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A FURTHER REPORT ON THE EXCAVATIONS AT SUN HOLE, CHEDDAR

by

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ABSTRACT

Recent intensive study of the sequence of deposits in a small area of the cave, using primarily sedimentological and palaeontological techniques, has revealed the presence of three main units, dating from the Late Devensian, from a full glacial episode (probably Devensian) and from an interglacial episode (possibly but by no means certainly Ipswichian). Re-examination of the finds and literature associated with the old excavations generally supports these conclusions. New radiocarbon dates suggest that the brief Palaeolithic intrusion, evidenced by flint artefacts and human bones from the old collections, occurred very near the end of the Devensian Glacial. Multidisciplinary work continues at this site.

INTRODUCTION

Sun Hole (ST 467.541) is an apparently small fissure cave situated half way up the western cliffs of Cheddar Gorge, Somerset. The cave was excavated by the late Professor E. K. Tratman during the periods 1927–8 and 1951–3. Further small scale excavation was carried out by J. B. Campbell in 1968. Numerous publications on this site have already appeared: Tratman and Henderson, 1928; Davis, 1955; Jackson, 1955; Ollier, 1955; Tratman, 1955; Bramwell, 1957; Ollier, 1958; Tratman, 1963; Campbell, 1970, 1977.

The present study, again initiated by Professor Tratman, seeks to clarify a number of outstanding problems:

(a) The sedimentary history of the deposits remained uncertain. The particle size analyses of Ollier and Campbell could not be reconciled. A more detailed study of the deposits was called for, using a much wider range of techniques.

(b) During several visits to the cave in the 70's, it became clear that microfauna was present in layers other than those in which it had previously been found. As a pilot project, care was taken to recover such remains from sediment samples before any potentially destructive analyses were undertaken.

(c) The chronology and environmental history of the cave as proposed by Campbell were not totally convincing. New biological, geological and chronometric data were needed.

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(d) During the early excavations, very coarse stratigraphic subdivisions and a spit recording system were used. The exact provenance of the Later Upper Palaeolithic artefacts, human skeletal remains and associated (?) fauna was therefore uncertain, even after Campbell's attempt to localize them. Consequently, all sampled material down to 0.063mm. was scanned under the microscope in the hope of locating concentrations of flint, bone and charcoal.

(e) The cave had never been bottomed. We have been able to add a further three metres, making a total of eight metres, but, happily, the deposits continue. We hope that excavation will proceed but stringent safety precautions will be necessary.

DESCRIPTION OF STRATIGRAPHY

Two systems of layer notation have already been employed for the site, that of Tratman (1955) and that of Campbell (1977). The former is much too coarse for our purposes, whilst the latter is a descriptive system which we feel is too subjective and which cannot easily be extended to the newly uncovered, deeper strata. We have therefore reverted to a simple numbering from the top wherever possible. Table 1. shows the equivalences as far as can be accurately established.

Only a brief description of the deposits can be given here; a more detailed discussion, with tables of primary data, will be included in a doctoral thesis now under preparation (S.N.C.). It may be stated immediately that our particle size analyses agree well with Ollier's results. Campbell's results are texturally much too coarse, probably due to dry sieving of whole samples and consequent recording of artificial aggregates as individual particles.

Sediment colours, using Munsell notation, are matrix colours at the time of sampling (dry high summer), since later humidity-standardized determination in the laboratory showed little differentiation between layers, probably due to oxidation effects. Sediment samples are denoted by the label "SNH". The section (Fig. 6) is essentially of the same exposure as that figured by Tratman (1955) and Campbell (1977); both these publications contain plans of the cave. Our section is semi-schematic with material over about 5cm. being drawn accurately. Sampling locations are shown as black triangles. For safety reasons, the section could not be cut vertically; the top of the section is some 2m. further north, i.e. distant from the observer, than the base and the drawing has been corrected for this effect. Note that layer boundaries are only shown where they can be clearly recognized on site. The term 'gravel' is used throughout to denote particle size and nowhere implies form or genetic relationships. The phrase 'dolomitic conglomerate' is descriptive; this material may or may not be Dolomitic Conglomerate (Triassic).

The deposits can be divided into three main units which will now be described, starting from the base.

TABLE 1

Supposed Equivalences Between the Layer Notations Used During the Various Excavations at Sun Hole.

PRESENT PAPER	TRATMAN (1955)	CAMPBELL (1977)
not observed	1–3 "Postglacial"	(D)
1	?4	?C
2		C/B
3		C/B
4		B2–9
5		B2–9
6	5'	B2–5 to B2–8
7		B2–4
8		B2–4
9	"Pleistocene	B2–4
10	deposits"	B2–4
11		?B2–3, ?B2–2
12		B2–2
13	5''	B2–1
14	6	A2
15	6	A2
16		A2
17		?A2, ?B1–3
18	"boulders"	B1–1, B1–2, ?B1–3
19		A1
20		A1
21 to 35 recently exposed		
E		
D	noted	noted
C		AO
B		AO
A		AO

UNIT III (Layers 35–19)

These layers have a generally high clay content. There is extreme variation in matrix carbonates, ranging from solid stalagmite and sinter (porous carbonate nodules) to clay-rich layers with under 20% total carbonates. There are abundant crystalline concretions, often resembling fragments of 'breccia', and surface growths on stones. The layers have a generally low gravel content with a predominance of coarse gravel over the finer grades; this conclusion was reached by visual examination on site supported by extrapolation of a normal curve fitted to the measured grades 1.0–22.62mm. Coarse and medium non-carbonate sands are important. Dolomitic sand, sesquioxide aggregates, crinoid ossicles and fragmentary mollusca are present, the last in sufficient quantities to be classed as a minor source material for the sediment itself in some layers. There is extensive fissuring, especially of concretions and dolomitic conglomerates, coupled with staining (red and dark brown), alteration and blocky disintegration of calcite mudstones, and grainy disintegration of dolomitic limestones. Fractured stalactite and curtain formations are abundant, sometimes altered to a biscuity consistency.

(35) 5YR 4/3 (SNH 53) Very compact silty clay; very low in matrix carbonates; rare altered coarse gravel and concretions. Diffuse boundary.

(34) 5YR 5/4 TO 4/4 AT TOP (SNH 54, 55) Compact clayey loam; increasingly sandy and carbonate-rich upwards; some altered coarse gravel; common concretions; common organic and sesquioxide aggregates in sand. Diffuse boundary.

