

*Plate 2. Wookye Hole Fourth Chamber, looking upstream. The excavation area is the bank on the left. Photo: N. Barrington.*

## ROMANO - BRITISH CEMETERY IN THE FOURTH CHAMBER OF WOOKEY HOLE CAVE, SOMERSET.

by

C. J. HAWKES, JULIET M. ROGERS and E. K. TRATMAN

With specialists reports by

G. C. BOON, J. M. ROGERS and R. D. STENNER.

### INTRODUCTION

Excavations in the entrance of Wookey Hole Cave in the early part of this century proved occupation there during the Iron Age and the Roman period (Balch 1914). Prior to that Buckland describes finding human bones and pottery in a distant part of the cave (Buckland 1823). Although it is not absolutely certain where he found these bones it seems likely to have been in the sandbank leading towards Charon's Chamber, on the other side of the River Axe, opposite the stalagmite boss known as "The Witch". Boyd Dawkins (1874) however, thought it was in the 4th Chamber.

In June 1946 cave divers found three human skulls, two femora, some other human bones and an almost complete Romano-British pot in the river just upstream of The Witch (Balcombe 1946). Between then and 1956 further discoveries by the divers increased the number of skulls found in the streamway between the 3rd Chamber and the resurgence of the River Axe, to eighteen. Some further post-cranial material, more Romano-British pottery, two pewter ewers, a Roman coin and some wine bottles were also found. The dating for the pottery and ewers is given as from the 2nd to 4th century A.D. (Mason 1949, 1957). The copper coin was of the Emperor Gratian 378-383 A.D. (Cheramodytes 1956). The wine bottles are of 17th to 19th century types. A Mr. Rogers, writing in 1694, gives an account of a visit to the cave and, in describing the 3rd Chamber which he calls "The Sellar", he mentions "tis very usual to carry Bottles of Wine and drink there upon a stone Table" (Balch 1947).

The divers' discovery of human bones, and the skulls in particular, caused great speculation regarding sacrifices to The Witch despite the fact that Mason, in 1949, did his best to allay these ideas by pointing out that most of the remains had come to rest upstream of The Witch and behind natural barriers of rock in the stream-bed (fig. 4). Subsequently Mason, Devenish and others recovered a few human bones from the laminated silts in the 4th Chamber; on the strength of this Mason proposed that the 4th Chamber had been used for burial purposes (Mason 1958).



This was the background against which the excavations in the 4th Chamber were undertaken by the U.B.S.S. in 1973-76. The purpose of the excavation was to find out if the 4th Chamber had been used as a place of burial and if so, when and for how long.

The 4th Chamber was in former times the furthest point into the cave that man could reach. This had been so from antiquity until the middle of the last century when a dam was made across the entrance of the cave, thus making the whole of the cave a reservoir providing a head of water to drive machinery in the paper mill down the valley. In making the dam, the water level in the cave was raised by about 1.75m. This drowned the archway into the 4th Chamber and since then, apart from times when the sluice gate has been opened, the 4th Chamber has been sealed off.

Chamber 4 is 12m. long by 10m. wide and has an average height of a little under 2m. The river running along the south side is between 2 and 2.5m. wide at its natural low level. It flows in from Chamber 5 under an arch 1.25m. above water level and out to the west under an arch of much the same height; here the river takes a 90° turn to the south to flow along the east side of the 3rd Chamber.

The bed of the stream, which slopes down towards and undercuts the south wall of Chamber 4, is mostly stony with fine silt. Towards the 5th Chamber the water becomes deeper, over 3m. compared with 0.75m. at the deepest in 4.

The north bank of the stream rises in an almost smooth slope of approximately 20° towards the wall of the 4th Chamber, flattening out to meet it at 1.9m. above the water level. It is composed of silt and mud. (fig. 5).

The north wall of the Chamber slopes up at 60°. At the east end and to the left of the arch into the 5th Chamber there is an oval hole in the rock 1m. wide by 0.75m. high. This goes through and down to a water surface 0.8m. × 1m. inside, the water being at the same level as the streamway.

### THE EXCAVATION

The area excavated lies at the eastern end of the 4th Chamber and forms more or less a rectangle 7m. east by 4m. north, somewhat abbreviated by the stream and the rock walls of the Chamber.

The first layer, soft sands and silts, was soon recognised as being material that had built up since the dam had been put in at the entrance and the cave had become a reservoir. Near the stream it was only a few centimetres thick, but towards the north wall it increased in thickness to about 0.75m. This layer was virtually without any finds, a few pieces of clay pipe stem were found just over the junction with layer 2.

The surface of layer 2 also sloped down to the streamway but at a much lower angle of 10° or less. Although also formed of silt and sand from the river it was much more compacted and it was noted that, as the

