?	Prob. not in situ
0206	Undetermined bone (including rib) and antler fragments	Lower area	Reindeer Stratum?	Prob. not in situ
0207	Several rib fragments of large mammal, cf Bovid but lacking diagnostic proximal end	Upper area	Reindeer Stratum	
0208	Posterior midshaft fragment of metacarpal or metatarsal of Cervid, cf. Red Deer (*Cervus elaphus*)	Upper area	Reindeer Stratum	
0209a	Distal articular condoyle of metapodial of Bear (*Ursus* sp)	Upper area	Reindeer Stratum	
0209b	Distal articular condoyle of metapodial of Bear (*Ursus* sp)	Upper area	Reindeer Stratum	
0210	Distal fragment of 1st phalanx of Bovid, cf. *Bison*	Upper area	Reindeer Stratum	
0211	Sesamoid of large Bovid, *Bos* or *Bison*	Upper area	Reindeer Stratum	
0212	Fragment of molar of large Cervid or Bovid	Upper area	Reindeer Stratum	
0213	Fragment of vertebral centrum of large mammal, juvenile	Upper area	Reindeer Stratum	
0214	Fragment of cervical vertebral centrum, cf. Bear (*Ursus* sp.), gnawed	Upper area	Reindeer Stratum	
0215	1 unshed antler of young Cervid, cf. Reindeer (*Rangifer tarandus*)	Upper area	Reindeer Stratum	
0216	1 unshed antler base of Cervid (pedicle and burr), cf. *Cervus elaphus*	Upper area	Reindeer Stratum	
0217a	Antler fragment of Reindeer (*Rangifer tarandus*)	Upper area	Reindeer Stratum	
0217b	Antler fragment of Reindeer (*Rangifer tarandus*)	Upper area	Reindeer Stratum	
0217c	Cervid, antler fragments	Upper area	Reindeer Stratum	
0218	Fragment of thoracic vertebra and neural spine of cf. Bear (*Ursus*)	Upper area	Reindeer Stratum	

Table 4.4.4. Mammal bones form the 2000's recovery collection. Identifications provided by Danielle Schreve (pers. comm).

4.5. Herpetofauna.

Chris Gleed-Owen

4.5.1. Introduction

CGO Ecology Ltd was instructed by Devon County Council to identify the herpetofaunal remains from a rescue excavation at Cow Cave, Chudleigh, Devon (SX 865 787). The work is a Heritage at Risk project funded by Historic England through Devon County Council. An interim report was produced by Proctor (2016). The excavations were carried out in early 2016, and the post-excavation analyses were conducted throughout 2016.

Faunal remains were picked from larger (>2mm) sieved residues by Chris and Janet Proctor: small residues (<2mm) and flots were processed by John Stewart and Monika Knul at Bournemouth University, and forwarded to the current author for herpetofaunal study. The following sequences were examined from excavations in Section C of the cave: Columns A, B, C, D; and the Dark Burrow Fill sample from the central stalagmite-lined pipe/burrow. A further sample from the south wall of the inner chamber was examined; the Microfaunal Bone Cluster sample.

This report describes the findings, and is a contribution towards the final report.

4.5.2. Methodology

The herpetofaunal remains were received from John Stewart (Bournemouth University), curated in small bags and tubes, labelled with Section, Column, Spit, sieve fraction, and any faunal subdivision attempted. Some herpetofaunal remains had been separated and labelled as such, but many others were identified from undifferentiated bone assemblages.

The material was examined under low-power binocular microscope, at x5 to x32 magnification, identified to the highest taxonomic level possible, and described using methods and terminology set out elsewhere (Gleed-Owen, 1998, 2014). Elements were generally identified as accurately as possible, sexed and sided where possible and relevant. For fragmentary anuran amphibian remains, identification was less rigorous, and number of identifiable specimens (NISP) estimated.

Following study, the bones were returned to the same bags/tubes. Results were tabulated in a Microsoft Excel spreadsheet, which should be referred to for full osteological descriptions if needed.

4.5.3. Results

Five species were identified: three amphibians (common toad *Bufo bufo*, natterjack toad *Epidalea calamita*, common frog *Rana temporaria*) and two reptiles (slow-worm *Anguis fragilis*, grass snake *Natrix natrix*). NISP for each species is as follows:

common toad 81, natterjack 30, common frog 14, indeterminate toad 364, indeterminate anuran 509, slow- worm 442, grass snake 2.

4.5.4. Discussion and conclusions

In Column A, remains were relatively scarce, comprising a single natterjack occurrence lower down, common toad higher up, slow-worm intermittent throughout, and a single common frog bone at the top. The whole sequence appears temperate, possibly an early to middle-Holocene succession from open to wooded landscape.

Remains in Column B were more abundant. Natterjack was intermittent (mostly present lower down), but common toad, common frog and slow-worm were present throughout. The whole sequence is temperate, and again may indicate succession to closed vegetation.

In column C, remains are reasonably abundant, with common toad, common frog and slow-worm throughout, but natterjack only near the top, and grass snake towards the top. The sequence is temperate throughout.

Column D contained only common toad, common frog and slow-worm.

The Dark Burrow Fill (from the central stalagmite-lined pipe/burrow) produced common toad, natterjack, common frog, and slow-worm, a temperate assemblage. The Microfaunal Bone Cluster sample contained common toad, natterjack, and common frog, from a temperate phase.

The amphibian remains are a mixture of adult, subadult and juvenile, including some very small post-metamorphic individuals.

The slow-worm remains are mostly osteoderms, and some vertebrae, as is usual in subfossil contexts. Each animal has around 5,000 osteoderms, and around 200 vertebrae, thus is over-represented by osteoderms.

There is evidence of digestion and predator-related crunching in bones throughout the sequences studied. Therefore, in addition to individuals entering the cave of their own accord, agents of accumulation may include raptors and/or mustelids.

A natterjack humerus from the Dark Burrow Fill sample was AMS-dated to 1049±24 years BP (uncal) (OxA-34821), which is much later than previous dated occurrences of this species in Devon. The youngest known occurrence of natterjack otherwise is at Broken Cavern in the Torbryan Valley, associated with dates of 4430±60 years BP (uncal) (OxA-6954) and 4540±65 years BP (uncal) (OxA-6953) from the same layer.

Natterjack, common toad, common frog and slow-worm were previously identified from the Simons material curated at the Natural History Museum (London), and adder *Vipera berus* was also identified (Gleed-Owen, 1998; Holman, 1988). An AMS date on natterjack from ‘Layer IV’ (the Reindeer Stratum) of the Simons excavations gave an age of 9270±70 years BP (uncal) (OxA-6992) (Gleed-Owen, 1998).

The herpetofaunal findings of the current project bear comparison with the previous work on Simons' material, and on other caves in southwest Britain (see Gleed-Owen, 1998). Natterjack toad appeared in the Lateglacial Interstadial in southwest Britain, and again in the earliest Holocene, before common toad arrived from the continent. Thus, presence of natterjack in the absence of common toad, could be a potential indicator of Lateglacial or earliest Holocene age. However, in the current study, there is insufficient consistency in the vertical occurrence patterns to be so bold.

Section	Column	Spit	Frac [mm]	Bufo bufo	Epidalea calamita	Bufonidae	Rana temporaria	Rana sp	Anura	Anguis fragilis	Natrix natrix	Predation
C	A	1	0.25	1					3	16		
C	A	1	0.5			1			>100?	57		
C	A	1	2	4		7		1	c.12+	1		
C	A	1	4			2			2			Y
C	A	2	0.25						0-5?	2		
C	A	2	0.5						3			
C	A	3	0.25	1		1			c.5			
C	A	3	0.5						1			
C	A	3	2						1			
C	A	4	0.5			1						
C	A	6	0.25							1-3?		
C	A	6	0.5						0-5?			
C	A	7	2			1						
C	A	8	0.5						1-5?			
C	A	8	2		[1]							
C	A	9	0.5						1-5?			
C	A	10	0.5						1			
C	A	11	0.5						1-5?			
C	A	11	2						1			
C	A	12	0.5							2		
C	A	12	2						2			
C	A	12	4						1			
C	A	13	0.5			1		2	2			
C	B	2 bag1	0.5			1			7	15		
C	B	2 bag1	0.5	1					9	4		
C	B	2 bag1	2			4			20-30	2		Y
C	B	2 bag1	4		3	5			6			
C	B	2 bag2	0.5			5			4	13		
C	B	2 bag2	2	[1]					1	1		
C	B	2 bag2	2			4	1		c.10+			Y
C	B	2 bag2	4			2						
C	B	2 bag3	0.5					1	c.5	2		
C	B	2 bag4	0.5			1		1	c.10	11		Y
C	B	2 N bag1	2			2		1	1			
C	B	2 N bag1	2	1,		4			c.25+	4		
C	B	2 N bag1	4			2						
C	B	2 N bag1	4	1		7			2			
C	B	2 N bag2	2			4		2	2			
C	B	2 N bag2	4	1								
C	B	3	0.5			7			c.10+	32		Y
C	B	3	2			1		1		1		
C	B	3	2	[1]		c.100+				16		
C	B	3	4	2,					1			Y
C	B	4	0.5	[2]		17		1	c.16	54		Y
C	B	4	2	1		2				3		
C	B	4	2	2,	1,					5		Y
C	B	4	4		1				2	1		
C	B	4	4	[1]	1	2			4			Y
C	B	5	0.5			c.5+		4	c.10?	30		Y

C	B	5	2	2	4	c.40+	1			2		Y
C	B	5	4			2		1				
C	B	5	4	1								
C	B	5	4		1	1						
C	B	6	0.5			2			c.5	9		
C	B	6	2						1	1		
C	B	6	2			1						
C	B	6	4	1		1			1			Y
C	C	1	0.5				1		17	16		Y
C	C	1	2	3		7		1	c.6+	2		Y
C	C	1	4					1				
C	C	2	0.5			3		1	11	18		
C	C	2	2							2		
C	C	2	2		[1]	6		4	7	1		Y
C	C	2	4	1								
C	C	2	4	1		1			1		1	
C	C	3	0.5	3		1			c.30	41		
C	C	3	2			3		3	2		1	
C	C	3	2	1		c.10+			c.10+	2		
C	C	3	4	[1]				1				
C	C	4	0.5			1		3	c.25	23		
C	C	4	2	[4]						3		
C	C	4	2	1,		c.10	[1]		c.30	10		Y
C	C	4	4	1					2			
C	C	4	4	[2]		3		1	1	1		
C	C	5	0.5						c.5	18		
C	C	5	2						1	2		
C	C	5	2	1						2		
C	C	7	0.5						1			
C	D	2	2			1		1				
C	D	2	4				[1]					Y
C	D	3	0.5							1		
C	D	3	2						1			
C	D	3	2	1		1			2			
C	D	3	4			1						
C	D	4	0.5						c.1-5			
C	D	4	2						2			
C	DBF		0.25	2		7			2	6		Y
C	DBF		0.5	2		c.30+			c.5	7		Y
C	DBF		2			2						
C	DBF		2	6		c.22+		1	c.12+	1		Y
C	DBF		4					1				
C	DBF		4	1	3	4			6			
S wall	MBC		0.25	[1]		c.10		1	c.10			
S wall	MBC		0.5	c.15				1	c.10			Y
S wall	MBC		2			1						
S wall	MBC		2	4	123		6					
S wall	MBC		4	1	1	4	3	4	7			

Table 4.5.1. Herpetofaunal remains from CC16, with NISP per species for each sample/fraction. Figures in square brackets are 'cf' identification. DBF = Dark Burrow Fill sample. MBC = Microfaunal Bone Cluster sample.

4.6. Molluscs from the 2016 excavations from Cow Cave

Chris O. Hunt

4.6.1. Introduction

This report describes and interprets land mollusc shell from the 2016 excavations at Cow Cave. Sampling details are noted in Proctor (2016). Material was sorted after wet-sieving and pollen analysis and includes all fragments over 2 mm. The shell fragments were identified with the help of a comparative collection and dissecting microscope.

4.6.2. The Molluscs

The molluscs are shown in Table 4.6.1. All material was fragmentary and most showed pitting and edge-rounding consistent with long burial in a slightly corrosive environment. Rare 'fresh'-looking fragments are identified as such in the table. Most material consists of flakes of body-whorls of large mollusc shells, most likely Helicids such as *Helix aspersa, Cepea* spp., or *Arianta arbustorum*. In a few cases microsculpture and/or colour-banding allows tentative taxonomic assignation. Most large landsnail fragments not assigned to taxon are likely to relate to one of the *Cepea* spp., but this is on lack of microsculpture rather than positive identification.