(33) 5YR 5/3 (SNH 56) Compact sandy clay; some matrix carbonates, especially dolomitic sand; some altered coarse gravel; common concretions; common organic and sesquioxide aggregates in sand; common dolomitic ghosts. Very diffuse boundary.

(32) 5YR 4/4 (SNH 57) Compact clayey loam; low in matrix carbonates; some altered medium gravel and concretions; common organic and sesquioxide aggregates in sand. Diffuse boundary.

(31) 5YR 4/3 (SNH 51) Compact sandy loam; generally low in matrix carbonates but sands quite rich in limestone clasts; common altered medium gravel; some concretions. Abrupt boundary.

(30) 5YR 4/3 (SNH 50, 49) Stone line at base including large crystalline concretions. Silty clay; very low in matrix carbonates; rare coarse gravel with some concretions near top; base quite rich in non-carbonate silt and sand, including quartz, organic material and sesquioxides, as well as in dolomitic sand; rather loose at base, becoming well compacted near top. Abrupt boundary.

(29) 5YR 4/4 WITH CREAM SPECKS Loose silty loam; some matrix carbonate, especially sand; common coarse gravel and concretions; affected by suffosion of Layer 26. Abrupt boundary where layer 28 is present.

(28) 6YR 5/4 WITH CREAM SPECKS Discontinuous sinter band. Abrupt boundary.

(27) 6YR 4/3 TO 5YR 4/4 AT TOP, CREAM SPECKS THROUGHOUT (SNH 48, 47, 46) Clayey loam; more silt towards base but increasing sand, coarse gravel and matrix carbonates upwards; some granular concretions as well as common crystalline concretions; quite loose towards top. Diffuse boundary.

(26) Highly suffosed breakdown layer with coarse rubble and some airspace; loose pockets. Irregular but quite abrupt boundary.

(25) 6YR 5/4 WITH CREAM SPECKS (SNH 45) Major sinter band with a little non-carbonate sand and silt as well as abundant clay. Abrupt boundary.

(24) 5YR 4/3 WITH CREAM SPECKS Compact silty loam; moderate matrix carbonates; increasing coarse gravel towards top; slightly suffosed in places. Diffuse boundary.

(23) c.6YR 7/6 (SNH 44) Irregular breccia with flowstone spreads and small stalagmites; some fracturing and disruption of these features. Abrupt boundary.

(22) 5YR 4/3 WITH CREAM SPECKS TOWARDS TOP (SNH 43, 42) Compact sandy loam; rich in clay at the base; quite rich in matrix carbonates; common coarse gravel. Abrupt boundary.

(21) 6YR 5/4 WITH CREAM SPECKS Thin sinter band. Rather diffuse boundary.

(20) 6YR 5/3 WITH CREAM SPECKS TOWARDS BASE (SNH 41, 40) Compact sandy loam; rich in clay towards top; moderate matrix carbonates; quite common coarse gravel, slightly altered; granular concretions near base; point-to-point cementation at top. Diffuse boundary.

(19) 5YR 4/3 (SNH 39) Compact clayey loam; moderate matrix carbonates; some slightly altered coarse gravel and concretions. Extremely abrupt boundary.

UNIT II (Layers 18–14)

These layers have a very high silt content with very little clay. There is a dominance of fine sand over other sand grades, especially with respect to non-carbonate, mostly quartzitic, sand, where the 0.090—0.063mm. grades account for 60–70% of the 1.0–0.063mm. material. Calcitic fine sand and silt is also a strong component, accounting for much of the matrix