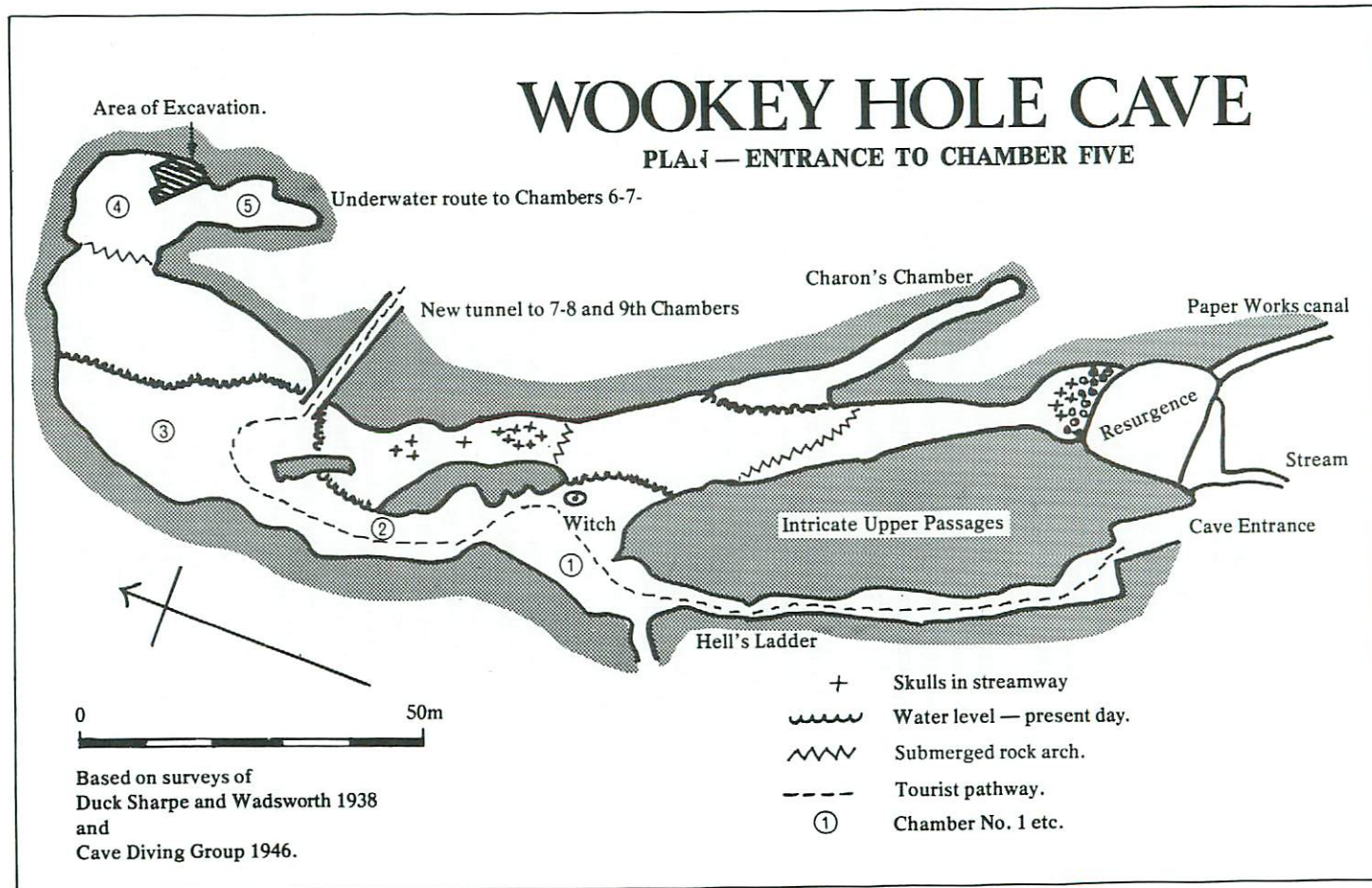


Fig. 4. Wookey Hole Cave. Plan.



water drained out of layer 1 back to the stream when the water level was lowered in the cave, it flowed over the surface of layer 2. Into this surface were pressed some further fragments of clay pipe and small, hand-wrought pins of an 18th or 19th century type—*vide* “pixie pins” (Balch 1947). One lead musket ball was also found. There is a reference to Alexander Pope bringing soldiers into Wookey Hole to shoot down the stalactites to take back to decorate his new grotto at Twickenham in the mid-18th century (Balch 1947).

Layer 2 appeared to be made up of thin laminae of silts. The west end of the excavated area (Area I on plan) was generally free from large rocks and the silt was thin (0.05—0.1m.) and particularly compact. Under the edges of rocks and in between the larger ones, particularly in Area II on plan, the layer 2 silt was less compacted and deeper, up to 0.5m.

Layer 2 produced human skeletal material in quantity, little however in true anatomical apposition, and many of the bones were broken and only partially present. Each piece was plotted before lifting, using a metre-square grid, and drawing all the finds at half-scale, and numbering the drawing with the find number before lifting the specimen.

In Area I the fragmentary state of many of the bones and the way they were often found under the edges of rocks, as well as the compacted nature of the layer, gave the impression that this part of the Chamber had been walked on a good deal and also that the stream in times of spate washed the bones in tight under the edges of the rocks. No evidence was found to suggest any substantial fall of rock from the roof since the beginning of the deposition of layer 2.

Areas II and III seemed to be the two main foci for the deposition of bodies in the area excavated. In Area II, where layer 2 had greater depth and was less compact, the impression was that this part of the Chamber had not been walked over so much and, being higher up the slope, had only occasionally been under water. Here in Area II portions of skeletons were found in anatomical order:— a rib cage, two forearms and hands, and two feet with lower legs. The remains of at least three individuals. Beneath the bones at the base of the layer there was a flat rock chocked up with smaller stones to produce a small level surface about half a metre square. Two rough cuboid lumps of clay, with approximately 8cm. sides, were also found near the stone, at the same level.

Area III lower down the slope and in front of the oval hole contained a second mass of bones. Here both the flooding river and the trampling of later visitors to the Chamber would certainly seem to have been the cause for the compaction of the silt. The fireplace mentioned below impinges on the south and east corner of the deposit. The bones in this area were more jumbled and damaged than in Area II and very few were in anatomical order. No complete skeletons, and no whole or nearly whole skulls were found during the excavation. There was no indication that any graves had been dug in which to bury the bodies. The silt had apparently built up around the bones as they lay on the surface.