Of note also is the presence of avian eggshell fragments in many samples. These were highly corroded but recognisable as such. No assignation to species could be made, however.

4.6.3. Interpretation

The fragmentary and corroded nature of most of these remains makes interpretation problematical but point to a complex taphonomy. A note of caution must be sounded about the integrity of the deposits: two fragments of very 'fresh'-looking shell were recovered, one from low in Sample Column B and one from the top of Sample Column C. These may reflect insufficient cleaning of the sediment face, or the presence of an unseen crack in the deposits allowing recent material to infiltrate, or burrows, but they may also reflect the propensity of molluscs to insert themselves into voids of all sizes for shelter. The largest assemblage, from the 'stalagmite-lined burrow' in Section C, certainly seems to relate to a burrow. Other than this, the common pitting and edge-rounding is consistent with long burial in a slightly corrosive environment, but the edge-rounding may also be consistent with transport as fragmentary material. Unfortunately fragmentation is too extreme to be able to attribute it to bird or rodent predation – both are possible but breakage by transport processes or during excavation and-or processing is also likely. The cave sediments appear to be largely colluvial in origin and it is likely that at least some of the shell fragments arrived in the cave as soils were relocated by colluviation.

Ecologically, all these taxa are associated with vegetated habitats – long herbaceous vegetation, scrub and woodland – and to varying degrees with rock-rubble and scree. It is also possible that some specimens, though probably not *Arianta* or *Leiostyla* (which are not known troglophiles: Hunt 1992; Weigand 2014; Hunt & Hill, in press), were living in the cave.

Chronologically, the key species is *Helix aspersa*, which seems to have appeared in Southern Britain during the Iron Age (Kerney 1977). Its presence low in Section A points to a relatively recent fill of a burrow in that location, as it does in the more obvious burrow in Section C.

Climatically, all the taxa reported here are taxa we would associate with temperate (interglacial or interstadial) environments (Hunt 1989). This of course does not necessarily mean that the spits containing mollusc remains relate to temperate environments. It is equally possible that the deposits formed by mass movement processes during stadials but incorporated relocated soils which had formed - and accumulated mollusc shell – during temperate phases.

It might be suggested from their stratigraphic position that the specimens from Sample Column B and Spit 1 in Sample Column C reflect Holocene faunas. The presence of molluscs and avian eggshell in Sample Column A, spit 6 and spits 9-10 and possibly in Sample Column C spit 11, and in the breccia 160 beneath the 148 ka stal floor point to a series of interstadial episodes, with the intervening spits, which appear to contain no appreciable mollusc remains, relating only to cold-stage sedimentation.

The 'pipe/burrow fill' of Column D does contain a few fragments of mollusc shell, but these are very corroded, *Helix aspersa* is not present and it might therefore be suggested that these are not recently-arrived deposits.

4.6.4. Conclusion

Mollusc remains from Cow Cave are sparse and fragmentary. There are suggestions that these sections contain material originating during the Holocene, from two or possibly three Devensian interstadial periods and one episode sometime in early OIS6 or late OIS7. It is clear from the distribution of fragments of *Helix aspersa* that the sediments were somewhat burrowed after the arrival of that species in the Iron Age. Unfortunately, the degraded, fragmentary nature of the mollusc remains precludes much further analysis. The faunas are so restricted that these conclusions can be regarded only as most tentative.

Column	**Spit**	Indet. large mollusc fragments	Fragments aff. *Cepaea* sp.	Fragments aff. *Arianta arbustorum*	Fragments aff. *Helix aspersa*	Fragments aff. *Oxychilus cellarius*	*Leiostyla anglica*	*Vitrea* sp.	Eggshell fragments	Speleothem crusts/fragments	Devonian shelly fossil fragments
A	**6**								1		
A	**9**	17							9		2
A	**10**	12							6		
A	**11**	1								2	
A	**12**	6		1	1				1	1	
B	**2N**	8									
B	**3**	3									
B	**4**	2									
B	**5**	4	1 (fresh)								
C	**1**					1 (fresh)					
C	**11**	1									
D	**2**	1							3		
D	**3**		2								
D	**4**								2		
Section C	**Dark Burrow Fill**			1	10 + 3 apices	1 apex (old)	1 apex				
Section C	**160, Broken Stalagmite Layer**							1 apex			
South wall	**Microfaunal Bone Cluster**	1									

Table 4.6.1. Mollusc remains from the 2016 excavations at Cow Cave. The last three listed samples are spot samples from Section C and the south wall of the inner chamber.

4.7. Palynology of Quaternary sediments from Cow Cave, Chudleigh Rocks, Devon

Chris O Hunt

4.7.1. Introduction

Palynological analysis of sediments from Cow Cave was done to help to resolve the age, origins and archaeological potential of the sedimentary bodies surviving in the cave. The work has wider significance, since there are few Pleistocene pollen records from Southwest England. Work concentrated on samples from Sample column A, Sample column C and the streamway deposits.

4.7.2. Methodology

Cave sediments are usually fairly sparsely palyniferous and the pollen is often very fragile and vulnerable to corrosion by the standard methods used by many palynologists, such as hydrofluoric acid digestion and acetolysis (Coles 1987). An extraction method devised by the author (Hunt 1985), which minimises exposure to corrosive chemicals, was therefore employed. Sediment samples of about 4 ml were boiled in sodium pyrophosphate solution, sieved on nominal 6 μm nylon mesh and swirled on a clock glass. For flowstone samples, a larger sample size of 10 ml was used and samples were decalcified in 10% hydrochloric acid before sieving on nominal 6 μm nylon mesh, boiling in sodium pyrophosphate solution, and sieving on nominal 6 μm nylon mesh. The organic residues from both procedures were stained with safranine and mounted in glycerol gelatin. They were examined using a binocular transmitted light microscope under magnifications of 400 and 1000 times and in sparse samples all pollen and other microfossils were counted. In those samples containing more than about 300 pollen grains, a known aliquot of the total sample was counted, with the remainder of the sample scanned to identify rarities. The analyses are presented in Tilia diagrams. Statistics were handled in SPSS, with cluster analysis using squared Euclidian distance, rescaling 0-1 and Ward's Method.

4.7.3. Results

Fourteen samples were processed from Sample column C, fourteen from Sample column A, plus one from the basal fluvial deposits. Those are shown in Table 4.7.1 and the pollen diagram is shown in Figure 4.7.1.

Sample code	Description	Location	Date sampled
0100	Column sample (= modern pollen sample)	Column A black skim from top	19/02/16
0101	Column sample	Column A spit 1 upper	19/02/16
0102	Column sample	Column A spit 1 lower	19/02/16
0104	Column sample	Column A spit 2 lower	19/02/16
0106	Column sample	Column A spit 3 lower	19/02/16
0108	Column sample	Column A spit 4 lower	19/02/16
0110	Column sample	Column A spit 5 lower	19/02/16
0112	Column sample	Column A spit 6 lower	19/02/16
0114	Column sample	Column A spit 7 lower	19/02/16
0116	Column sample	Column A spit 8 lower	19/02/16
0118	Column sample	Column A spit 9 lower	19/02/16
0120	Column sample	Column A spit 10 lower	19/02/16
0122	Column sample	Column A spit 11 lower	19/02/16
0124	Column sample	Column A spit 12 lower	19/02/16
0126	Column sample	Column C spit 1 upper	19/02/16
0128	Column sample	Column C spit 2 upper	19/02/16
0130	Column sample	Column C spit 3 upper	19/02/16
0132	Column sample	Column C spit 4 upper	19/02/16
0134	Column sample	Column C spit 5 upper	19/02/16
0136	Column sample	Column C spit 6 upper	19/02/16
0138	Column sample	Column C spit 7 upper	19/02/16
0140	Column sample	Column C spit 8 upper	19/02/16
0142	Column sample	Column C spit 9 upper	19/02/16
0144	Column sample	Column C spit 10 upper & lower	19/02/16
0146	Column sample	Column C spit 12 upper & lower	19/02/16
0148	Column sample	Column C spit 14 upper & lower	19/02/16
0038b	Fragment of clean stalagmite floor, upper part of Stalagmite breccia	Section C, GPS 550, 551	19/02/16
0160	Spot sample, Stalagmite breccia	Stalagmite Breccia, Section C	19/02/16
0162	Spot sample	Subsample of upper gravel, Trench	19/02/16

Table 4.7.1: Samples analysed from Cow Cave by date of report.

The pollen and microfossils from the cave can be divided into a number of pollen zones (Table 4.7.2; Figure 4.7.1). The groupings partly follow cluster analysis of the samples (Figure 4.7.2). These suggest a sequence of environmental events, discussed below.

Zone	Samples	Key taxa
G-1	162	Poaceae, Cyperaceae, *Pinus*, *Quercus*, *Polypodium*, *Corylus*/*Myrica*, *Empetrum* type, *Juniperus*, *Saxifraga*, Lactuceae, Diatoms, Type 119, Testates, VAM
C-1	160, 0038b	*Pinus*, *Polypodium*, Lactucae, Pteropsida, *Calluna* type, Cyperaceae, Poaceae, *Pteridium*, Testates, VAMs, Triassic-Lower Jurassic taxa
C-2	148, 146	Pteropsida, *Pinus*, *Polypodium*, *Juniperus*, Lactucae, Poaceae, Testates, VAMs, Triassic-Lower Jurassic, Carboniferous-Permian and Devonian-Lower Carboniferous taxa
C-3	144, 142	*Pinus*, Pteropsida, Lactucae, *Picea*, *Polypodium*, *Centaurea scabiosa*, *Listera cordata*, *Lycopodium clavatum*, *Bellis* type, *Botrychium*, Poaceae, Testates, Fungal zoospores, VAMs, Upper Cretaceous-Tertiary, Triassic-Lower Jurassic and Devonian-Lower Carboniferous taxa
C-4	140, 138	*Pinus*, Pteropsida, Lactucae, *Picea*, *Botrychium*, Poaceae, Testates, VAMs, Upper Cretaceous-Tertiary, Triassic-Lower Jurassic and Devonian-Lower Carboniferous taxa
C-5	136, 134	Pteropsida, *Pinus*, Lactucae, Testates, VAMs, Upper Cretaceous-Tertiary, Triassic-Lower Jurassic and Devonian-Lower Carboniferous taxa
C-6	132- 126	Lactuceae, Pteropsida, *Polypodium*, *Pinus*, *Corylus*/*Myrica*, *Empetrum* type, *Calluna* type, *Gentiana pneumonanthe*, *Bidens* type, *Botrychium*, *Centaurea nigra*, Poaceae, *Pteridium*, Testates, VAM, Upper Cretaceous-Tertiary, Triassic-Lower Jurassic taxa
A - 1	124-118	Lactucae, Pteropsida, *Pinus, Arctium* type, *Polypodium, Calluna* type, *Bellis* type, *Bidens* type, *Carduus* type, *Helianthemum, Serratula* type, Caryophyllaceae, *Pteridium,* VAMs, Fungal Zoospores, Triassic/Lower Jurassic and Carboniferous-Permian taxa
A - 2	116-108	Pteropsida, Lactucae, *Pinus, Blechnum, Dryopteris, Artemisia, Helianthemum,* VAMs, Fungal Zoospores, Triassic/Lower Jurassic, Upper Jurassic/Lower Cretaceous taxa
A - 3	106-100	Lactucae, Pteropsida, *Pinus, Polypodium, Pteridium, Calluna* type, *Bellis* type, *Succisa pratensis,* Fungal Zoospores, VAMs

Table 4.7.2: Pollen zonation.