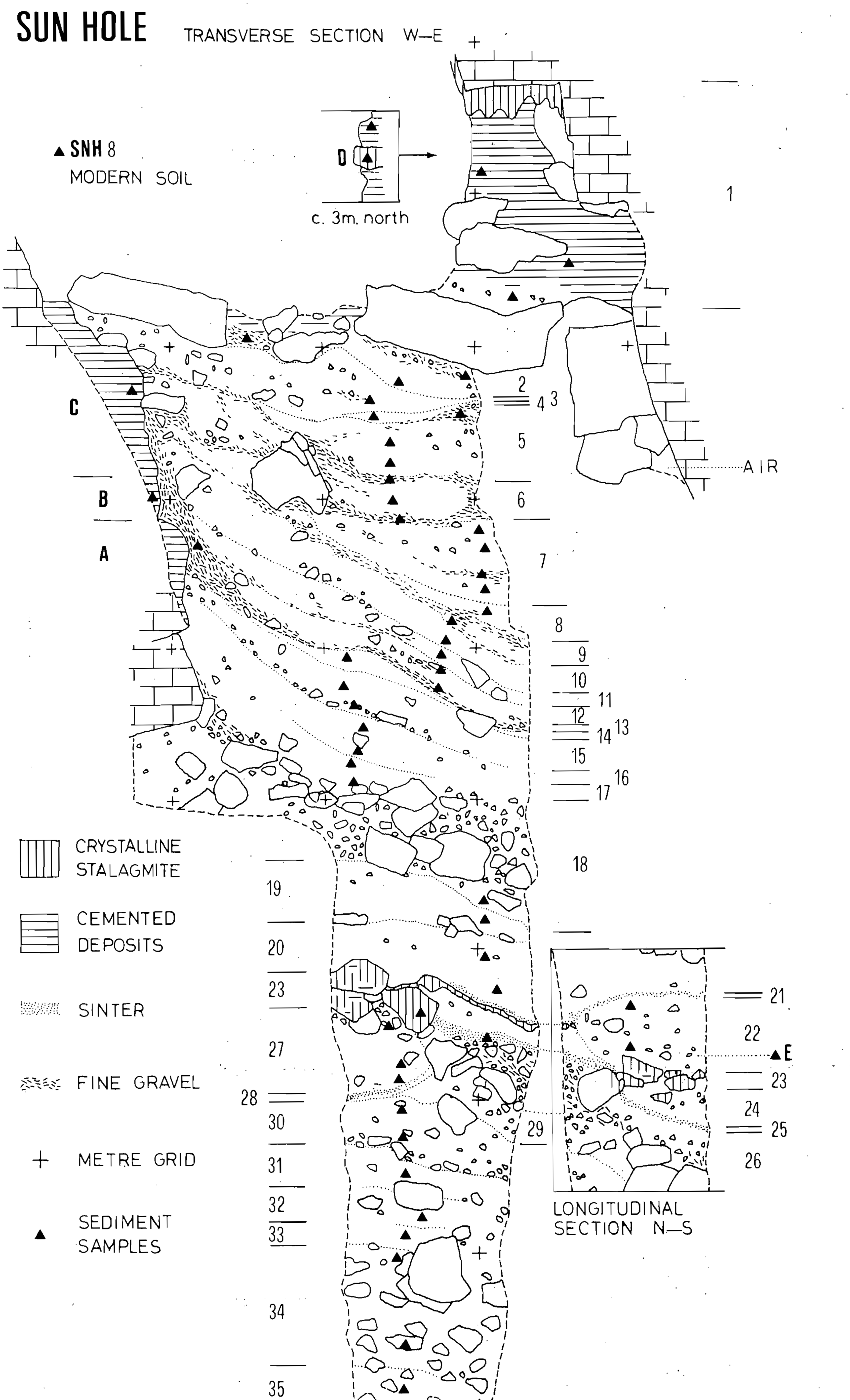

Fig. 6: Sections of the Sun Hole Deposits

SUN HOLE — SEDIMENTARY PROCESSES

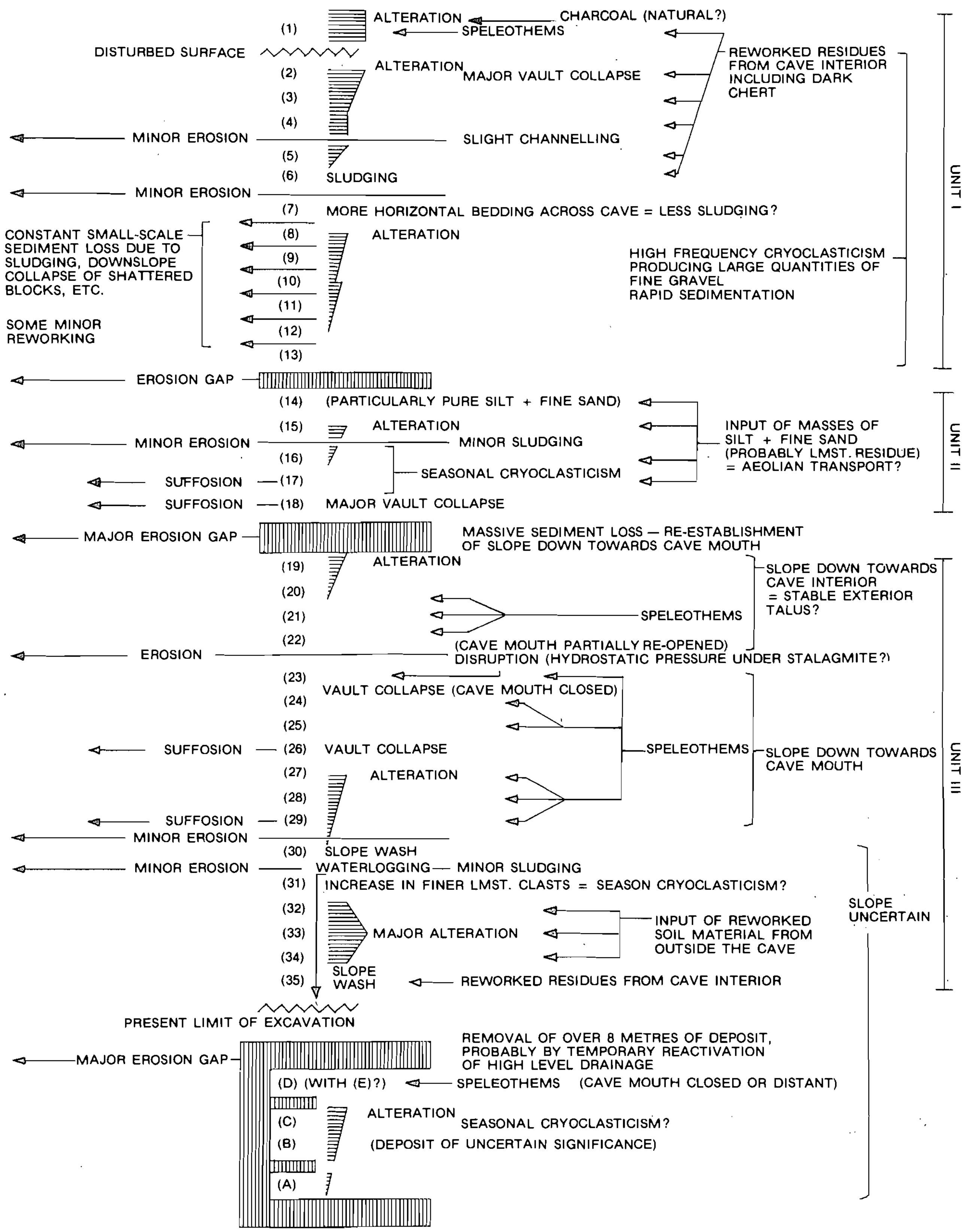

Fig. 7: Schematic Diagram of the Sedimentary Processes Responsible for the Sun Hole Deposits.

carbonate, although some concretions are present in certain layers. Stalactite fragments are only present in quantity towards the base of the unit. Gravel is still quite coarse and is a little more common than in Unit III. There are very few signs of alteration and even the fragile dolomitic conglomerate is often intact. There is very little dolomitic sand.

(18) Major breakdown layer containing large boulders and much coarse gravel; common airspace. This layer has suffered extreme suffosion, the only significant matrix material being a thin band of fine sand and silt (6YR 5/3, SNH 38) between the boulders at the base of the layer; this probably represents a lag deposit. Layer 18 may contain less disturbed finer strata towards the west wall, material which has not been sampled due to its dangerously loose composition. Irregular diffuse boundary.

(17) 7.5YR 5/4 (SNH 37, 36) Silt and fine sand; quite low in matrix carbonates but with a slight rise towards the top accompanied by a little clay; common medium gravel; matrix loss towards base by suffosion and point-to-point cementation throughout; quite loose. Rather diffuse boundary.

(16) 7.5YR 5/4 TO 6YR 5/4 AT TOP (SNH 35, 34) Fine sand and silt; increasing carbonates towards top; common coarse gravel; well compacted. Abrupt boundary.

(15) 5YR 4/3 TO 4/4 AT TOP (SNH 33, 32) Stone line at base. Silt and fine sand; low in matrix carbonates, decreasing even further towards top; rare, slightly altered coarse gravel, especially near base; a little clay towards top; well compacted. Rather diffuse boundary.