# WOOKEY HOLE CAVE

FOURTH CHAMBER  
SECTION ON GRID 13.50 FACING SOUTH EAST

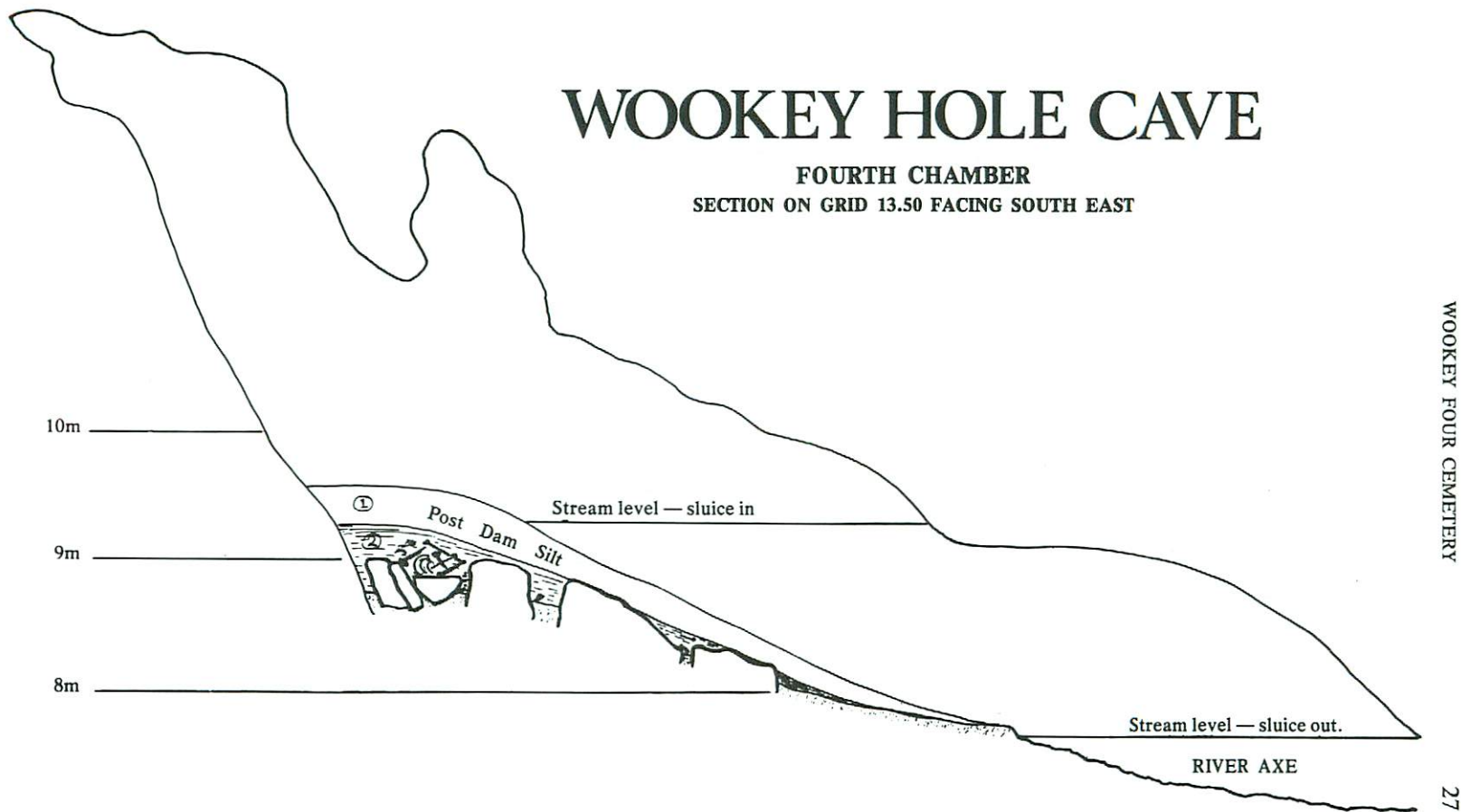


Fig. 5. Wookey Hole Cave. Section of Fourth Chamber.

The non-human skeletal remains consisted of two sheep bones (a portion of mandible and part of the distal end of a humerus), the metapodial of a small mammal, a few amphibian bones, probably frog, and the skeleton of a bat.

All the pottery, less than 100 sherds, was fragmentary and none was found in Area II where the main mass of bones occurred. Most were found in Area I (fig. 6). Eight bronze rings were found, some still in place on the finger bones, and a bronze bracelet was still in place round forearm bones. These had stained the bones green. An enamelled bronze brooch was also found (plate 4). The dating of the coins cover the years A.D. 260-274. Of non-skeletal finds iron studs were the commonest objects. These were found both singly and in groups in all parts of the site. The groups of studs, in several cases, were in juxtaposition with bones of the foot, showing that the bodies had been buried with shoes on (fig. 9). A latch lifter, comparable to those found in the front part of the Cave (Balch 1914), lay on the surface of a large, flat rock near the stream. However, the likelihood of there having been a door, or even a partition, in this part of the Cave seems remote. Under layer 2 there is a sticky orange-yellow clay layer which, in turn, rests upon a coarse river grit, which was water-logged. Both these layers (3 and 4) proved to be without any archaeological finds in the areas excavated.

This sequence of stratification was constant over the excavated area except in front of the oval hole at the eastern end of the Chamber. Here, under the recent post-dam silt, was a hard area roughly circular 0.5m. diameter, and in this were discrete black discs up to 0.02m. across, mostly very thin, but some up to 0.007m. thick. These were set in a dirty grey layer, possibly ash; in this "ash" were some pieces of plant material, proved on examination to be poplar twigs. All this was confined in a convex area, apparently a bowl fireplace. In section this showed many laminae suggesting repeated use of the fireplace over a period of time, probably with intervening flooding. Within, and near the bottom of the bowl, a pin and some cinder-like material were found. The pin was of a type comparable to those found pressed into the surface of layer 2 (c.18-c.19). The pin showed signs of having been heated. The depth of the bowl was approximately 0.08m. and its diameter 0.55m. Layer 2 underlay the northern side of this feature. To the west of the "fire place" there was a small area between some rocks where the deposits were rather disturbed. This contained some broken hazel-nut shells and some broken egg-shell, which were probably of the same date as the fireplace, but there were also a few human bones, possibly due to some disturbance of the lower deposits during the 18th century.

Many initials were found scratched on the wall and roof near the oval hole at the east end of the Chamber. A lot of them were superimposed on one another and of a crude nature, but one or two had been executed with some care. There was no reason to suppose that any of them were older than the 17th to 19th centuries. Above the hole