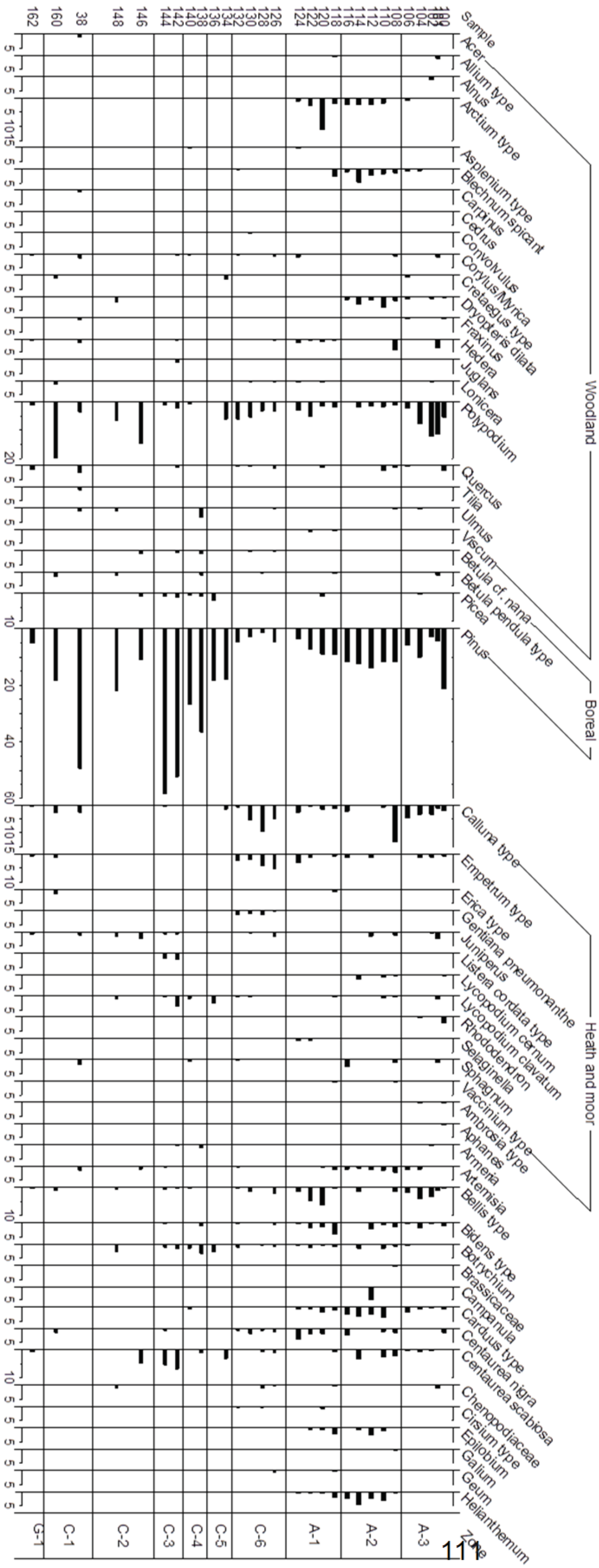

Figure 4.7.1. Palynology of samples from Cow Cave.

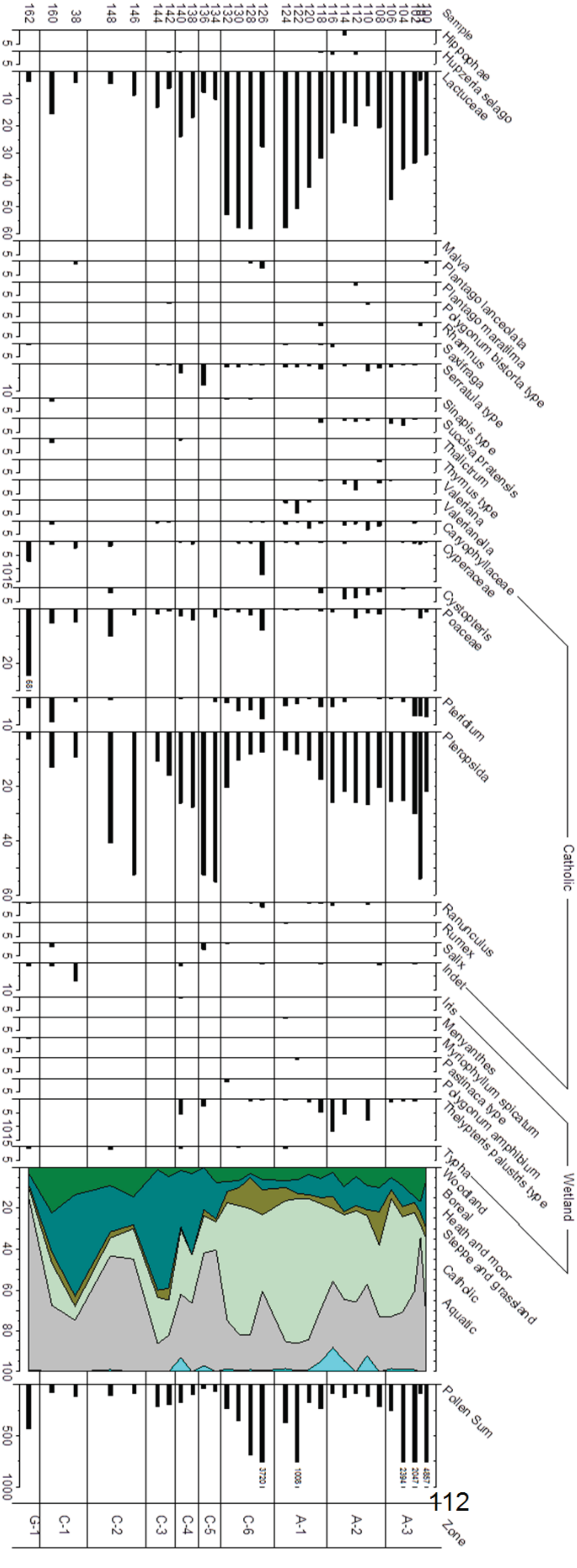

Figure 4.7.1. continued. Palynology of samples from Cow Cave

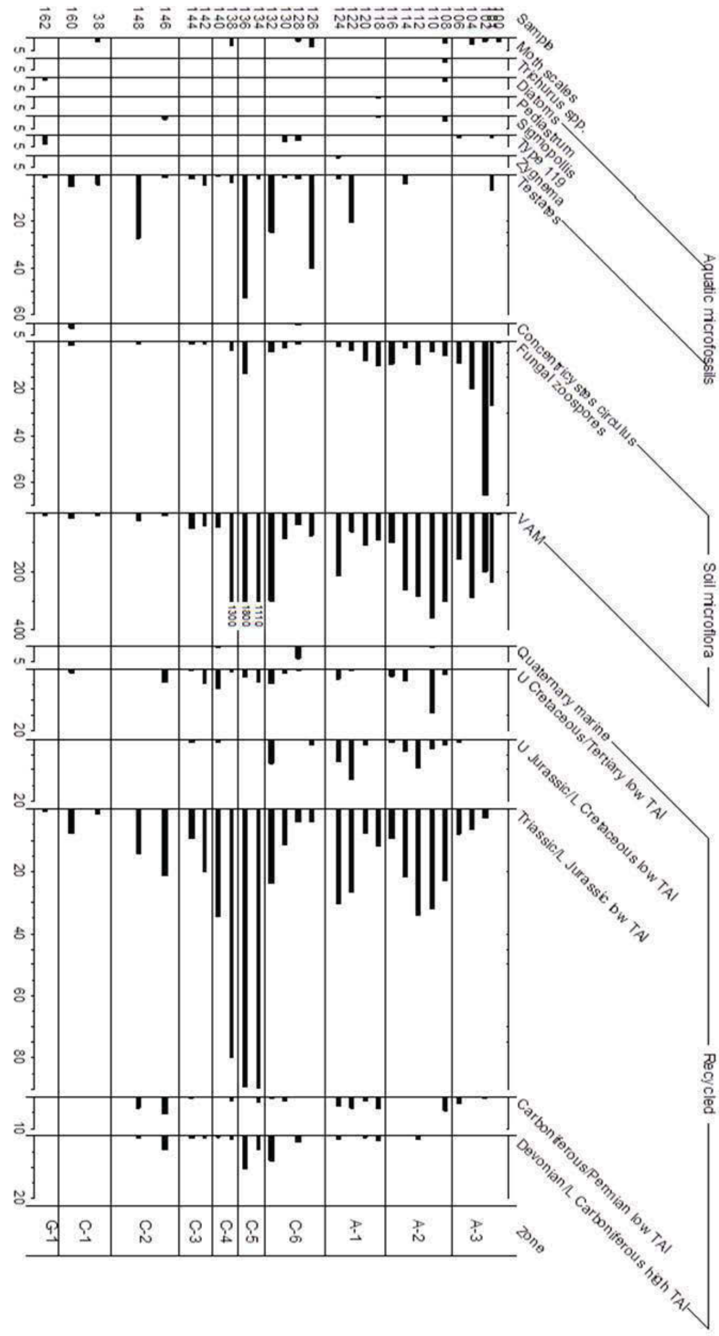

Figure 4.7.1 continued. Palynology of samples from Cow Cave

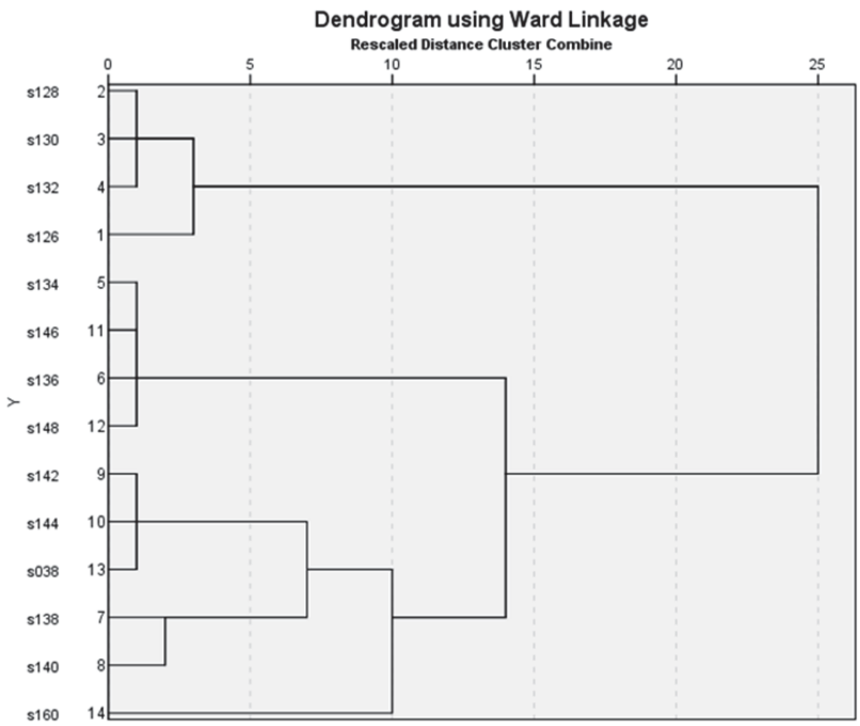

Figure 4.7.2: Wards Method dendrogram of samples from Cow Cave Sample column C

4.7.4. Pollen taphonomy

Taphonomy of cave sediments is very different from that in the types of depositional environments – bogs and lakes - most commonly studied by palynologists. Pollen may be directly deposited in caves by atmospheric fallout, but other depositional processes may also be important. These include deposition by running water, in mudflows and other mass-movements, and through the agency of insects, birds, animals and people. The depositional pattern will vary from cave to cave, and in any given cave through time, depending on the aspect relative to prevailing winds, geomorphology of the cave, the sedimentary processes operating at the time, activity of insect, animal and human populations, the cave-entrance flora and so on.

In the case of Cow Cave, the basal gravel unit, represented by sample 162, has sedimentological properties consistent with deposition by running water. The rest of the samples are from layers showing sedimentary features consistent with subaerial deposition.

The Cluster Analysis suggested that the three very common taxa - Pinus, Lactuceae and Pteropsida – had very different behaviour from the other taxa present (Figure 4.7.3). This is likely to be the result of the taphonomic properties of these taxa – they are known to be very resistant to corrosion and therefore may be over-represented in these samples. Other taphonomic issues are discussed below in the sections dealing with the pollen zones.