(14) 7YR 6/4 (SNH 31) Silt; low in matrix carbonates; rare coarse gravel; well compacted. Extremely abrupt boundary.

UNIT I (Layers 13–1)

Fine sand and silt continue as major components, although they contain less carbonate than below. Coarse limestone sand becomes very common. Clay plays a minor but consistent role. Concretions and surface growths on stones are quite common, as are small stalactite fragments. Fine angular gravel, often forming irregular lenses sometimes almost devoid of fine matrix, is a dominant feature throughout. Alteration, staining, fissuring, blocky and grainy disintegration and pink chalky coatings on stones are quite common but are very variable from layer to layer. Similarly, crinoids, dolomitic sand and coloured minerals (haematite, dark cherts, etc.) show a patchy distribution. Compaction is very variable within this unit; low compaction is probably primary, since the gravel lenses are not continuous enough to allow much later suffosion.

(13) 7.5YR 5/4 (SNH 30, 29) Silt with fine sand; moderate matrix carbonates; extremely abundant fine gravel; quite loose in places. Diffuse boundary.

(12) 7YR 6/4 (SNH 28) Silt with fine sand and a little clay; moderate matrix cárbonates; some fine and medium gravel, slightly altered; some concretions; well compacted. Rather diffuse boundary.

(11) 7YR 6/4 (SNH 27) Silt with fine sand; moderate matrix carbonates; common medium gravel, very slightly altered at top; some concretions; moderately compacted. Quite abrupt boundary.

(10) 7.5YR 6/4 (SNH 26) Sandy silt; moderate matrix carbonates; some medium and fine gravel, rather altered especially towards base; well compacted. Irregular but rather abrupt boundary.

(9) 7.5YR 6/4 (SNH 25) Sandy silt; slight increase in matrix carbonates; coarse, medium and fine gravel, rather altered; some concretions; well compacted. Rather abrupt boundary.

(8) 5YR 4/3 (SNH 24) Silty loam; quite low in matrix carbonates; some altered fine gravel; some concretions; well compacted. Rather diffuse boundary.

(7) 7.5YR 6/4 (SNH 23, 22, 21, 20) Sandy silt, with sand and matrix carbonates increasing upwards; fine and medium gravel, usually in the form of discontinuous lenses; a few concretions near the top; well compacted except within gravel spread. Abrupt boundary.

(6) 6YR 5/3 WITH 7.5YR 6/4 AT BASE AND TOP (SNH 19, 18, 17) Silty loam; slightly altered fine gravel lenses, especially continuous at base and top; moderate matrix carbonates; some concretions; slight rise in clay and non-carbonate medium sand towards the top; some dolomitic sand; quite well compacted in the middle but much less so at base and top where gravel is very loose. Quite abrupt boundary.

(5) 6YR 4/4 TO 7.5YR 6/4 AT TOP (SNH 16, 15, 14) Silty loam; slightly altered fine gravel lenses; matrix carbonates, alteration and occurrence of concretions increasing towards top; some dolomitic sand; well compacted though a little less so at top. Abrupt boundary.

(4) 7.5YR 5/4 (SNH 13) Sandy loam; moderate matrix carbonates; some medium gravel, heavily altered; common concretions; some dolomitic sand; well compacted. Abrupt boundary.

(3) 6YR 4/3 (SNH 12) Sandy silt; moderate matrix carbonates; some medium and fine gravel, heavily altered; common concretions; well compacted. Rather abrupt boundary.

(2) 7YR 5/4 WITH 7.5YR 6/4 AT BASE AND TOP (SNH 11, 10, 9) Sandy silt; increasing matrix carbonates towards top as well as increasing quantities of fine gravel; some clay and heavy alteration towards base, together with point-to-point cementation; common concretions; large roof slabs within this layer; quite well compacted except at surface. Modern disturbed surface.

(1) 7.5YR 5/4 WITH CREAM SPECKS (SNH 5, 4, 3, 1) Heavily cemented deposits on the east wall, capped by granular stalagmite; increasing quantities of matrix carbonates towards top as well as clay; non-carbonate sands, though decreasing upwards in relative importance, become coarser. Contiguous with dormant (?) stalactite.

In addition to these units, there are five 'layers' which cannot as yet be inserted into the main stratigraphy:

(A) 7.5YR 6/4 WITH CREAM SPECKS Highly cemented sandy silt; common medium gravel; very patchy remains only on west wall.

(B) 6YR 4/4 (SNH 7) Slightly cemented silty sand, in structural groove on west wall; moderate matrix carbonates; rare, very fine gravel. Diffuse boundary with Layer C.

(C) 7.5YR 6/4 WITH CREAM SPECKS (SNH 6) Highly cemented sandy silt; moderate matrix carbonates; quite common medium gravel; presence of limestone plaques that have been warped to curvilinear or even angled forms; common concretions. Erosion surface.

(D) (SNH 2) Crystalline stalagmite blocks embedded within the granular stalagmite capping Layer 1. These are fragments of a floor which was once at least 15cm. thick.

(E) (SNH 52) Large broken stalagmitic boss, coarsely crystalline, lying in Layer 22. This could be referable to Layer 23 but it cannot be even vaguely matched with any *in situ* formation, these being very much smaller, less well crystallized and less pure. The boss could be contemporary with Layer D.

DISCUSSION OF SEDIMENTARY PROCESSES

Fig. 7 represents the sequence of sedimentary processes which are thought to have given rise to the Sun Hole deposits. Only the more obvious features are noted since we are well aware of the dangers involved in over-interpretation of very small sections. Certain major aspects of this sequence require some discussion.

The clastic particles, which constitute an important component throughout the deposits, include material from a wide range of carbonate rocks. The dominant type is a dark grey calcite mudstone, mapped by the IGS (Sheet 280) as "chinastone", derived from the Clifton Down Facies of the Lower Carboniferous in which the cave is formed. Exposures in the cave walls and just outside the entrance show the presence of brachiopods, possibly chonetids, as well as of oolites that have been somewhat modified by micritization and, in places, by silica replacement. These features can be seen in many of the calcite mudstone clasts included in the deposits. There are also surprisingly large quantities of dolomitic rock: dolomitic conglomerate, with extremely rounded limestone pebbles set in a dolomitized matrix, and a grainy, yellowish dolomitic limestone. Silicified crinoid ossicles are common, especially in the lower layers, although there is no trace of their parent limestone. There are rare occurrences of an unidentified, coarse light grey limestone, which is also present in the slope deposits just above and west of the cave entrance. Fragments of a vuggy breccio-conglomerate and of a semi-lithified current-bedded deposit, found in almost all the layers as an extremely minor constituent, would seem to represent ancient cave fill.