# WOOKEY HOLE CAVE

## FOURTH CHAMBER EXCAVATION

1973 - 1976

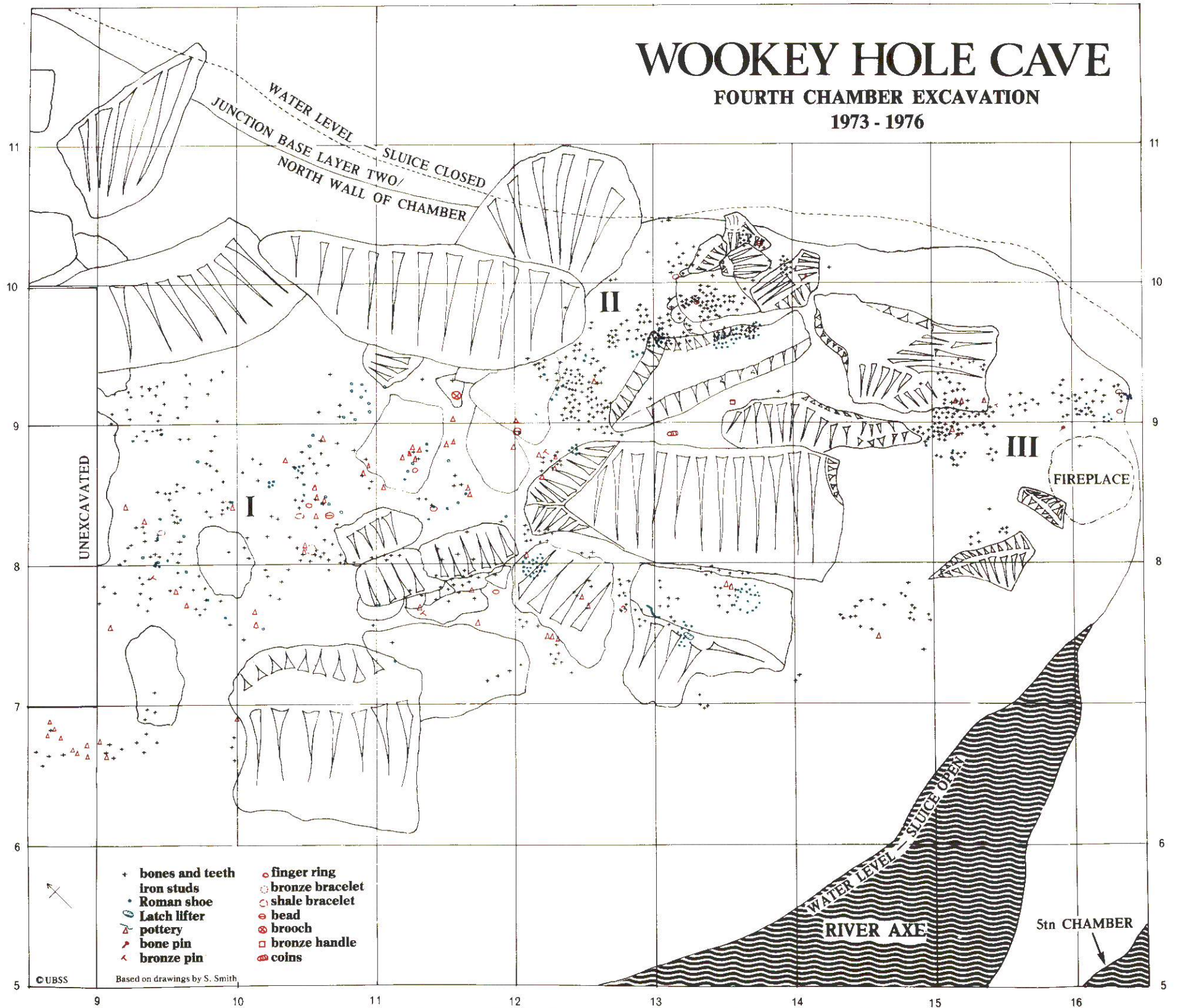


Fig. 6. Wookey Hole Cave. Plan showing distribution of finds in Fourth Chamber. Roman numerals = Areas.





*Fig. 6.a.* Skeletal assemblages.

there was an asterisk cut well into the rock, about 7cm. across; although this could have been a survey point it is thought unlikely as it did not look like recent work. A few initials were also found scratched on the roof in other parts of the Chamber.

Within the hole, and below water-level, were a number of small rocks over a layer of mud. When the rocks were removed, the mud was sampled and, in the area immediately adjacent to Chamber 4, a lot of plant material was found to be present, similar to that found in the "fireplace" area.

Cores were taken inside the hole and in the 5th Chamber also from a further small chamber that lies behind the hole and is linked to it by a small air connection (approximately 10cm. square) over the water. In general the cores showed a layer of coarse river silts and grits at the bottom, with finer muds overlaying them, and only in the area immediately within the hole from the 4th Chamber was there any plant material in visible amounts.

The cave divers were called in to dive in the 5th Chamber to see if any objects had rolled off down the slope into deep water. This was unsuccessful as the fine silt very rapidly obscured all vision. A system of dredging was then evolved, using two under-water electric pumps on the river bed; the first one directed a jet of clean water at the silt and the second was positioned to suck away the resulting cloud of silt. This worked fairly well but directing the jet and the pump from a raft moored in the 5th Chamber on water 2.5m. deep, had its complications, even with the use of an under-water light and a glass-bottomed box. A considerable amount of silt was cleared from several areas but no finds were made.

## CONCLUSIONS

The disposition of the bones found indicates that bodies were placed in the 4th Chamber. The finger ring and the bracelet suggest a 3rd century date. The brooch is of a late 2nd or early 3rd century date but, as Boon points out, it was not new when placed in the cave. The coins must have been brought to the cave after 274 A.D. The stamped Oxford colour-coated ware pottery is unlikely to have been available on Mendip until about the mid-4th century. 'Boot Burials' are more often found from the late 3rd century onwards. This then gives a period of use for the 4th Chamber of a little over a century. It should be emphasised however that, as far as the bodies are concerned, the only items in direct association with the bones, were the bracelet, the finger rings and the shoe nails. There is no evidence for the deposition of bodies taking place either before or after this period, but it is clear that this part of the Cave was visited more recently on a considerable number of occasions, from the evidence of the "fireplace", the pins, the musket-ball and the fragments of clay pipe found.



## DISCUSSION

The use of caves and underground vaults for the burial of the dead in the Roman period was common enough, but here at Wookey Hole the burials were found approximately 200m. into the cave. Once again precedence may be claimed in the catacomb burials in Rome and in other cities in the Roman Provinces, where burials were made a long way from the entrances. However the fact that the burials here are at the furthest point into the cave that man could reach, where the river wells up out of the rock, may be seen as significant. Although one cannot entirely dismiss the possibility of sacrifice, it seems unlikely. The fact that there was no sign of any cut marks on the bones may be seen as at least an indication that there was no dismemberment of the bodies. The wide variation in age also makes it less likely to represent sacrificial killing. It also seems highly improbable that it could have been a collection of people caught by a sudden flood, despite the fact that there were no signs of any graves having been dug.

To return then to the idea that this was a place of sepulture. The studs and nails around the feet showed that they had footwear on, this in conjunction with the rings on the fingers, the bracelet around the arm bones and the bone pins, all suggest that the bodies had been brought in clothed.