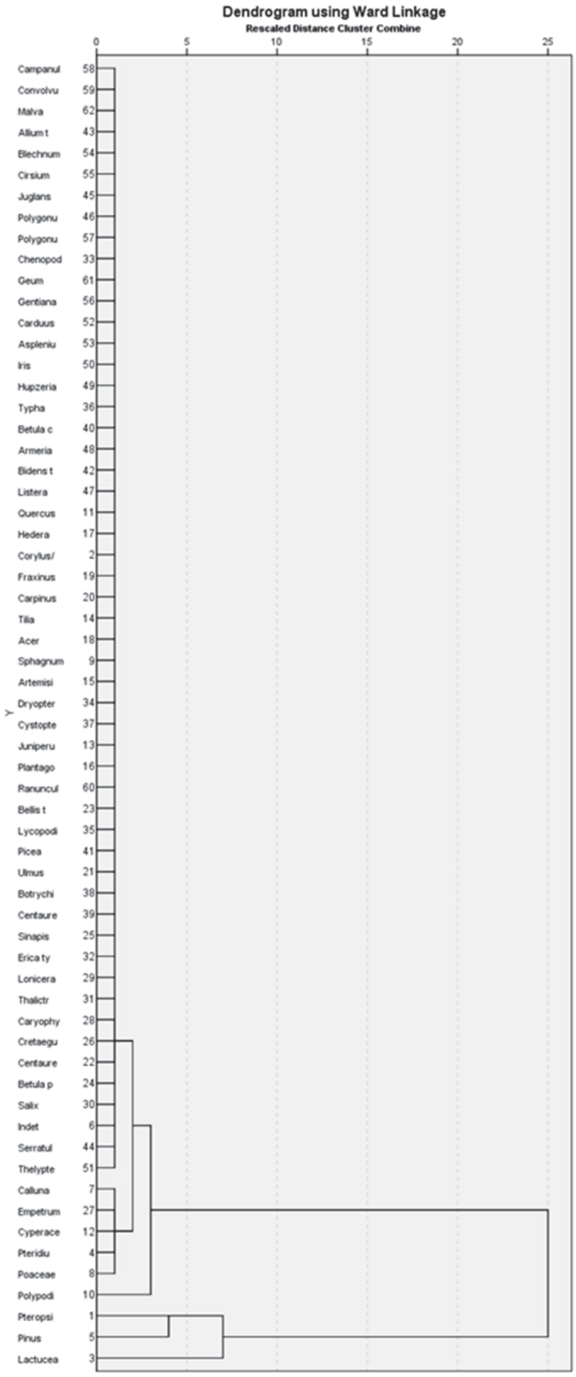

Figure 4.7.3: Ward's Method dendrogram of pollen taxa from Cow Cave Sample column C

4.7.5. Stratigraphic Implications, Palaeoecology and Depositional environments

Zone G-1: Basal Gravel

The lowest horizon sampled is the gravel deposit (Sample 162, Zone G-1). The pollen includes the emergent aquatic milfoil (*Myriophyllum*), abundant very small Poaceae grains probably attributable to reeds (*Phragmites*), willow (*Salix*) and the freshwater microfossil Type 119. This is compatible with deposition from a river, which was most probably shallow and with bankside reeds and willows. The combination of milfoil and Type 119 (which was first reported in eutrophic canals in Amsterdam) suggests quite eutrophic but well-oxygenated flowing water. Eutrophication might reflect inputs of nutrients, most likely dung or animal remains, into an otherwise clean river, in this pre-industrial period. This may thus be consistent with the finding of bones of large mammals in this unit. It is very likely, therefore, that the gravel unit reflects a time when the precursor of the Kate Brook flowed through the cave.

The presence of oak (*Quercus*), hazel type (*Corylus*/*Myrica*), polypody fern (*Polypodium*) and pine (*Pinus*) points to a temperate episode. Although the sample is dominated by Poaceae (grass family), over half the count for this taxon is of the very small grains probably generated by *Phragmites* (reeds) and thus may be partly reflecting the presence of riverine environments locally. The remaining Poaceae were probably generated by grasses and thus quite open vegetation close to the deposition site, although the tree pollen might reflect stands of trees at a distance. The proximity of large mammals, however, might suggest that the openness of the landscape reflected grazing rather than climate stress. The lack of recycled palynomorphs in this sample points to a stable landscape with little erosion, again characteristic of a temperate stage. Given other stratigraphic information it is likely that this sample can be referred to some part of OIS7. This is a climatically-complex stage, with a number of phases of 'interglacial' aspect, separated by phases characterised by more open environments and at present it is unclear when, within this stage, this sample was laid down. If the Kate Brook was flowing through the cave in OIS7, this suggests ~20 m of subsequent incision during the last ~200 ka.

Zone C-1: Breccia

Sample 0160, from the lower part of the stalagmite breccia lying beneath the thin broken stalagmite floor, contains pine (*Pinus*), birch (*Betula*) some heathland pollen (*Empetrum*-, *Calluna*- and *Erica*-types), some steppe or grassland species and some *Polypodium* spores. The presence of the soil organisms - Fungal zoospores, *Concentricystes circulus*, VAMs (symbiotes on the roots of plants and likely represented in this situation because of soil erosion), recycled pre-Quaternary palynomorphs from the Upper Cretaceous/Tertiary and Triassic/Lower Jurassic suggest some sediment mobility in the environment and potentially aeolian transport, probably quite localised, from the Triassic and Upper Cretaceous outcrops to the east. This is an ecologically mixed assemblage, perhaps consistent with the breakdown of woodland, the opening of vegetation and disturbance of soils at the end of a temperate phase. It can be assigned to an episode in the earlier part of OIS6 or very late OIS7 but is not of fully-interglacial aspect.

Zone C-1: Broken stalagmite floor

The 'anchor point' in the sequence is the mid-OIS6 U-Th dates of 160.8 ±3.2 and 176.2 +4.4/-3.9 ka in the thin broken stalagmite floor from which sample 0038b was derived (see section 4.10; of the two dates obtained on sample 0038, the lower estimate of 160.8 ±3.2 ka is considered the more reliable). This sample yielded an assemblage characterised by high pine (*Pinus*), temperate woodland taxa including oak (*Quercus*), hornbeam (*Carpinus*), ash (*Fraxinus*), lime (*Tilia*) and ivy (*Hedera*), heath and grassland species including juniper (*Juniperus*), heather (*Calluna* type), wormwood (*Artemisia*), grasses (Poaceae), plantain (*Plantago*), sedges (Cyperaceae) and *Sphagnum*. This suggests a fairly open pine woodland with some broadleaved trees and some areas of more open vegetation and probably reflects a major interstadial. Although the speleothem deposition reflects a vegetation cover and soil formation causing dissolution of carbonates, it is likely that soils were not completely stable during this episode because rare pre-Quaternary palynomorphs and VAMs are present. This pine-dominated assemblage is strongly reminiscent in character of an assemblage dominated by pine with some oak dated to 165 ka at Robin Hood's Cave, Creswell (Coles et al. 1985). These are likely to reflect the same mid-OIS6 interstadial, which is otherwise unreported in the UK, although visible, for instance, in the long pollen records from the Velay, France.

Zone C-2: Sample column C, Spits 14-12

It is likely that the breakage of the mid-MIS6 stalagmite floor occurred during the later, stadial part of OIS6, with the subsequent induration of this layer occurring in OIS5. Above this indurated layer, the deposits almost certainly accumulated through colluvial processes, and the pollen within them is therefore largely to be regarded as recycled. It nevertheless can give indications of pollen rain outside the cave during a sequence of climatic episodes.

In Zone C-2, very small assemblages and relatively high levels of pre-Quaternary taxa are consistent with stadial conditions. It is likely that indicators of temperate environments - such as elm (*Ulmus*), hawthorn (*Cretaegus*) and the polypody (*Polypodium*) and undifferentiated fern (Pteropsida) spores - are recycled, while the climate of the time is more likely reflected by the presence of taxa such as dwarf birch (*Betula nana* type), juniper (*Juniperus*), wormwood (*Artemisia*), moonwort (*Botrychium*), and knapweed (*Centaurea*). This perhaps suggests very open rather dry environments with relatively sparse, patchy scrubby and grassy vegetation. Local aeolian recycling is suggested by the Upper Cretaceous/Tertiary and Triassic and Lower Jurassic taxa. Amongst the latter, there is a strong Lias component including *Tasmanites* and *Cymatiosphaera* spp., suggestive of outcrops around Lyme Bay or in Somerset or South Wales. There is also a contribution from the Culm, of very thermally mature Devonian/Lower Carboniferous spores and a further group of thermally immature Carboniferous-Permian spores, most probably derived from Permian outcrops upstream in the Kate Brook valley.

Zones C-3, C-4: Sample column C, Spits 7-10

Larger pollen assemblages with much pine (*Pinus*) in zones C-3 and C-4 may reflect an interstadial. The assemblages also contain some spruce (*Picea*), lesser twayblade (*Listera*), clubmoss (*Lycopodium*), moonwort (*Botrychium*), daisies (*Bellis* type), knapweed (*Centaurea*). These assemblages most probably reflect open pine-spruce woodland with some more open mossy and weedy or grassy patches in a cool, initially damp climatic regime. *Listera* today has an upland, northerly distribution in the British Isles and is found very rarely in the Southwest on the north-facing upper slopes of Exmoor. The presence of spruce (*Picea*) may link this episode to the Chelford Interstadial (Simpson & West 1958; Worsley 2015) which probably lies late in OIS5. The presence of recycled pre-Quaternary taxa and occasional temperate indicators, such as walnut (*Juglans*), are consistent with continuing ground instability and sediment movement by aeolian processes – the rising pattern is likely to indicate that this becomes more marked upwards.

Zone C-5: Sample column C, Spits 5,6

The very small assemblages in C-5 and abundant recycled pre-Quaternary taxa most probably reflect a stadial. It is quite possible that all the palynomorphs in these assemblages are recycled. It is unclear which episode this might be: but the lack of a recognisable *in situ* flora is perhaps more suggestive of episodes such as OIS4 or OIS2 than with the less marked stadials of OIS3.

Zone C-6: Sample column C, Spits 4-1

The abundant to very abundant pollen in zone C-6 is likely to be indicative of a major phase of temperate climate. These assemblages are characterised by very high Lactuceae, with occasional clusters of grains. This is likely to be the result of the import of pollen by ground-nesting bees or bumblebees and has been reported previously from caves in the Near East (Fiacconi & Hunt 2015). Stratigraphic evidence suggests that Column C spits 4-2 may relate to a late-glacial interstadial or the beginning of the Holocene and Column C spit 1 most likely reflects very recent sedimentation.

Other than the very abundant Lactuceae, the remainder of the assemblages are marked by a few temperate woodland indicators including oak (*Quercus*), hazel type (*Corylus*/*Myrica*), hard fern (*Blechnum*), honeysuckle (*Lonicera*), ivy (*Hedera*); a heath/moorland component (*Empetrum* type, *Calluna* type, *Gentiana* *pneumonanthe*); and indicators of grassy places such as daisies (*Bellis* type), knapweed (*Centaurea*), plantains (*Plantago*), grasses (Poaceae) and sedges (Cyperaceae). This would be compatible with a mosaic of heath, woodland and grassland and with either a Late Glacial/Early Holocene age. It would appear that the marsh gentian *Gentiana pneumonanthe* is a useful marker for the Late Glacial/Early Holocene and is not found in more recent assemblages.

Zone A-1: Sample column A, Spits 12-9

There is a very strong taphonomic imprint to the samples in this zone, with very high Lactucae and other Asteraceae suggesting input of pollen by bees. There is evidence for piping in this part of the section, so the integrity of these samples is perhaps questionable, but there are no very sharp discontinuities which might be expected if material were introduced from very different contexts, although the presence of the exotic *Picea* in sample 120 may indicate an input of some material less than 200 years old into this sample. Nevertheless there are considerable differences between the pollen and microfossils of this zone and those overlying, which points to overall integrity.

Pollen counts are high in this zone, consistent with relatively high biological productivity. There are indicators of fairly abundant pine (*Pinus*) although not enough to suggest pine woodland. There is some evidence of the kind of sheltered habitats usually associated with temperate woodland, including Burdock (*Arctium*), Ivy (*Hedera*), Polypody fern (*Polypodium*) Honeysuckle (*Lonicera*), occasional grains of oak (*Quercus*) and hazel/sweet gale (Coryloid)). There are minor heathland taxa, notably heather (*Calluna* type). Grassland is suggested by taxa such as wormwood (*Artemisia*), daisies (*Bellis* type), moonwort (*Botrychium*), rockrose (*Helianthemum*) and probably buttercups (*Ranunculus*). Bur-marigolds (*Bidens* type), cornsalads (*Valerianella*), thistles (*Carduus* type), soft thistles (*Serratula* type) and probably sandworts (Caryophyllaceae) point to areas of bare, disturbed ground. Eroding soils are suggested by, fungal zoospores and VAMs while regionally-derived mobile, perhaps aeolian-transported sediments are indicated by the abundant recycled palynomorphs. It is likely that sheltered habitats amongst the rocks supported some trees and temperate indicators in what was otherwise a dry partly-vegetated landscape with patches of grassland.