The presence of dolomitic rocks was first noticed by Ollier (1955, 1958), who suggested that the yellow type could have come from the Triassic Conglomerates to be found within a kilometre to the W.N.W., for example at Batt's Coombe. He also implied that transport would have been through a cave system, not overground. If the cave is indeed part of a much larger system, this would help to explain the presence of such diverse rock types, a diversity for which there is no other obvious explanation. These rocks would have been brought to the vicinity of the Sun Hole passage by water transport and later, perhaps very much later, reworked by collapse and sludging into their present positions, losing all signs of water-rounding in the process. This hypothesis is not particularly attractive but it is as yet the only one available.

The 'hanging breccias' (Layers A–C) are cemented sediments, not to be confused with the much older vuggy breccio-conglomerate mentioned above. Campbell (1977) noted fragments of what he called an older breccia in Layers 17–20, which he supposed to have been derived from these hanging deposits. Although some particulate material may well have fallen from the walls into the younger sediments, the breccia to which Campbell refers is due to autochthenous concretionary processes associated with suffosion and waterlogging. There are no large carbonate-cemented aggregates that can be recognized as having come directly from the hanging deposits, barring perhaps the fragments of crystalline stalagmite which could be derived from Layer D (cf. Layer E and the thick slabs of stalagmite recovered by Tratman (1955) from within Unit II). It should be noted that there is no proof as yet that these hanging deposits are older than all the other deposits, nor in fact that they are even internally in the right stratigraphic order. However, this would seem to be the most likely interpretation and it is that which is represented in Fig. 7. Nevertheless, these deposits could fit into the gap between Units III and II, or even between Units II and I.

When fresh, the calcite mudstone has a very low porosity and permeability. After 200 experimental 12-hour freeze-thaw cycles of –10 to 25°C, in a tray with 2cm. of water, samples of various sizes showed practically no fissuring, only a few sand- and silt-sized particles being produced. It is therefore suggested that in Sun Hole the main control of particle size during vault shattering is not the intensity of cryoclasticism but rather the structural properties of the limestone. Initially, clasts produced by chemical weathering, various types of stress release and frost shattering will tend to have a distribution with a coarse mean. In general terms, the higher the frequency of temperature oscillations about zero, the more rubble will be produced. A high rate of sedimentation will favour mechanical (percussive) fracture as new material falls onto old without the benefit of a fine matrix 'cushion'. Perhaps 30% of the gravels from Unit I show good conchoidal fractures with all the stigmata of struck flint; this is a property of the calcite mudstone and conchoidal fractures would not occur in coarser limestones. Secondary cryoclasticism, making use of any remaining weaknesses in the clasts, such as microfissures created during mechanical fracturing or by alteration, will further comminute the material.

In various layers within the sequence, especially those of Unit III, there is widespread deep fissuring of the dolomitic rocks and of crystalline concretions. The calcite mudstone may show a blocky fracture or may even itself be slightly fissured. The fissuring is expressed as a mosaic of curved and stepped cracks which do not penetrate right to the heart of the particle. Such fissuring has been noticed in French caves (cf. Laville, 1976) and has been attributed to frost action. However, Miskovsky (1972) has noted that the fissuring is more common on altered limestone. At Sun Hole, the fissuring is only present in altered layers, the more altered, the more fissuring. Slow hydration and recrystallization in very damp deposits could account for this phenomenon. There is no reason to invoke frost shattering, although this process will obviously attack already fissured limestone. The particularly abundant fine gravels of Layer 6 would seem to have resulted from just such a combination.

Alteration has been estimated mainly by the presence of certain features on larger carbonate particles. The calcite mudstone surfaces show rounding of angles, red and black staining, deep pock marks (differential solution of oolites) and ribbing (high relief of calcite veins). These effects are usually only superficial, although staining may penetrate along structural planes; alteration does not markedly increase porosity in this limestone. Perfectly rounded limestone pebbles and dolomitic sand are released from the dolomitic rocks. Ghosts may be present, which represent undisturbed but totally decomposed dolomitic limestone and stalactite; where these are present in quantity, waterlogging is assumed to be the cause. Alteration requires water, a transport medium which would have contributed some of the clays usually found in altered layers and which would be necessary for the growth of concretions within the sediments. A temperature rise would not be necessary but any rise would certainly accelerate alteration and movement of carbonates in solution.

'Sinter' is a term used here to denote particulate, tufa-like carbonates. It is made up of porous granules which in section show complex structure. The core of each granule is mostly white microcrystalline carbonate set in extremely convoluted concentric laminae, separated by slightly darker lines. Some recrystallization has occurred, with large crystals growing radially across the laminae. Granules are coated and cemented into larger units by 'orange' crystalline calcite, identical to that which composes the soil concretions. The internal structure of these granules resembles algal growths. There are also dark dendritic inclusions that recall the stems of some cryptogams. It is thought that the granules were formed on the cave roof and walls around lichens and mosses and that, as growths eventually smothered the plants and became unstable, they fell to the floor to form sinter bands. Such growths would require water and at least some indirect light.

The growth of crystalline stalagmite so near a cave entrance, even allowing for possible cliff retreat, and under such a thin overburden of limestone, would suggest abundant percolation water and the presence of active surface soils with vegetation. When stalagmite is relatively pure, other depositional processes must have ceased and air circulation must have been restricted to allow the growth of good crystals. Layers 19–22 slope up towards the cave entrance, at least within the small area examined by us, suggesting that the cave was indeed closed during the deposition of the stalagmite of Layer 23. A stable exterior talus would be difficult to maintain during periods of extensive solifluction; rather, a mat of binding vegetation is indicated. Note that a small talus, with reversal of the normal south-trending dip of the deposits, formed during the Holocene (Tratman, 1955).