The pottery may have been containers for food for the journey to the after-life. Latch lifters have been found among grave goods on other sites and may be intended to open any door or gate encountered en route. The coins in their leather purse could be interpreted as money to pay Charon for the passage over the River Styx. These grave goods, though scant, are comparable with some of the material found by Balch (1914) in the entrance passage of the Cave and also by Ashworth and Crampton (1963) in the Hole Ground Roman Buildings which are a little over 100m. from the entrance to the Cave. From this it may be inferred that the bodies in the 4th Chamber are likely to have been the dead from either or both of these sites during the dates prescribed by the dating of the grave goods. However at both these sites the occupation stretches back into the Pre-Roman Iron Age.

Funeral rites were changing in Roman Britain during the 2nd century. Prior to this time cremation had been widely practised but by the 3rd century inhumation had become usual, and this may account for the commencement of the cemetery.

We know little of the state of the Cave prior to the present day and accounts vary considerably, none of them going into any detail. In that the 3rd Chamber was a place where ladies and gentlemen were known to hold dances in the late 17th century, the path could not have been all that difficult (Balch 1947). Also Dr. Claver Morris writing in his diary for July 23rd 1709 " - - - About 5 a'clock My Neece Leigh with Jinney Gendrault, Mrs. Leigh's Maid, My Wife's Maid and My Man J.C. & Mr. Prickman went and saw Wookey Hole; it cost me 2s. 6d. for Beer and Candles. But we had no Guide".

William of Worcester visited the cave in about 1470 and was taken to the 3rd and possibly the 4th Chamber. The cave was even then known as "a place to be visited" (which must surely bring it into the category of one of the earliest show caves in Britain). It may be assumed then that there was a satisfactory path into the 3rd or 4th Chambers at least as far back as the 15th century and although this is only a third of the time since burials were made in the 4th Chamber, it is reasonable to assume that access was not difficult in the 4th century.

Balch, in his excavations at the entrance to the Cave, found no human bones in the early Pre-Roman Iron Age layer, but in the later Iron Age and early Roman Period he found broken human bones mixed with the animal food bones and the broken pottery in the ash around the fireplaces. He reluctantly came to the conclusion that these were indications that cannibalism was practised by these people. However, in the upper Roman levels, which may be equated with the period of use of the 4th Chamber, there are fewer human bones and not "in such a form as to make likely that they are relics of cannibal orgies." Balch suggests also that interment may have taken place in other parts of the Cave. In the Hole Ground excavation report the only human skeletal remains mentioned are the seven child burials, most of whom were buried on their right sides with their heads resting on blocks of stone. A tentative dating for one of these is given as 4th century A.D.

Although there were many teeth found in the 4th Chamber, and quite a lot of mandibular fragments, the comparative lack of skulls was noticeable, and this, taken in conjunction with the high proportion of skulls in the skeletal material found by the divers in the streamway, led to the suggestion that as the bodies decomposed some skulls rolled down the slope and into the streamway, shedding some of the teeth and the mandibles en route. The skulls then floated or were washed downstream until they came up against natural barriers in the river-bed; the first main barrier was between Chambers 2 and 1, and the other one just before the resurgence.

Besides the human bones found in the 4th Chamber, the streamway and the entrance passages as far as Hell's Ladder, Balch also mentions finding bones and pottery in the bank of the river near Charon's Chamber and in the Upper Series of passages. Human bones have also been found in the River Axe outside the Cave downstream as far as Glencot, about 1km. from the entrance. There is also a reference to a human skeleton being found in the valley between the Cave entrance and the paper mill in 1863, when building a gasometer (S.A.N.H.S. 1865).

Bones found in the streamway, both in and outside the Cave, could have come from the 4th Chamber, but those in the Upper Series and entrance passages could not as they are too high to have been reached by the river in flood. A small excavation by Mason in 1947 in the 3rd Chamber found no skeletal material but there is a great probability of there being other burials within Wookey Hole Cave.



## ACKNOWLEDGEMENTS

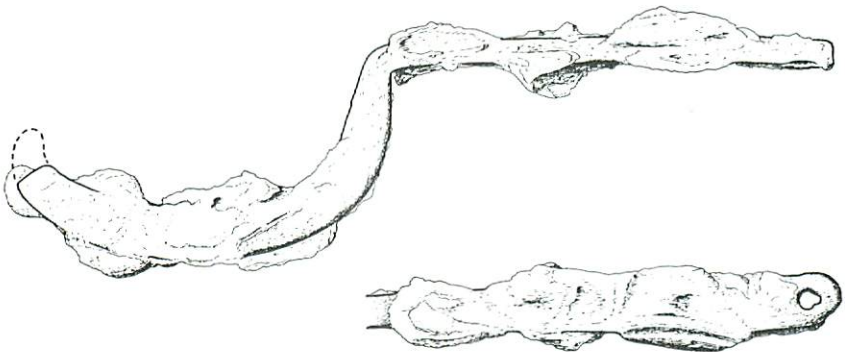
Our main acknowledgement is to Wookey Hole Caves Limited, who not only gave permission to excavate and assisted with lighting and the regulation of the water level in the Cave, but also gave considerable financial support towards the photography and publication of this report.

We also acknowledge grants for publication from the Maltwood Trust for Archaeological Research and The Council for British Archaeology.

G. Balcombe and E. J. Mason were most helpful in providing information on the Cave Diving Group finds.

The excavating team, all voluntary helpers, were partly U.B.S.S. members, with considerable support from non-members, of whom S. Smith and D. Wassell from Leicestershire deserve special mention, the former for doing the site drawings and both for a tremendous amount of meticulous excavation.

Record photographs were taken by A. Phillpott, A. Pearson and N. Barrington.



*Fig. 7.* Iron latch-lifter.



*Plate 3.* Bones. Area II

*Photo: A Philpott.*



*Plate 5.* X-ray of shoe studs.



## THE HUMAN BONES FROM THE FOURTH CHAMBER, WOOKEY HOLE CAVE.

by  
JULIET M. ROGERS, M.B., Ch.B.

One thousand, three hundred and fifty five separate bones and teeth were examined. The majority of the bones were damaged to a greater or lesser degree, only a minimum of reconstruction was possible and no stature estimation could be made. Bones from square 1300/9.50 (Area II fig. 6) were less damaged and were in some instances still in partial articulation.