Zone A-2: Sample column A, Spits 8-4

Although relatively low in this zone, the abundant Lactucae point to a continuing taphonomic overprint, perhaps caused by the input of pollen by bees. Pollen counts are low in this zone, consistent with relatively low biological productivity or very high sediment flux. The pollen assemblages contain a few shelter-demanding taxa including burdock (*Arctium*), male fern (*Dryopteris*), polypody (*Polypodium*), that were probably growing in sheltered habitats amongst the rocks. Pine (*Pinus*) is relatively high, but below the threshold for pine woods. Scattered heathland taxa are present, most notably hard fern (*Blechnum*). Some grassland is indicated by taxa such as wormwood (*Artemisia*), harebell (*Campanula*), rockrose (*Helianthemum*) and devilsbit scabious (*Succisa pratensis*). Disturbed ground is suggested by taxa such as thistles (*Carduus* type), probably sandworts (Caryophyllaceae) and the relatively abundant VAMs, Fungal Zoospores and recycled taxa. At the top of the zone, there are occasional grains of temperate trees such as oak (*Quercus*) and elm (*Ulmus*). The landscape during this zone was probably quite open and geomorphologically active, possibly reflecting climatic rigour or farming activity, though no cultivated taxa were identified.

Zone A-3: Sample column A, Spits 3-0

The taphonomic imprint of Lactuceae in this zone is extremely strong, consistent with continuing activity by nesting bees. Pollen counts are very high, consistent with a slowing of sedimentation, with sediment mobility in the landscape also declining, as indicated by declining recycled taxa. The presence of exotics in this zone, including spruce (*Picea*), cedar (*Cedrus*) and azalea/rhododendron (*Rhododendron*), point to accumulation since these taxa were imported into the country, approximately 200 years ago. Encroaching temperate woodland is indicated by the appearance of occasional hazel/sweet gale (Coryloid), alder (*Alnus*), ash (*Fraxinus*), hawthorn (*Cretaegus* type), oak (*Quercus*) and elm (*Ulmus*) and of the shelter-demanding polypody (*Polypodium*). Pine (*Pinus*) is also likely to have been present. Indicators of heathland such as heather (*Calluna* type) seems to decline through the zone, as do the indicators of grassland.

4.7.6. Conclusion

The pollen study has identified a series of depositional phases in Cow Cave. These relate to OIS7, early OIS6, late OIS5, a Devensian stadial and perhaps the basal Holocene in Sample Column C. It is likely that the whole of Sample Column A can be referred to the Holocene (*sensu lato*) with sedimentation rates being relatively high in this area. These findings reflect broadly the conclusions reached from other indicators. The OIS7, OIS6 interstadial and Chelford assemblages are all nationally rare and thus it is important that the cave is conserved.

4.8. Identification of charcoal for radiocarbon dating

Dana Challinor

Five hand-collected samples of charcoal were submitted for the identification of the charcoal and selection of suitable dating material. The charcoal was examined at low magnification (using a Meiji stereo microscope at X10-X45 magnification), which was sufficient to confirm the identification of a single taxon; *Quercus* sp. (oak) (Table 4.7.1). The charcoal was extremely soft and covered with sediment which, on gentle pressure, had a tendency to dissolve into dust. At least one sample (0032) did not contain any material which was identifiable as wood charcoal and another sample (0033) was mostly sediment with charcoal flecks – definitely wood, but too small to identify. The remaining samples, all from Column B contained some fragments of oak, including heartwood. Of the larger material (0003 and 0004) which was found in a secure context relating to a large pipe/burrow shaft feature in the Reindeer Stratum (but post-dating both the formation of the shaft and the deposition of the Reindeer Stratum), the charcoal from 0003 was both larger in quantity and better in preservation. Tyloses were observed in this material, but they occurred infrequently and the charcoal is thought to derive from the sapwood-heartwood transition zone. No evidence for ring curvature was noted. The material from this sample was sent for ^{14}C dating.

These features permit some estimation of the age of this sample (0003) at time of death. Sapwood estimates for British oaks are between 10-55 years, providing a minimum age for the death of the sapwood, i.e. felling of the tree. There is some heartwood formation in the material, which would have died prior to that point. At least 12 rings are present, which probably includes some sapwood rings, but there were no signs of ring curvature which (although the material is fragmented) suggests it's not that close to the cambium (or the pith) so it was a mature tree. Thus, erring on the cautious side, even if the oldest part of the tree died hundreds of years earlier, the age of the sampled charcoal can be estimated at a maximum of about 60-70 years but could be considerably less.

The identification of oak indicates the presence of mixed deciduous woodland, which is appropriate for the Holocene, where records for Devon place it within the oak-hazel province (Rackham 2000). Earliest records of charcoal from the Lower Palaeolithic in Britain are of pine and birch (Smith 2002), but oak was recorded from a Pleistocene (no refined dating available) palaeochannel in Hampshire (Gale 1995). The latter is not securely associated with human activity, but an *in situ* hearth from Tornewton Cave, Devon, yielded yew (*Taxus*) charcoal (Cartwright 1996).

Context number	Details	Identification	Notes
0001	Column B spit 5	*Quercus* sp. h-w	
0003	Column B spit 2	*Quercus* sp.	Rare tyloses – heartwood/sapwood transition zone. Sent for dating.
0004	Column B spit 2	*Quercus* sp.	Indeterminate maturity.
0032	Column A spit 9	-	Not identifiable, may not even be wood charcoal. V small flecks, no anatomical structure visible.
0033	Column A spit 10	-	Wood charcoal flecks, but not id'able

Table 4.8.1: Charcoal from Cow Cave

4.9. Radiocarbon dating

Chris Proctor

Samples for radiocarbon dating were selected from the recovered bone and charcoal, in conjunction with the relevant specialists: John Stewart (mammals and birds); Chris Gleed-Owen (herpetofauna); and Dana Challinor (charcoal). Due to the small amount of identifiable faunal material recovered, only a limited number of samples were considered worth submission for dating. These included two large mammal bones, 0008, cervid, from Column C spit 5; and 0016, cervid/bovid, from Column C spit 6. Two bones of Natterjack toad *Epidalea calamita* (DBF-001 and MBC-001) were also selected for dating. Given the small number of samples, it was considered that dating might not satisfactorily answer one of the main aims of the ^{14}C dating exercise – to determine the age of the Reindeer Stratum. This was particularly so given that a previous age determination of natterjack toad from the site had yielded a Holocene age (Gleed-Owen, 1998), and neither of the megafaunal specimens comprised well identified material indicative of Pleistocene age.

A further sample of mammalian megafauna was available in the form of material recovered by John and Bruce Boulton from the collapsing face of Section C in the mid 2000's. As noted in the mammal report this material was recovered from two areas, of which the "Upper area of recovery" corresponds to material recovered from an *in-situ* context within the Reindeer Stratum. This area corresponds to the area sampled by us as Columns D and the middle part of Column C and although the location was not precisely recorded its original position is known to within c. 0.5 metre. This collection included definitely Pleistocene species such as Reindeer *Rangifer tarandus*. With the agreement of Historic England, a further 5 samples were selected from this material, denoted by an 02xx sample number in the results table. One further sample was submitted for dating. This was a sample of one of the large fragments of oak charcoal found in Column B, spit 1: sample 0003.

The ten samples selected were submitted for dating to the University of Oxford Radiocarbon Accelerator Unit at the Research Laboratory for Archaeology and the History of Art. Ultrafiltration pretreatment was used for all the bone samples, due to their possible Devensian age. A sequential ABA (acid-base-acid) pretreatment.was used for the charcoal sample (0003). Results are given in table 4.9.1. Of the ten samples submitted 8 returned usable data although two of these (both bone) yielded low collagen yields. The remaining two samples failed due to no collagen yield.

Of the successfully dated mammalian megafauna from the Reindeer Stratum of Section C, sample 0008 came from Column C spit 5. The other samples (all from the 2000's rescued material) came from the face nearby, between Column C and Column D; they thus come from an approximately equivalent stratigraphic position. All these samples yielded similar results. All lie beyond the limit of the ^{14}C calibration curve. Only one, OxA-X-2698-54 (0217A) yielded a finite age, of 48500 ± 3400 years BP (uncal). However this sample had a low collagen yield and the date lies very close to the limit of ^{14}C dating, so the age should be treated with caution and should perhaps be better treated as a minimum. The other samples all yielded minimum ages of 45900 to 49900 years BP (uncal). Taking this set as a whole, they indicate an age of >45900 years BP (uncal) for this part of the Reindeer Stratum, dating it to the early Middle Devensian or earlier.

Only one of the Natterjack bones, OxA-34821 (DBF-001) was dated successfully, yielding an age of 1049 ± 24 years BP (uncal), which equates to a calibrated age of 902 - 1025 cal AD at 95% probability (figure 4.9.1). This provides evidence for late survival of natterjack toad in the Chudleigh area (the species is now extinct in SW England). In addition it provides a date for the pipe/burrow fill.

The oak charcoal, OxA-34833 (0003) returned an age of 7100 ± 36 years BP (uncal), equating to 6049-5901 cal BC at 95% probability (figure 4.9.2). This is an overestimate of the time of burning as the dated wood came from the sapwood/heartwood transition zone and can be approximately estimated to have been aged around 15 to 70 years at death (section 4.7). Thus the time of burning can be estimated at ~6034-5831 cal BC. This provides the first evidence of a Mesolithic human presence in the Chudleigh Rocks area. The date is also stratigraphically important. It provides a minimum age for the pipe/burrow within which the charcoal lies, and a maximum age for the stalagmite boss covering it.

OxA	Sample number	Material	Species	Pretreatment	$\delta^{13}C$	Age
OxA-X-2698-56	0008	Bone	Cervid	UF	-21.39	>49900
OxA-X-2698-54	0217A	Antler	*Rangifer tarandus*	UF	-20.81	48500 ± 3400
OxA-34799	0209A	Bone	*Ursus* sp.	UF	-20.09	>49000
OxA-34800	0211	Bone	*Bos primigenius*	UF	-19.85	>45900
OxA-34801	0216	Antler	Cf. *Cervus elaphus*	UF	-20.49	>46900
OxA-34802	0217B	Antler	*Rangifer tarandus*	UF	-19.41	>49800
OxA-34821	DBF-001	Bone	*Epidalea calamita*	UF	-20.38	1049 ± 24
OxA-34833	0003	Charcoal	*Quercus* sp.	ABA	-25.66	7100 ± 36
P-42049	0016	Bone	Cervid/bovid	-	-	Failed (no collagen)
P-42078	MBC-001	Bone	*Epidalea calamita*	-	-	Failed (no collagen)

Table 4.9.1. Radiocarbon determinations from material from Cow Cave. Dates prefixed OxA-X- denote low collagen yield (<1%). UF denotes ultrafiltration pretreatment, ABA denotes sequential ABA (acid-base-acid) pretreatment.

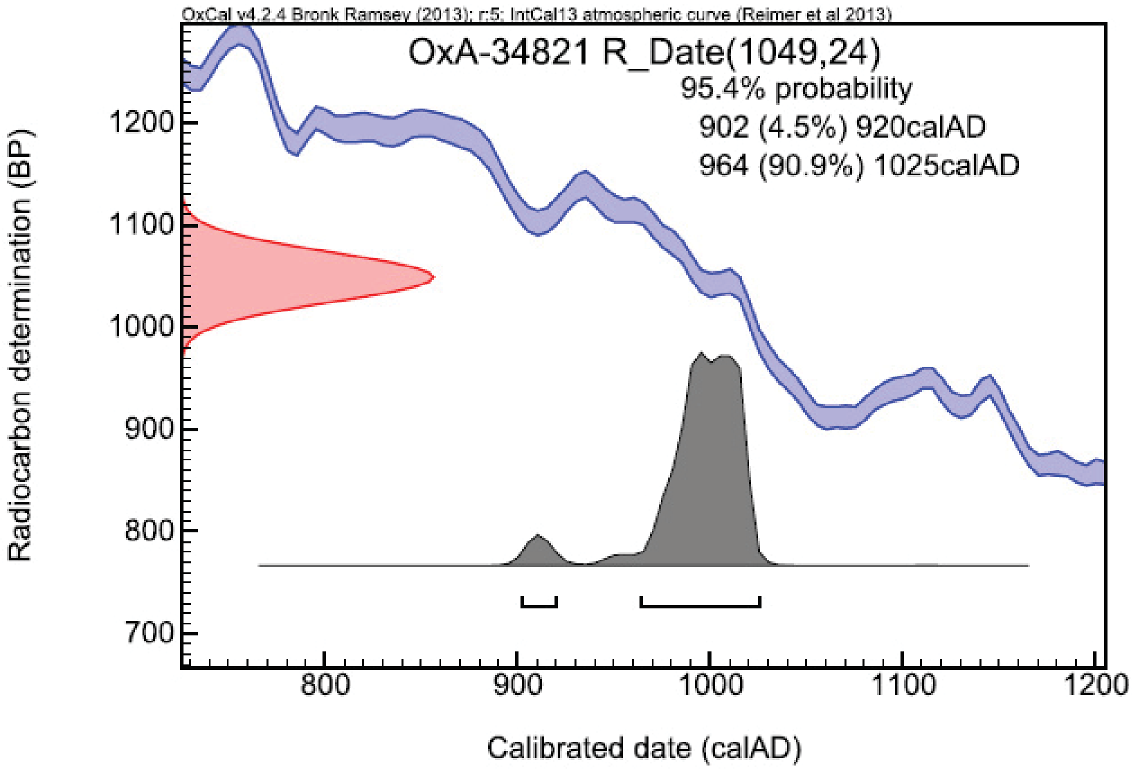

Figure 4.9.1. Calibrated date for OxA-34821, Natterjack Toad bone DBF-001.