Abundant soil material was washed into the cave during the early part of Unit III. This material consists of sand-sized and smaller, irregular aggregates containing oxides of iron, aluminium and manganese with colloidal silica, clay minerals and much organic material. The same layers also contain unassociated clays and quite large quantities of comminuted mollusc shells. The abundance and state of preservation of these shell fragments, coupled with the closed fabric of the sediments, militate against a recent intrusion. No particles showing strong soil fabric are present. These features would suggest derivation from thin residual soils with low pedality, the normal azonal type on limestone slopes. It is of interest that the modern soil outside the cave, apart from having enormous quantities of mollusc remains, is also rich in fragments of partially silicified oolites derived from the local bedrock, fragments which are absent from the cave sediments. Conversely, silicified crinoid ossicles are common in Unit III but absent from the modern soil. It therefore seems probable that most of the ancient soil material entered the cave from some point further back in the system, not through the Sun Hole entrance. Small amounts of these possibly soil-derived fossils occur throughout Unit III and also towards the top of Unit I.

Silts and fine sand are important right through the sequence but are particularly abundant in the layers of Unit II. The non-carbonate component resembles the quartzitic residue of the local bedrock; indeed, most of the local Carboniferous Limestone facies contain quartz grains in this size range. However, the fine material in Unit II cannot be the result of *in situ* weathering since the clays, which are also present in the limestone, are absent in these layers, as are signs of strong alteration. Similarly, if the residues had been washed into the cave, the clays would also be present or there would be signs of higher energy water transport (eg. current bedding) and the particle size distribution would not be negatively skewed. Furthermore, there is a significant mode in the carbonate silts and fine sand which can hardly have been produced by chemical weathering. The only other explanation would seem to be that the material has been wind-sorted. We hope to test this hypothesis by scanning electron microscopy of quartz grain surface textures. If this is indeed local aeolian material, conditions must have been rather dry and the vegetation cover at best discontinuous.

The importance of the entries on the left hand side of Fig. 7 must not be overlooked. The arrows represent the minimum number of erosive events present in the sequence. Erosion, being a subtractive process, is very difficult to estimate. Erosion is assumed to have occurred when there is a sharp boundary between layers and at least a slight change in sedimentation pattern. When there is a radical change in sediment type which cannot be explained by topographic shifts (eg. between Units III and II), a major gap is suggested. In a cave like Sun Hole, with deposits sloping down towards a steep hillside grading into a vertical cliff, we might suspect that the gaps represent greater lengths of time than the extant sediments. The actual mechanism of erosion is not always clear; many of the erosive events in Sun Hole seem to be associated with sludging or merely slope collapse. There is no sign of stream erosion, although it is possible that this process was responsible for 'flushing' the cave and leaving the hanging deposits; this hypothesis requires that the 'hanging breccias' be older than all the other sediments yet exposed. We expect to find stream deposits eventually if excavation can be continued to sufficient depths.

Suffosion, the slow removal of fine matrix from sediment bodies that have a rigid, coarse 'skeleton', has been an important process in many layers, especially those representing vault collapse. The process is still active in Layer 18, where percolating water, having removed large quantities of matrix, is now depositing crystalline calcite in the resulting voids. Those fines which still exist within such a deposit are not necessarily part of the original matrix; they may be reworked material from either above or below the suffosed layer.

DESCRIPTION OF THE PLEISTOCENE FAUNA

Previous accounts of the Sun Hole fauna have cited remains of 21 species of mammal, including man. Material from the 1927–8 and 1951–3 excavations was reported by Jackson (1955), who concluded that it was Late Pleistocene in age and was very closely comparable to faunas recovered from the upper levels of numerous British caves. Tratman (1963) recorded additional species determined by R. J. G. Savage and observed that the absence of such forms as spotted hyaena, mammoth and woolly rhinoceros indicated a Late Glacial date. No new species were reported by Campbell (1977); we have not studied his material.

All the mammalian finds are recorded as having been restricted to the upper 8 feet (2.4m.) of what was then an 18 foot (5.5m.) section. The base of the "8th. foot" marked an abrupt change in lithology in Tratman's account, taken to be the equivalent of the junction between Units I and II as described here. Sadly, the recording system adopted in the earlier excavations was based upon a series of horizontal foot spits. As the deposits of Sun Hole dip rather steeply (cf. Fig.6), it is impossible to relate the finds obtained between 1927 and 1953 to the detailed stratigraphy now known. The sloping datum assumed by Campbell in his attempt to plot the human artefacts from the older digs onto his redrawn section of the upper part of the cave deposits is without foundation. In spite of this loss of information, it is reasonably certain that all the previously reported finds from the Pleistocene levels in Sun Hole come from the deposits of Unit I.

The following list of mammals is based on a re-examination of the U.B.S.S. collections. Campbell rightly doubts the record of wild boar (*Sus scrofa*) which is based on the mandibular symphysis of a horse; an unpublished record of spotted hyaena (*Crocuta crocuta*), mentioned by Campbell, could not be confirmed from existing material.

UNIT I FAUNA:

Talpa europaea L.	mole
Homo sapiens L.	man
Canis lupus L.	wolf
Vulpes vulpes (L.)	red fox
Ursus arctos L.	brown bear
Mustela nivalis L.	weasel
Felis sylvestris Schreber	wild cat
Equus ferus Boddaert	wild horse
Rangifer tarandus (L.)	reindeer
Castor fiber L.	beaver
Apodemus sylvaticus (L.)	wood mouse
Dicrostonyx torquatus (Pallas)	collared lemming
Lemmus lemmus (L.)	Norwegian lemming
Clethrionomys glareolus (Schreber)	bank vole
Arvicola terrestris (L.)	water vole
Microtus sp. (usually listed as *M. arvalis* group but may be a morphological variant of *M. gregalis*)	
Microtus gregalis (Pallas)	narrow-skulled vole
Microtus oeconomus (Pallas)	northern vole
Ochotona pusilla Pallas	steppe pika
Lepus timidus L.	Arctic hare

All of the faunal remains from the most recent excavation in Sun Hole were recovered from samples collected for sediment analysis. Determinations based on this material are presented layer by layer in Table 2. As there has not yet been any further sampling of the sequence with the specific aim of extending the faunal record, the present results must be regarded as a first and very incomplete glimpse at a newly fossiliferous series of deposits. If one compares the Unit I fauna in Table 2. with that listed above from the earlier excavations, it is immediately obvious that the recent samples do not include anything like the complete assemblage; this is also assumed to be true of the new records from Units II and III.

In addition to the fauna recorded in Table 2., remains of *Dicrostonyx torquatus* were recovered from Layer C of the 'hanging breccias'.