The aim of the examination was to establish the following facts about the remains excavated from the fourth chamber insofar as the restricted amount of material allowed:—

- 1) The minimum number of individuals represented.
- 2) Their age.
- 3) Their sex.
- 4) The occurrence of trauma, or of pathological or congenital abnormalities.
- 5) The possible connection with the skulls and other bones found in the streamway (Mason 1951).

### THE MINIMUM NUMBER OF INDIVIDUALS

Because of the haphazard nature of the skeletal deposit it was not possible to make a simple count of the total number of skeletons, consequently the minimum number of persons present had to be estimated (Chaplin 1971).

Each separate bone and tooth was identified, aged and sexed where possible and assigned to its appropriate side. Teeth can be aged more accurately than bone fragments and thus may be attributed to a more extended age range. The different types of teeth for each age group were counted, yielding the minimum number of individuals possible for each age group and thus a grand minimum of at least twenty eight persons were shown to be represented. (Fig. 8). Three separate skeletal assemblages could be recognised in square 1300/9.50 (Fig. 6a) belonging to a female aged 25-35 years, a 20-22 year old of unknown sex and a third adult. In square 1200/09.00 two further assemblages consisting of lower limb bones of two juveniles aged between 12 and 17 years were recognised.

## AGE

Age was estimated by using the stage of eruption or the degree of attrition of the teeth (Brothwell 1963) or from the stage of epiphyseal fusion of the bones (Genoves 1969 a). There were at least three children under 5 years one of whom was aged between 6 and 12 months. Two children were aged between 5 and 10 years and six were aged between 10 and 15 years. No teeth came from any individual who appeared to be over 30 years of age. Slight osteophytic lipping on a lumbar vertebra suggested the presence of one person in the 35-45 age group (Bourke 1967). Fig. 8 shows the age distribution of those individuals identified by their teeth.

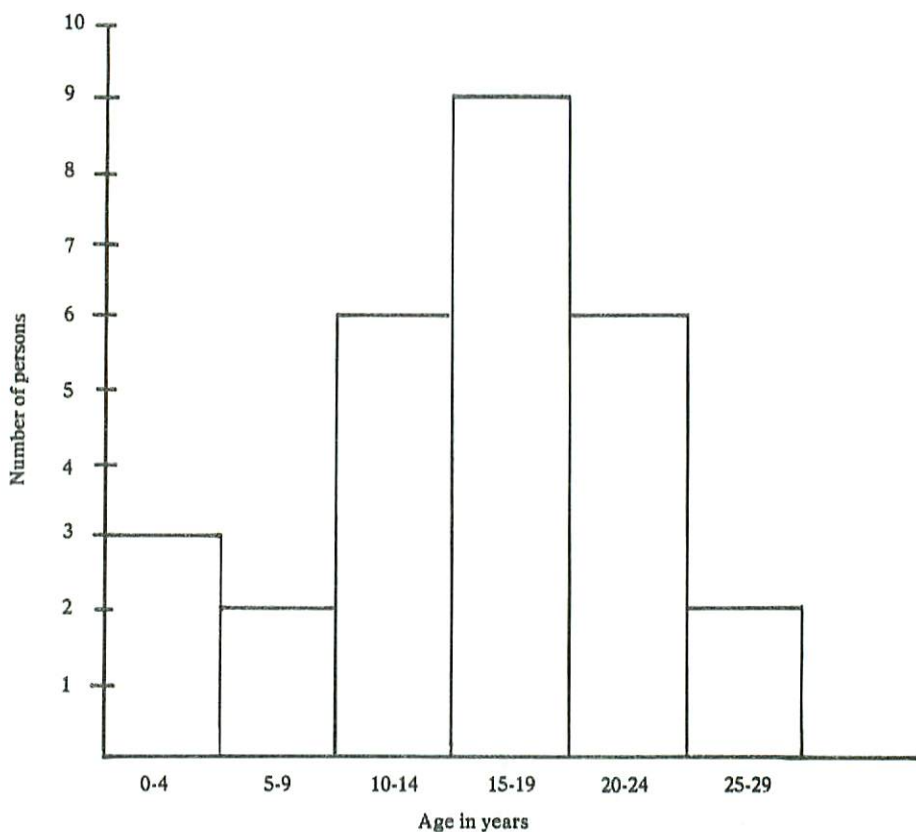


Fig. 8. Histogram showing ages of 28 individuals.



## SEX

Sex determination used the criteria described by Genoves (1969 b). However because of the fragmentary nature of most of the bones very few items could be sexed. The exceptions were supra orbital margins from four individuals, of which two were probably female and two probably male. Fragments of six different bones were also present all of which were female.

## CONGENITAL VARIATIONS

Portions of seven separate frontal bones were identified. Metopism was present in one frontal fragment. One individual with the lower part of the vertebral column surviving had six lumbar vertebrae, the sixth showing sacralization on the left side. A right patella showed signs of having had a secondary centre of ossification on the upper lateral margin; this occurs in only 5% of the present day population.

## PATHOLOGY AND TRAUMA

*General*

No fractures were noted and there was no sign of any wound or mark that could have been inflicted before or after death, while dismembering a body for instance. As noted above, one lumbar vertebral fragment had a small osteophyte on it. The only other pathological condition present was a small area of periosteal reaction on the shaft of a juvenile femur. This may have been due to early osteomyelitis or a reaction to soft tissue inflammation or to trauma.

*Dental*

Although two maxillae and ten separate mandibles are preserved (though damaged) the majority of the teeth were loose. The total number of teeth both loose and in jaws was 238: only 5 of these had any caries (2.1%). In four of these teeth, 2 premolars and 2 third molars, the caries were cervical and in one deciduous molar the lesion was on the occlusal surface. Eleven teeth had enamel hypoplasia. Two groups of four teeth each (maxillary permanent incisors and canines) were affected with similar severity and probably came from two individuals. Hypoplasia is associated with malnutrition or disease during the formation of the enamel (Brothwell 1963). Only in the mandibular and maxillary fragments could the incidence and degree of periodontal disease, antemortem tooth loss and abscess formation be ascertained. (see Table 2). In the one hundred and eight available tooth spaces in all the mandibular and maxillary fragments, one abscess was noted and nine teeth had been lost ante-mortem, the sockets being healed.