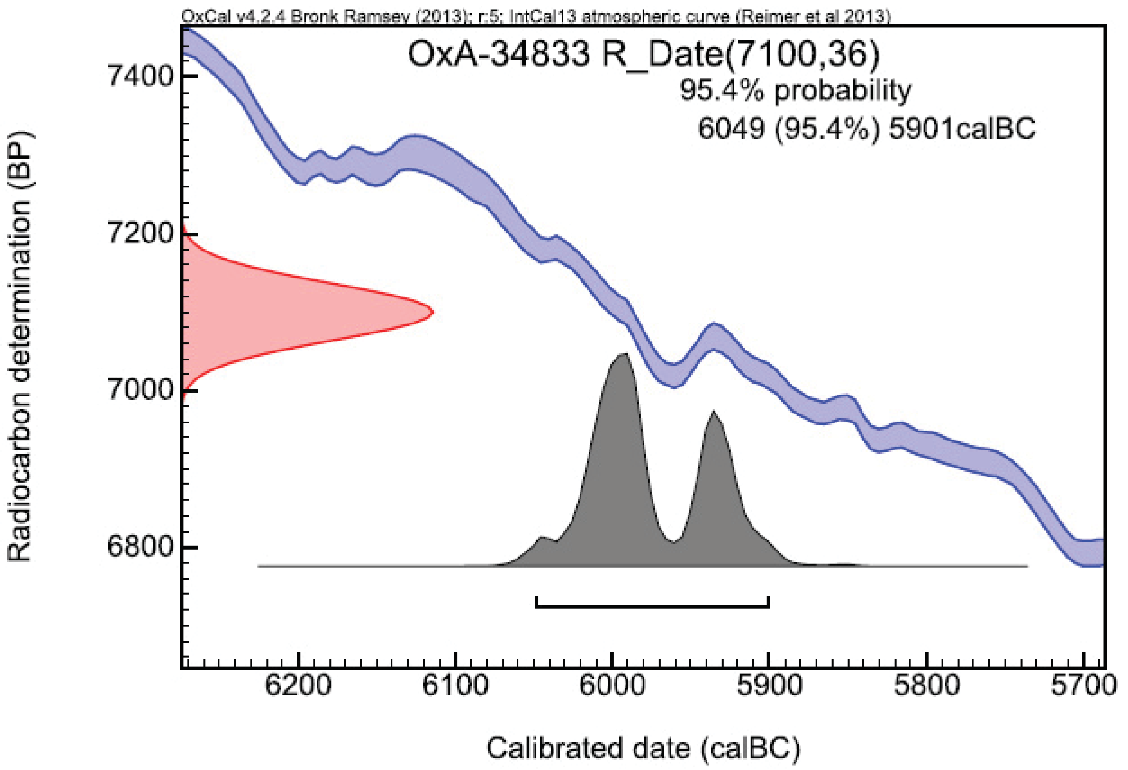

Figure 4.9.2. Calibrated date for OxA-34833, Oak charcoal sample 003.

4.10. U-Th ages for flowstone material from Cow Cave, Devon.

David Richards and Vanessa Fairbank

Two phases of flowstone growth from Cow Cave, Devon, were dated by U-Th methods (Hoffmann *et al*, 2007). Samples of ~100-200 mg were cut with diamond blade or milled with drill. Measured U concentrations were low (< 180 ng g-1), as were measured ($^{230}Th/^{232}Th$) activity ratios (12-35). Corrected ages and uncertainties account for significant contribution from initial Th.

0037C – lowest flowstone. Densest material from base of deposit was used for U-Th analysis (see figure below). Two separate samples yielded similar ages equivalent to MIS 7e (~230 ka), in stratigraphic order, although statistically indistinguishable.

0038A – flowstone fragment. Two ages, reversed, but similar to the oldest age in correlative material from Lundberg *et al* (2008). The upper sample has older age and the material was more porous (a few pores evident, some laden with sediment). Perhaps there has been some U loss from this upper surface that would have been exposed for millennia, resulting in older apparent age.

Figure 4.10.1. U-Th ages from flowstone sample 0037.

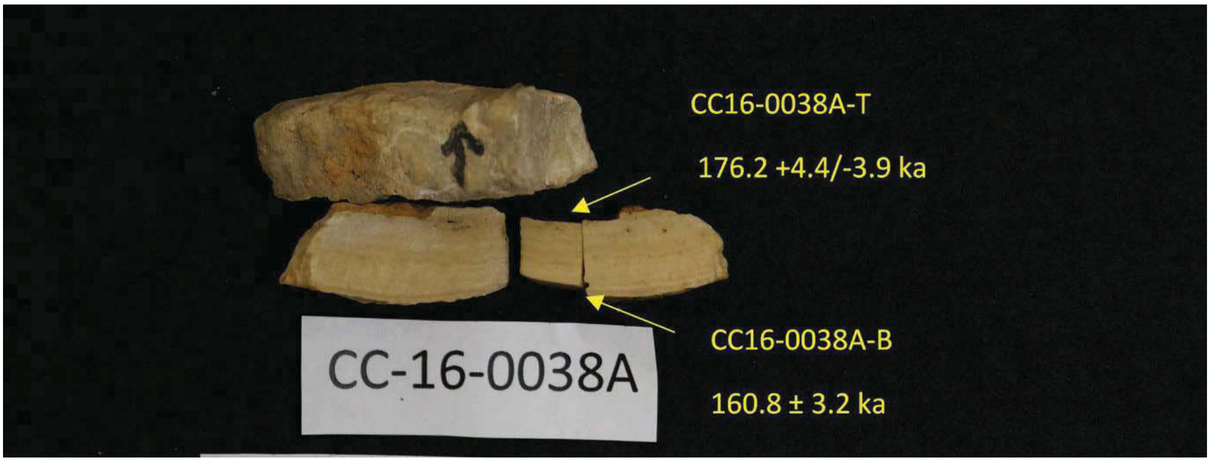

Figure 4.10.2. U-Th ages from flowstone sample 0038.

Sample ID	Sample	Sample location, description	^{238}U (ng/g)	±	$[^{230}Th/^{232}Th]$ activity ratio	±	$(^{230}Th/^{238}U)$ activity ratio	±	$(^{234}U/^{238}U)$ activity ratio	±	$(^{234}U/^{238}U)_{initial}$ activity ratio	±	U-Th age	±
BIG_UTh_Q001	CC16-0037C-6	6 mm from base	111.3	0.2	12.28	0.04	0.9494	0.0063	1.0651	0.0045	1.1245	0.0070	**229.1**	**+6.6 -6.2**
BIG_UTh_Q002	CC16-0037C-3	3 mm from base	112.8	0.2	22.82	0.09	0.9449	0.0064	1.0634	0.0045	1.1205	0.0072	**227.0**	**+ 6.6 - 6.1**
BIG_UTh_Q004	CC16-0038A-T	upper section, darker, sediment-laden pores	177.3	0.4	14.28	0.08	0.8964	0.0081	1.0983	0.0035	1.1616	0.0050	**176.2**	**+ 4.4 - 3.9**
BIG_UTh_Q005	CC16-0038A-B	basal section, more dense than upper	150.6	0.3	34.49	0.22	0.8509	0.0075	1.0870	0.0023	1.1369	0.0032	**160.8**	**± 3.2**

Analytical errors are reported at the 2σ level.

$(^{230}Th/^{238}U)_A = 1 - e^{-\lambda_{230} T} + (\delta^{234}U_{measured}/1000)[\lambda_{230}/(\lambda_{230} - \lambda_{234})](1 - e^{-(\lambda_{230} - \lambda_{234}) T})$, where T is the age.

Ages quoted here are corrected for initial Th.

Decay constants are 9.1577×10^{-6} yr^{-1} for ^{230}Th, 2.826×10^{-6} yr^{-1} for ^{234}U (Cheng *et al.*, 2000), and 1.55125×10^{-10} yr^{-1} for ^{238}U (Jaffey *et al.*, 1971).

The degree of detrital ^{230}Th contamination is indicated by the measured $(^{230}Th/^{232}Th)_A$, we use an initial $(^{238}U/^{232}Th)_A$ of 0.8 ± 0.4

Table 4.10.1. U-Th analyses of flowstones from Cow Cave.

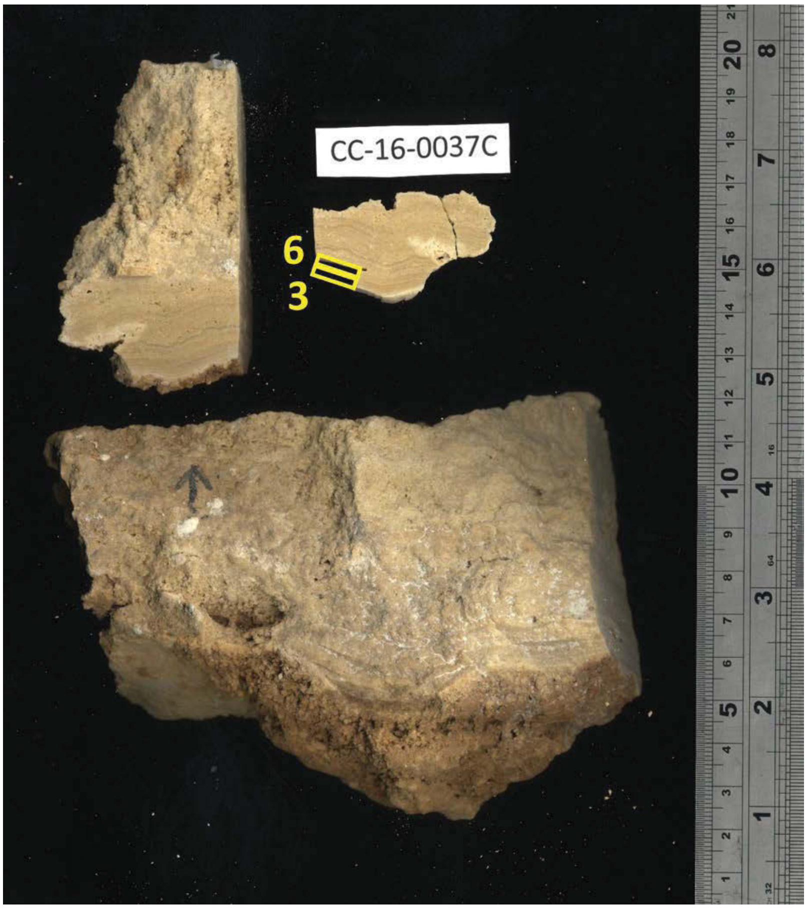

Figure 4.10.3. Context of dated samples from flowstone 0037.