TABLE 2

Fauna from the 1977–1980 Excavation in Sun Hole

Layer numbers:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Talpa europaea L.	*																						FLOWSTONE FORMATION											*	
Sorex araneus L.																																	*		
Ursus cf. *arctos* L.																			*																
indeterminate small carnivore	*																																		
Saiga tatarica (L.)					*																														
Apodemus sylvaticus (L.)	*																																		
Dicrostonyx torquatus (Pallas)		*	*	*	*	*	*	*							*																				
Lemmus lemmus (L.)																		*																	
Clethrionomys glareolus (Schreber)	*																																		
Arvicola terrestris (L.)	*																														*				
Microtus arvalis/agrestis group	*	*				*	*																				*			*					
Microtus cf. *oeconomus* (Pallas)	*																																		
Microtus gregalis (Pallas)	*		*													*																			
Microtus sp.			*	*	*		*			*	*			*					*								*			*		*	*	*	
Microtinae indet.									*									*		*		*			*						*				*
Rodentia indet.												*																							
cf. juvenile lagomorph		*																																	
Aves indet.							*																												
Pisces indet.							*																												

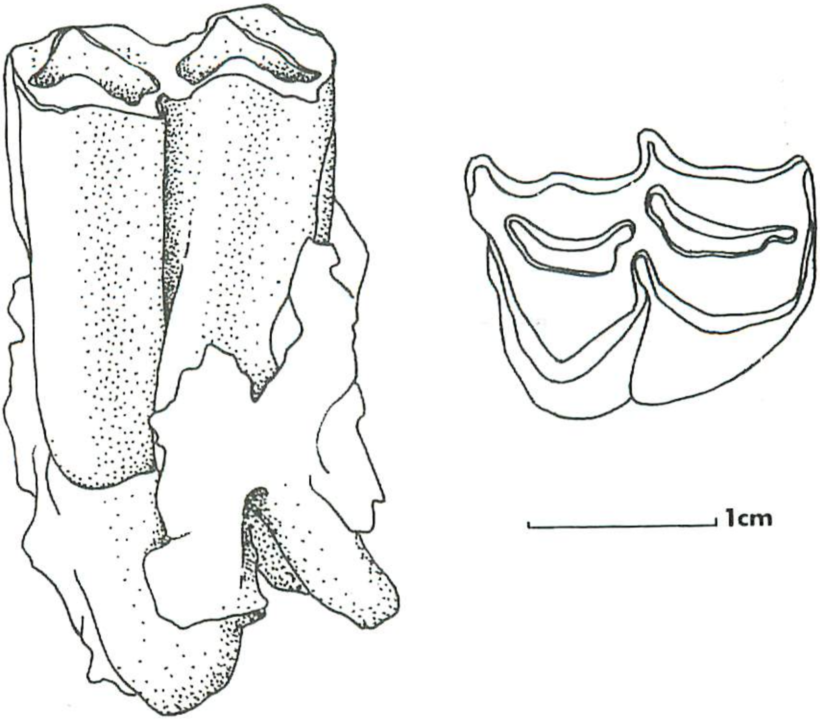

Fig. 8: Upper M2 of *Saiga tatarica:* lingual view (left) occlusal view (right).

DISCUSSION OF THE PLEISTOCENE FAUNA

Saiga tatarica is a new record from the cave and only the second from Britain. The animal is represented by an upper M2 recovered from Layer 5 of Unit I (Fig. 8). Saiga antelopes are now restricted to the dry steppe and subdesert areas of the southern U.S.S.R., but extended into the fringes of the forest-steppe regions further north during historical times. It is reported to avoid uneven ground rigorously. The main modern predator of the saiga other than man is the wolf (*Canis lupus*), which is quite well represented at Sun Hole. This find may represent a wolf kill on the Somerset Levels during what appears to have been one of the very rare incursions of saiga herds into the British region.

The occurrence of beaver (*Castor fiber*) is particularly interesting in that it provides a basis for reconstruction of the local environment during at least part of the period represented by the Unit I deposits. Beavers require a body of water to live in and a fairly plentiful supply of immediately adjacent trees and saplings for food and for the construction of their dams and lodges. Wooded conditions would also suit the brown bear (*Ursus arctos*), the wild cat (*Felis sylvestris*), the wood mouse (*Apodemus sylvaticus*) and the bank vole (*Clethrionomys glareolus*). Lightly wooded country would not exclude any of the recorded animals, though the topographic complexity of the area around Sun Hole would almost certainly have produced significant variation in vegetation cover. In this context, it is worth quoting Bramwell's (1957) comment on the presence of *Lyrurus tetrix, Pica pica* and a member of the Hirundinidae (swallow family), identified by him from the upper deposits of the cave: "I am, however, of the opinion that some bushes and scrubland existed in the sheltered valleys to support such birds as Black Grouse, Magpie and the Passerine type." (p.39).

When considering the new microvertebrate finds, the principal litho-stratigraphic boundaries (Unit boundaries) do not necessarily provide a sufficiently detailed framework to express the significant changes seen in the faunal sequence. Unit I is divisible on faunal grounds into three parts, Layer 1 with what may be a very early Holocene fauna wanting in lemmings and including mole and wood mouse, Layers 2 to 8 with abundant *Dicrostonyx torquatus,* and Layers 9 to 13 in which lemmings are absent and fauna generally scarce. It should be noted that, although the fauna from the old excavations cannot be accurately located within the present stratigraphic framework, the animals preferring at least some woodland (beaver, etc.) were recorded from well within the Pleistocene deposits. It seems very unlikely that these animals were found in the equivalent of our Layer 1, especially since these sediments are easily recognized by their massive carbonate content and were, in fact, clearly described by Tratman as lying well above the spits which produced the woodland types.

Unit II continues downwards through Layers 14 to 18 with a very sparse fauna indeed. The record of *Lemmus* in Layer 18 is significant in being the lowest evidence so far recovered of any characteristic cold climate forms.

Unit III is by far the most interesting of the newly sampled deposits. Cold forms are entirely absent even though *Microtus* species are quite well represented. Although no diagnostic forms have been found, there is nothing from the deposits of Unit III that would be inconsistent with an interglacial assemblage. If this preliminary suggestion can be substantiated by additional sampling, it will be the first good evidence of an interglacial fauna in the Cheddar area and one of very few in Mendip as a whole.