Table 2. *Oral Pathology in the most complete mandibular fragments*

<i>Finds No.</i>	<i>Approx. Age</i>	<i>Tooth space</i>	<i>No. of teeth present</i>	<i>No. lost ante-mortem</i>	<i>Caries</i>	<i>Calculus</i>	<i>Periodontal disease</i>
234	25—30	10	3	5	0	3 moderate	moderate
418	25	16	13	3	1	13 moderate	severe
509	12—16	6	6	0	0	3 moderate	nil
1007	18—21	9	6	0	0	5 trace	slight
1011	22—25	6	3	1	0	3 trace	slight
1209	18—21	16	15	0	0	0 nil	nil
1446	15	9	6	0	4	3 moderate	nil
1976	18	5	2	0	0	2 trace	severe

Calculus occurred only on the buccal surface of the teeth. Calculus deposit on the loose teeth was either not present or occurred in very small amounts.

#### THE POSSIBLE CONNECTION WITH THE STREAMWAY BONES

Between 1947 and 1956 E. Mason and members of the Cave Diving Group recovered 18 skulls and some post cranial bones from the river bed between the second chamber and the mouth of the cave (Mason, 1951, 1958, West 1951) (fig. 4). It is likely that these bones had been washed downstream from the Fourth Chamber. Because of the fragmentary nature of the cranial material from the excavation it is not possible to look for similarities with the streamway material except to note that the only occipital fragment from Chamber 4 displays the same type of "bulge" or "bun shape" (Mason 1951) in 11 of the streamway skulls.

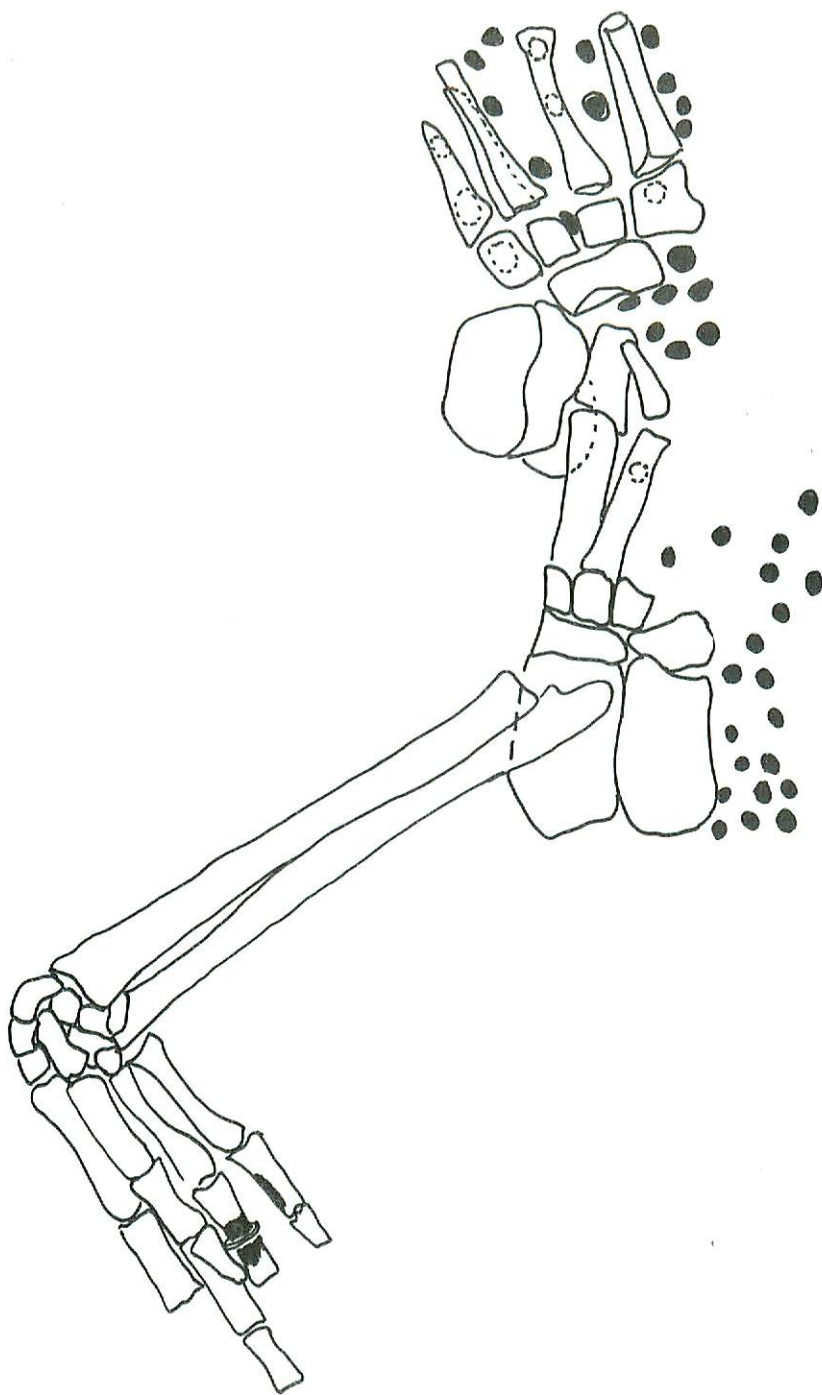
#### CONCLUSION

The human remains from the Fourth Chamber represent at least twenty-eight individuals of both sexes ranging in age from 6 months to perhaps 35 years of age. Although the bones were lying in great confusion there were no marks on the bones to suggest that dismemberment had taken place. It is probably likely that clothed bodies were placed in the chamber complete and that the flooding stream disturbed the bones and left a protective cover of silt in some cases before decomposition had fully taken place, otherwise groups of articulated bones would not have been preserved.

Because of the small number of persons represented, it is not possible to compare them as a population with others of a similar date, although the age range suggested is in line with what is known of other Romano-British populations (Everton & Rogers).

The small Romano British communities in Hole Ground and the mouth of the cave are discussed elsewhere in this report. The likely size of these communities, the probable span of their occupation and the number of skeletal remains are consistent with the suggestion that Chamber 4 was the group cemetery for this small community.





*Fig. 9.* Feet with shoe-studs and hand with ring. The bronze staining on the fingers is shown black.