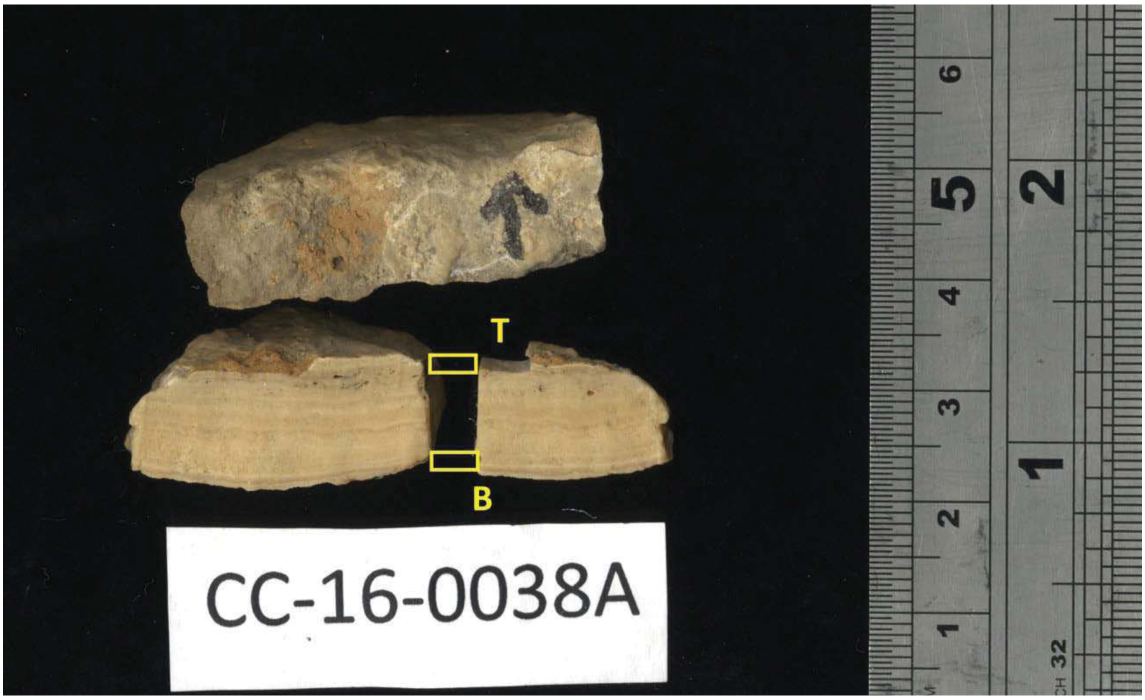

Figure 4.10.4. Context of dated samples from flowstone 0038.

5. Discussion and conclusions

5.1. Brief summary of results.

The project achieved its main aims of conducting a limited rescue excavation to better stabilise the overhanging and collapsing face of Section C, and to place a grille to limit access to the back of the cave. The excavation work carried out in order to achieve these aims provided the opportunity for a scientific investigation which has significantly advanced our understanding of the chronology of the site and its significance in the wider landscape.

5.2. Significance of results for interpretation of the site.

Previous workers (Lundberg *et al*, 2008; Simons, 2010) had already established that the sediment sequence in Cow Cave was deposited over a long period of Quaternary time, extending back to beyond ~167 ka and perhaps as far back as the Aveley Interglacial (oxygen isotope stage 7, ~180-240 ka). This investigation has broadly confirmed that, but has significantly altered the interpretation of the ages of a number of units within the sequence.

The lowermost unit, the Stream Deposit, lies below the broken massive stalagmite floor (0037) which has been U-Th dated to the Aveley Interglacial (oxygen isotope stage 7). This provides a minimum age for the Stream Deposit, suggesting a Middle Pleistocene age. The pollen assemblage appears to relate to a temperate environment with open areas and stands of trees, most likely dating from oxygen isotope stage 7e. The presence of diatoms, algae and aquatic plants and lots of reeds in the assemblage suggests almost certainly this was deposited by a stream flowing through the cave. Given the lithological provenance of the Stream Deposit, this stream can reasonably be concluded to have been the Kate Brook. This provides an important fixed point in the incision of the Chudleigh Glen. The Stream Deposit has multiple beds showing significant lithological differences between them, and might have been deposited over an extended period. Such is hinted at by the mammal fauna. Few identifiable mammals were recovered during this investigation but Simons (2010) reported cold faunal elements (the lemmings *Lemmus* and *Dicrostonyx* sp.). He also attributes beaver *Castor* sp. found during the TNHS excavation to this unit, on the basis of adhering slate matrix, which would imply the presence of woodland. If correct, then together with the temperate pollen assemblage obtained during this investigation it implies either substantial climatic variation during the deposition of the Stream Deposit or the presence of derived material within it, which might possibly be related to the oxygen isotope stage 8 - 7 boundary. A flint flake found by Simons (2010) has been attributed possibly to a Levallois technology. Two more flakes from the 1927-1935 excavation now in

Torquay Museum have also been attributed to the Levallois (Simons, 2010; B. Chandler, pers. comm.) and may be from the Stream Deposit. If this Levallois interpretation of the flakes is upheld, then together with the pollen assemblage this supports an Aveley Interglacial (oxygen isotope stage 7) age for the Stream Deposit (Pettitt & White, 2012).The charcoal found in the upper gravel in the Trench during pollen analysis also supports a human presence at this time.

The lowermost unit of the Broken Stalagmite Layer is a thick stalagmite floor, also seen in situ where it spans the Alcove. This massive floor must represent deposition in peak interglacial conditions. Confirmation of this is provided by the U-Th ages of 227.0 +6.6/-6.1 ka and 229.1 +6.6/-6.2 ka obtained from a thin growth layer within it (0037) which date the floor to the Aveley Interglacial (oxygen isotope stage 7). Thick stalagmite growth layers occur above and below the dated layer; the floor's deposition must have spanned a significantly longer period than the dates themselves imply.

A further fixed chronostratigraphic point within the lower part of the sequence is provided by the two U-Th dates from a detrital stalagmite fragment (0038) from the brecciated upper part of the Broken Stalagmite Layer. This yielded ages of 160.8 $\pm$3.2 ka and 176.2 +4.4/-3.9 ka, of which the first estimate of 160.8 $\pm$3.2 ka is considered the more reliable. These results are comparable with U-Th ages of 167 $\pm$2 ka and 148 $\pm$1 ka obtained from stalagmite fragments from the same stratigraphic level by Lundberg *et al* (2008). All these dates show the thin floor (or floors) to date from an interstadial within the oxygen isotope stage 6 cold stage. This stalagmite breccia layer appears not to have moved far so is probably in correct stratigraphic position. The U-Th dates thus date that layer and provide a minimum age for the underlying deposits. The pollen assemblage from the dated stalagmite block (0038) suggests a pine-based interstadial with some broadleaved trees, and closely resembles that from a stalagmite floor at Robin Hood's Cave, Creswell dated to 165 ka, thus supporting the attribution of the floor fragment to an interstadial within stage 6. A further pollen assemblage from the breccia immediately below (0160) is interstadial to cold stage but is quite mixed. A reasonable conclusion from this is that the brecciated layer represents oxygen isotope stage 6, with growth of thin stalagmite layers during interstadials and brecciation of the entire layer late in stage 6 (certainly after the U-Th dates). The cementing of the top of this breccia seen in the central part of Section C can be tentatively assigned to the Ipswichian Interglacial (oxygen isotope stage 5e, ~130-120 ka). Lundberg *et al* (2008) argue that by comparison with the stalagmite record seen in Kent's Cavern (Lundberg & McFarlane, 2007), the Ipswichian Interglacial should be represented by a major stalagmite floor in Cow Cave. However this argument is fallacious. It is true that all the major interglacials over the last ~500 ka are indeed represented in Kent's Cavern, but it is a very large site with over 900 metres of passages. Their results show that at any one growth site within Kent's Cavern, individual interglacials are often represented by a hiatus in stalagmite growth. This can be attributed to flow switching in the rock above – stalagmite growth is dependant not only upon a warm moist climate but the presence of an active drip within that part of the cave at the relevant time.

As already discussed (section 1.2) Sutcliffe and Kowalski's (1976) identification of *Microtus nivalis* in the Reindeer Stratum, and their suggestion that this indicated a pre-Ipswichian age of the deposit, is no longer accepted (Stuart, 1982, Danielle Schreve, pers. comm.). Likewise Lundberg *et al's* (2008) argument that the lack of a thick floor between the Broken Stalagmite Layer and the Reindeer Stratum suggests a stage 6 (pre-Ipswichian) age for the Reindeer Stratum does not stand up to scrutiny (see above). A better estimate of the age of the Reindeer Stratum is provided by ^{14}C dates and pollen assemblages obtained during this investigation. The ^{14}C dates were all obtained on material from a bone-rich layer about 30-60cm above the base of the deposit. All the dates gave similar results of >46.9-49.9 ka. As such they provide a minimum age for the lower part of the Reindeer Stratum, constraining it to the early Middle Devensian or older. The pollen results allow us to further constrain the age of the deposit. The basal spits have a cold-stage flora, above which is a boreal forest type assemblage at the level of spits 9-10. This is a good match for the Chelford Interstadial flora, suggesting a late stage 5 age for this part of the sequence. Slightly above this is the bone layer that yielded the ^{14}C dated samples, which can therefore be constrained to between the Early, to early Middle Devensian (end part of stage 5 - early stage 3) in age. The uppermost part of the Reindeer Stratum, not excavated by previous workers and sampled by us as column A, has yielded a pollen assemblage suggesting a Holocene age, but has also yielded collared lemming *Dicrostonyx* sp. suggesting it also contains derived material dating from a cold phase of the Middle or Late Devensian (oxygen isotope stage 3-2, ~65-11.7 ka). This upper part of the deposit is retained here as part of the Reindeer Stratum but given the likely Holocene age and slight lithological differences from the lower Reindeer Stratum, it should perhaps best be separated as a distinct unit.

Evidence of Late Glacial Interstadial deposition in the cave is provided by a mandible and tooth of pika *Ochotona pusilla* found by Simons (2010) in the Reindeer Stratum of Section C; this species is only known from this period within the British upper Middle to Upper Pleistocene. Further evidence of the Late Glacial is provided by the small trapezoidal backed blade found somewhere in the cave by the TNHS (Beynon, 1932; Simons, 2010), which can probably be referred to the late Magdalenian.

The youngest part of the sequence comprises the pipe/burrow tunnels within the Reindeer Stratum, and their fill of Tufaceous Stalagmite and Dark Earth. In addition to providing evidence for Mesolithic activity (see below), dated charcoal from within one of these structures shows that it had already formed by ~5900-6500 BC (cal). This charcoal can be stratigraphically demonstrated to be older than both the Tufaceous Stalagmite and Dark Earth in this particular pipe/burrow, showing both deposits to be Holocene. This is supported by the presence of herpetofauna of Late

Glacial/Holocene type within the Dark Earth. The Reindeer Stratum immediately underlying the large pipe/burrow on the south side of Section C has yielded a temperate pollen assemblage and abundant herpetofauna, both of which point to a Late Glacial or Holocene date for the sediment. This implies that the Reindeer Stratum immediately underlying the pipe/burrow has been disturbed and mixed with Late Glacial/Holocene material; it might either represent a fill of reworked Reindeer Stratum, or sediment which has been disturbed and overturned by animals using the tunnel. The mottled colour of the Reindeer Stratum immediately underlying the pipe/burrow may reflect such disturbance. Further evidence for animal presence is provided by the fact that much of the herpetofaunal bone shows evidence of digestion and predator-related crunching. This suggests that these tunnels within the Reindeer Stratum might owe their origin largely to the activities of burrowing animals. Column A also shows possible signs of intrusion of later material in the form of frog and toad bones. This may be related to the presence of significant void space (either primary porosity or possibly eluviation cavities) in that column.

The charcoal found in spit 1 of column B, ^{14}C dated to ~5900-6500 BC (cal) provides the first evidence for late Mesolithic activity in the Chudleigh Rocks area. Given the position in which the charcoal was found within a pipe/burrow, it was probably washed in from above. The good state of the charcoal suggests that its intrusion into the cave probably occurred soon after burning outside. Evidence of Neolithic mortuary use is provided by human bones found during the 1927-35 excavation and dated by Sheridan *et al*., (2008).

5.3. Remaining questions on site interpretation.

The Section C chronology has now been placed on a much more secure footing than formerly. However a number of outstanding avenues for research remain.