There is no evidence to suggest that any of the large mammal remains found in Sun Hole are human food debris. Hare, beaver, saiga and reindeer are all part of the known diet of modern wolf packs; horse was also probably in this category but is now virtually unknown in the wild. The micro-vertebrates are most probably derived from the regurgitated pellets of birds of prey such as the snowy owl.

ARCHAEOLOGY AND RADIOCARBON DATING

The Later Upper Palaeolithic (L.U.P.) artefacts from Sun Hole were found during the early excavations by the U.B.S.S. group; 43 were available to Campbell for study, of which only 8 were retouched tools. Campbell did not recover any struck flint material or charcoal from his excavation. One of our aims was to localize the Palaeolithic layer(s) by microscopic scanning of all sediment samples: this attempt failed. One flint blade was found at the very top of Layer 2 in a most probably disturbed position; no other flint, not even sand-sized chips, was identified. No significant concentrations of bone debris were recognized. Only the very top of Layer 1 contained charcoal; this was present as abundant sand-sized particles and might represent either Holocene human occupation (cf. Tratman and Henderson, 1928) or natural vegetation fires. Although these results are disappointing, we intend to subject samples from any remaining deposits nearer the cave entrance to the same treatment as soon as they can be cleared of the present cover of tip. The puzzle remains as to why a few human bones were found associated (?) with what was obviously a very minor intrusion into the cave.

Campbell obtained a date of 12,378 ± 150 B.P. (BM–524) on a radius of *Ursus arctos* from the B2–7 horizon of his excavation, apparently the equivalent of part of Layer 6 of Unit I, providing valuable confirmation of the expected age of the fauna. However, Campbell argued that this bear bone could be situated within the stratigraphic range of the L.U.P. artefacts and that the date applied to the human occupation, indeed, that bear was actually hunted. We are not convinced that the rather isolated pocket of sediment in which the dated bone was found can be accurately placed within the main stratigraphy; we have not ourselves observed this deposit and our argument is based on Campbell's section drawing alone. Furthermore, there is no evidence that bear, or any other animal, was exploited by man at this site.

Three more bone samples have been radiocarbon dated from the old U.B.S.S. collection. None of these samples can be shown to be archaeological specimens but, with this slight possibility in mind, large herbivore bones were chosen. The samples are referenced with the depths of the excavation spits measured from the top of the Pleistocene levels as recognized by Tratman. In order to provide enough material for collagen extraction, each sample contained a number of different bones; these bones were considered by J. W. Jackson to represent single individuals of the species named (Tratman, pers. comm.). The results are as follows:

Birm-819	10,110 ± 160 B.P.	0.9-1.2m.	*Rangifer tarandus*
Birm-820	10,280 ± 200 B.P.	1.5-1.8m.	*Rangifer tarandus* and *Equus* sp.
Birm-821	10,470 ± 190 B.P.	2.0-2.3m.	? *Equus* sp. (bone and tooth)

It should be noted that (a) the central dates are in stratigraphic order; (b) the dates suggest relatively rapid sedimentation, a proposition fully supported by the present study; and that (c) the 2σ bracket covered by the dates (9,790 to 10,830 B.P.) is in keeping with the faunal and sedimentological data. If the archaeological remains fit somewhere within this span of sedimentation, as seems most likely, the younger dating appears more plausible, judging from similar material elsewhere (cf. Jacobi, 1980), than does Campbell's older date. We reiterate that none of the dates are in archaeological association; this question cannot be finally settled until the 'occupation layer(s)' is/are unequivocally recognized.

GENERAL DISCUSSION

The sequence at Sun Hole obviously comprises deposits representing considerable periods and varied environments. Layer 1, and those upper deposits described by Tratman (1955; his layers 1–4) but probably no longer available for study, are Holocene in age. The remainder of Unit I represents at least part of Late Devensian time, as indicated by the radiocarbon dates; the faunal remains, and to some extent the sediments as well, suggest significant fluctuation in environment during this period. Unit II is composed of sediments laid down under more rigorous conditions, probably colder and drier. Unit III, with its soil-derived material, phases of carbonate precipitation and lack of cold fauna, would seem to represent an interglacial environment, though here again there are suggestions of climatic fluctuation in the sediments. The dating of the 'hanging breccias' is problematic; these are cold climate deposits, with the stalagmite, which may perhaps cap them, representing a milder phase.

It would be a simple matter to interpret every minor shift in the faunal and sedimentological parameters and to pigeon-hole all these deposits with the 'classic' labels of British Quaternary stratigraphy. We choose not to do this, since we feel that our information is not sufficiently complete and we have realistic hopes of widening our data base in the near future. For instance, all or part of Unit III might be of Ipswichian age but it could equally well represent various other interglacials. Why be impatient when larger faunal collections and uranium-series dates on stalagmite will surely provide firm evidence one way or another? Similarly, we have restricted our present report to verbal data in order not to seduce the reader with seemingly authoritative tables of numbers and proportions. This is particularly true of the sedimentological study, where we have concentrated upon the range of processes evidenced rather than upon complex shifts through time. We repeat that only one narrow section in the cave has been studied so far.

There remains one further aspect of the available data which may have important implications for the study of British Quaternary cave deposits. Campbell was able to recover very small quantities of pollen from material split from his sediment samples. The genera represented in Campbell's layer A2, probably the 'coldest' sediment so far exposed, include traces of *Abies* (fir), *Tilia* (lime) and *Alnus* (alder). There is a large increase in thermophilous tree pollen in Campbell's layer A1, equivalent to the top of Unit III, including *Carpinus* (hornbeam), but these types of pollen are also present well up into Unit II. It is clear that pollen has migrated both down the sequence and perhaps also stratigraphically upwards, following suffosion paths stepping up the inclined sequence whilst maintaining a generally downward trend. It is fashionable in this country to dismiss cave pollen as meaningless because cave sediments as a whole are, mistakenly, thought to be too open and coarse and therefore always subject to pollution. At first glance, Campbell's results from Sun Hole would seem to support this conclusion. However, it is difficult to dismiss the presence of *Picea* (spruce) and *Abies* in Campbell's samples, neither of which occur naturally in the British Holocene (cf. West, 1977); *Picea* is last recorded in the Chelford

Interstadial, *Abies* in the Ipswichian. Is it mere coincidence that our evidence also points to interglacial conditions during Unit III? Some of the layers of Unit III, below the level reached by Campbell, are very rich in contemporary colloids and should function as closed systems for pollen preservation, especially those layers with organic as well as mineral colloids. We fully intend to build upon Campbell's preliminary work in this field.

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