Several questions are raised by the results of the 1927-1935 TNHS excavation. Their faunal list contains a number of faunal elements that have not been found in any part of the cave excavated more recently (Beynon, 1932; Simons, 2010). These include hyaena *Crocuta crocuta*, lion *Panthera spelea*, woolly rhino *Coelodonta antiquitatis* and horse *Equus cf. ferus*, all species that would not be out of place in a Middle Devensian (oxygen Isotope stage 3) context. The presence of hyaena in particular hints that a hyaena den deposit might have been present somewhere in the cave. It is certainly quite possible that a Middle Devensian deposit of this type was excavated by them somewhere in the cave, and if so it might broadly correlate with part of the Reindeer Stratum higher in the sequence than preserved in the main face of Section C. However, as Simons (2010) points out, the possibility that this fauna is older (perhaps derived from part of the Stream Deposit) also needs to be considered. There are two ways in which this question might be addressed. Firstly, the excavation journal from the TNHS dig is still held by Torquay Museum. This gives daily totals for bones found, along with where in the cave they were working, and might offer the possibility of locating quite where this fauna came from. Unfortunately the TNHS excavators did not recognise the stratigraphic complexity now known, and they give few details of find depths. This may make it impossible to determine from the journal which part of the sequence the finds came from. Another avenue of investigation might be ^{14}C dating of the bones themselves. If they are Middle Devensian, then they may well lie within the range of ^{14}C dating and will give finite ages. However this approach would not produce useful results if they are beyond the limit of the technique, and it might be difficult to justify funding for ^{14}C dates because of this.

The TNHS excavation also yielded flint artefacts. They reported the discovery of a number of pieces (Beynon, 1932) but the majority have since been discounted as natural, leaving a small collection comprising two Levallois type flakes, and a small trapezoidal backed blade. Their find spots within the cave are currently unknown. The excavation journal lists discoveries of artefacts and sometimes gives their dimensions, which offers the possibility of matching at least some of the flints in Torquay Museum with the journal entries, constraining their find locations.

The best preserved and most intensively studied deposits are at the back of the cave, and indicate entry of Reindeer Stratum material via gull fissures in the roof. However the entrance passage remains much more poorly known. Section A was described by Simons (2010) but his work on this section is in need of reassessment and sediment remnants on the opposite wall have never been mapped or studied in detail. This could be important in establishing when the entrance was open and whether any substantial quantity of Pleistocene sediment entered through the entrance and was deposited there. Substantial entrance deposits could have been present, limiting the size of the open entrance or even blocking it; alternatively if the slope outside was sufficiently steep there may never have been a significant accumulation of sediment at the entrance. Answering this question could have implications not only for interpreting the Pleistocene history of the cave but Later Prehistoric use by humans as well.

The evidence that much of the cave deposits were cleared out in historic times raises an interesting possibility for future investigation. This material should still be present tipped down the slope below the cave and could contain much Pleistocene bone deposit, as well as Palaeolithic artefacts. Unfortunately this same location was used by the TNHS to tip spoil from their excavation, so it would be necessary to remove their spoil first to test this hypothesis.

5.4. Assessment of damage to the site.

Several types of recent damage have been observed during site meetings and in the course of this investigation.

Disturbance to the cave deposits on Section C and elsewhere has been observed on several occasions. Collapses of Reindeer Stratum on the south end of Section C have been observed since the early 2000's. Some of this is undoubtedly natural, resulting from the crumbling, overhanging face here. However, progressive collapse was exposing visible bone, and a watching brief kept by John Boulton has showed that some of this material has disappeared, presumed removed by fossil collectors or casual visitors. Apart from the loss of the specimen, such collecting causes further erosion of the face. A significant assemblage of bone was exposed by collapse in the early 2000's; fortunately this was saved by John and Bruce Boulton and kept for further study (see sections 4.4.4, 4.9). Another cause of disturbance to Section C that has been alleged from time to time is digging by cavers. There is some evidence that someone may have tried to force entry to the tunnel extending northeast from the north end of Section C, and this has resulted in minor damage within it. However it is certain that no digging has occurred on the main face or elsewhere in the cave. Cavers' digs are excavated to clear chokes with the aim of breaking into new passages beyond. Their excavations for the purpose are accordingly on a large scale: certainly there is no evidence of this type of digging in Cow Cave. Elsewhere in the cave, evidence of deliberate disturbance of sediments was seen on Section A where a small patch of sediment had been deliberately removed using a chisel. It is difficult to know why this was done unless to remove bone, but so far this has been an isolated incident on that face.

The cave has been visited by climbers, to shelter from the weather, and occasionally for use as a toilet. The latter use is another which may have caused damage by introducing organic materials. Of more concern has been the setting of fires in the cave by visitors. These have often been set against the walls, and have involved scratching out a hearth. When set against the walls, these fires have caused considerable damage to the adjacent sediment which has been baked and strongly reddened in colour. These fire damaged areas will now be too damaged for many kinds of sedimentary and environmental analysis to be carried out. Damage will also have occurred to the sediment underlying the hearths but this is not visible due to the wet dark earth which floors the cave and is moved around both by visitors and trickling water in wet weather, obscuring areas of damage. Fires are known to have been set in the central floor area on a number of occasions. The damage associated with them may present problems for future excavations as it will only become apparent once excavation, and perhaps analysis, has been commenced.

Fake cave paintings appeared on the angle of the entrance passage east wall and inner chamber south wall, first noted on a site visit in 2005. Fortunately apart from one small breccia remnant above the ledge, the paintings were painted on the bare rock of overhanging upper wall, and did not affect any sediment remnant. Of more concern is the possibility that they might have covered any pre-existing engravings on the wall. There is no clear evidence of Late Palaeolithic activity in the cave; a small trapezoidal backed blade found during the 1927-1935 TNHS excavation provides the only evidence and that might be intrusive. However the adjacent Pixie's Hole contains a substantial Late Magdalenian occupation horizon, so it would be entirely possible to find engravings in Cow Cave. The cave has been visited by Paul Pettitt to search for engravings and none were found, but nonetheless the addition of modern art to the walls presents an unacceptable risk.

5.5. Assessment of current risks to the site.

The excavation of the overhanging face of the Reindeer Stratum on the south side of Section C succeeded in cutting back to a much more stable vertical face. This should limit further collapse in future years. However, the Reindeer Stratum is a loose, unconsolidated deposit most of the way across the section. The likelihood of further collapses cannot be ruled out even in areas where the face is sloping rather than vertical. There is nothing that can reasonably be done to prevent this as further excavation would itself remove further sediment and merely result in exposure of a new face which would probably still be as liable to collapse as before. This issue is further addressed below (section 5.6).

Installation of the grille now prevents casual access to the inner part of the cave and this should prevent any further visitor damage to most of the important sediment sections. Given that most of the worst damage, including fire setting, the fake cave paintings and removal of bones with its associated erosion of the sediment face, has been attributable to casual visitors, this represents a major improvement in site protection. However, due to the constraints set by the shape of the cave and the need not too make it too visually intrusive, the grille was set at a narrow point some 11 metres in from the entrance. Section A lies wholly outside the grille and thus remains vulnerable to damage by visitors. An instance of damage to the sediments has already been noted, and shortly after the excavation a fire was set close to Section A, fortunately not damaging it. Other sediment remnants on the opposite wall are significantly above floor level and are hard to reach. They are unlikely to be at risk.

5.6. Recommendations for future site management.

The protection measures now in place at the site rely heavily on the grille and its continued integrity. Cave entrance grilles have been in use at Pixie's Hole and

Boulton's Rift caves elsewhere on Chudleigh Rocks for many years (since the early 1980s). Shortly after their installation they were subject to vandalism but this has become much rarer in recent years. However in July 2016, the Pixie's Hole main entrance grille was vandalised, and the entrance gate was broken to force entry. There is nothing that can be done about any vandalism that occurs at the time of the break-in, as it impossible to keep a constant watch on the site. But it is important the a regular watch be kept on the all the cave grilles at Chudleigh including that at Cow Cave so that should entry be forced, the site can be secured before other unauthorised visitors cause any further damage. A further issue surrounding cave grilles is that they are not permanent structures. In the 30+ years since their installation the Boulton's Rift grille has entirely disintegrated, and the Pixie's hole main entrance grille is now very rusty, weak and due for replacement. This poor state of the grille was undoubtedly a significant factor in the July 2016 break-in. Neither of these grilles was galvanised. As the Cow Cave grille has been galvanised it should last longer. Once significant corrosion is noted regular (annual) inspections for corrosion should be introduced as part of the monitoring process. Once severe corrosion occurs then replacement should be undertaken before the structure is severely compromised.

As already noted, it was impossible to leave the sediment sections in a completely secure state. This is a problem endemic to any site where standing sediment faces must be left exposed over long periods. However two areas stand out as being of particular concern. Section A remains outside the grille and is thus vulnerable to damage by casual visitors. Fortunately this is not an obviously fossiliferous exposure so should not present a tempting target for bone hunters. However a recent instance of damage to the sediments has occurred, and a watch should be kept for any similar damage. However, apart from this isolated example there is little evidence that Section A has been damaged in recent years. This section might become more vulnerable to fire setting now that the grille prevents visitors from setting fires further into the cave. There is little that can be done to prevent this unless the culprits are caught in the act, but regular monitoring will establish how use of the cave has changed and whether this has resulted in significant new problems. It may be that fires were being set at the back partly to provide illumination for parties. Now that free access is limited to the front this temptation is removed. Near the front, the cave is floored by rock slabs and any fires set on those will cause much less damage.

As entry to the back of the cave is now controlled by the grille, access needs to be considered for legitimate users. These include researchers, archaeological, historical, geological, caving and other groups. Maintaining access to Cow Cave on a controlled basis consistent with the site's management was agreed as a condition of installation of the grille. It is critical to maintaining goodwill for archaeological conservation at this and other sites. As the grille incorporates a locked gate, access can simply be managed by arranging for suitable groups to be able to obtain a key for the gate. Some of these groups, and in particular amateur archaeological, historical and geological groups, are also likely to wish to be accompanied by an expert who knows the site. As part of this project, post excavation visits have been arranged for local societies including the Devonshire Association, Devon Archaeological Society, Devon Spelaeological Society and Plymouth Caving Group. Visits are also planned for local amenity and historical societies.

Archaeological and geological societies already have good engagement with research developments in cave archaeology and Quaternary geology. It would be worthwhile to encourage engagement with cavers through publishing summary results of this and other investigations in the scientific and popular caving literature. An increased awareness among cavers of the importance of archaeological sites in caves will further their conservation and lead to improved reporting of new sites.

6. The Project archive

6.1. The Material archive

The material archive is being accessioned to Torquay Museum. The material archive comprises:

(a) Flints: all definite and possibly humanly modified material from the excavation, including all flint from the Reindeer Stratum and higher strata. Catalogue on Table 4.3.1.

(b) Animal Bones: all mammal, bird, herpetofauna and fish bone recovered during the excavation. To this is added the mammal bones previously recovered in the 2000s. Catalogues in preparation.

(c) Molluscs: all molluscs recovered during the excavation. See list, Table 4.6.1.

(d) Charcoal; all charcoal recovered during the excavation. Catalogue in preparation.

(e) Lithological samples: Specimen bulk lithological samples of the main sedimentary units, and the 2 lithified Stream Deposit samples. In addition the rare lithologies found in lithological analysis are being retained. Catalogue in preparation.

6.2. The Digital archive

The digital archive will be transferred to the Archaeology Data Service (ADS) for long-term curation. A copy will also be lodged at Torquay Museum, along with the material archive. The digital archive comprises:

(a) Copy of the field notebook and finds record.

(b) Copies of the field drawn sections.

(c) Copies of photographs taken during the excavation, and a catalogue of the photographs.

(d) Copies of annotated drawn sections, sample point diagrams and photographs used to record details of sediments, survey points and sample points.

(e) Copies of catalogues of finds from the excavation, and any further documentation arising from the analysis.

(f) Copies of all reports relevant to the investigation including: the Final proposal; the Excavation Rationale; the Method Statement; the Interim Report; the Final Report.

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9. Appendices.

(a) **Drawn sections.**

The three drawn sections are given here at A3 size, to a scale of 1:12.5 (8cm = 1 metre). These include:

Section C front plane section.

Section C back plane section

Trench plan and section.

(b) **Survey data.**

(1) Survey data, Excel file. This file includes all survey data obtained using differential GPS and EDM surveying during the excavation. The data is annotated to give the features surveyed.

(2) Cave model, Survex files. These four files present the EDM data for Cow Cave as a 3D model, using Survex cave survey software. Lines have been plotted outlining the main sediment sections and remnants. The data file also includes compass/clinometer survey data which covers parts of the cave not surveyed by EDM. For the purposes of this file the compass/clino data are tagged as surface survey data. The software and related documentation including a user's manual can be downloaded free from:

https://survex.com/

The four files are:

The raw data file (text file)
The output log
The loop closure error file
The processed file.

The processed file can be viewed by double right clicking on the file icon, to bring up the 3D model. The model is navigated using the mouse: see the manual for further file viewing instructions.