## REFERENCES

- ASHWORTH, H. W. W. and 1964 Hole Ground Roman Buildings Wookey Hole. *Wells Nat. Hist. & Arch. Soc. Report* 7, 5.
- CRAMPTON, D. M.
- BALCH, H. E. 1914 *Wookey Hole, its Caves and Cave Dwellers*. Oxford Univ. P.
- BALCH, H. E. 1947 *Mendip. The Great Cave of Wookey Hole* (3rd. Edition). John Wright and Sons, Bristol.
- BALCOMBE, F. G. 1946 *Cave Diving Group Newsletter* No. 3.
- BOURKE, J. B. A Review of the Paleopathology of the Arthritic Diseases in Antiquity (Brothwell and Sandison eds.) pp. 352-370 Thomas, Illinois.
- BROTHWELL, D. 1963 *Digging up Bones*. Brit. Mus. Nat. Hist.
- BUCKLAND, W. 1823 *Reliquiae Diluvianae*. John Murray, London, p.165.
- CHAPLIN, R. 1971 *The study of Animal Bones from Archaeological sites*. Seminar Press, London.
- CHERAMODYTES 1956 Mendip Notes. *Wessex Cave Club Journal* 4, (54) 9.
- DAWKINS, W. B. 1865 Report of lectures on Excursion to Wookey Hole *Proc. Som. Arch. & Nat. Hist. Soc.* 12, 1.55.
- 1874 *Cave Hunting*. Macmillan, London, p.30.
- EVERTON, R. and Report on Human Bones from Ilchester By-Pass (Not yet published).
- ROGERS, J.
- GENOVES, S. 1969(a) Estimation of Age and Mortality in *Science and Archaeology*. Brothwell & Higgs Eds. pp. 440-452.
- GENOVES, S. 1969(b) Sex Determination in Earlier Man in *Science and Archaeology*. Brothwell & Higgs Eds. pp 429-439. Thames & Hudson London.
- HOBHOUSE, E. 1934 *The Diary of a West Country Physician A.D. 1694-1726* Simpkin Marshall Ltd.
- MASON, E. J. 1949 *Cave Diving Group Newsletter* (15), 9 and (15), 15.
- 1951 Report on Human Remains and Materials Recovered from the River Axe in the Great Cave of Wookey Hole. *Som. Arch. & Nat. Hist. Soc.* 96, 238-243.
- 1958 *Cave Diving Group Newsletter* (27), 3.





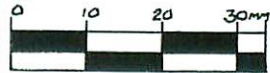
A



B



C



*Plate 4. Wookey Hole Cave Fourth Chamber.*

A. Bronze bracelet and bronze stained forearm bones.

B. Enamelled Bronze Brooch.

C. Finger ring found around and staining ring-finger bone.

*Photo: R. Goderton.*

## A DESCRIPTION OF THE FINDS

by  
GEORGE C. BOON, F.S.A.

## COINS

Fifteen coins were found adherent together, surrounded by a stain in the sandy matrix which was that of the small leather bag or purse in which they had been kept. They are all regular *antoniniani*, such as formed the currency c. A.D. 275 when, on grounds of the very small degree of wear which they exhibit, they were deposited. No other coins were found during the excavations in the Fourth Chamber. Balch's list, mainly from the entrance passage, is predominantly of the fourth century, with very few of the late third, although most of the earlier coins are so very worn that they would certainly have been in currency then (Balch 1914 a). (For the record it may also be pointed out that the series as preserved in Wells Museum includes one, a *sestertius* of Hadrian, which is certainly a modern cast.) It is of interest that no "barbarous radiates" are included in the present group of fifteen; they were extremely common at this period.

Reference below is to *The Roman Imperial Coinage*, Vol. 5, in which all the varieties are listed under the regions in question—Gallienus, Claudius II and Quintillus for the Central Empire, coins struck at Rome; and Victorinus and Tetricus I representing the short-lived Gallic Empire, coins struck at Cologne.

*Gallienus, Sole Reign, A.D. 260-8*

1. DIANA CONS AUG (stag to right), mintmark XI, *RIC* 179.
2. JOVI PROPUGNAT, mintmark XII, *RIC* 214.

*Claudius II, A.D. 268-9*

3. ANNONA AUG, *RIC* 18.
4. GENIUS EXERCI, *RIC* 49.

*Quintillus, A.D. 269-70*

5. CONSECRATIO (eagle): posthumous issue for Claudius II, *RIC* 265 Claud.

*Victorinus, A.D. 269-71*

6. INVICTUS (star in left field), *RIC* 106.
7. SALUS AUG, *RIC* 71.
- 8-9. VIRTUS AUG. *RIC* 78.



*Tetricus Senior, A.D. 271-4.*

10. LAETITIA AUG, RIC 88 (unusually heavy at 4.51 g.).
11. PAX AUG, RIC 101 or 102.
- 13-15. SPES PUBLICA, RIC 272.

#### METAL OBJECTS

1. Fig. 10.a Pl. 4. Handsome bronze plate-brooch, well preserved with a good green patina, 31 by 29mm., slightly convex, hinged pin in the open position, imperfect, worn. The enamelled face contains an opaque yellow centre and the outer ring has a Maltese cross in turquoise-blue with translucent dark green in the spandrels; the corner lugs have turquoise spots on the short, and dark green spots on the long, axis. A close parallel in design from Camerton (Som.) has a red centre and an outer ring of red and green with red lugs (Wedlake 1958 a). Prolonged search has produced no other brooch of the same design, though the type is in general common. Wedlake suggested that the Camerton brooch may be of British manufacture and with this the character of the green enamel is in harmony; it occurs for example on a Silchester brooch (Boon 1974 a) which is certainly British. The development of this type of brooch is plain. The progenitor is a Conquest-period continental brooch with lugs and usually an attached central setting (Boon 1969). This gave rise to brooches well known on the Continent and also in Britain, e.g. from Caerwent (Ward 1911) or Nor'nour (Hull 1968) which retain the lugs and have a convex centre rising to a tiny finial or stud. These latter are second-century brooches. The Wookey brooch may be of the late second or early third century but was far from new when deposited in the Cave.
2. Fig. 10.b. Silver finger-ring, inner diameter 17-18mm. There is a stud-like bezel between expanded shoulders bearing simple linear decoration. The ring is third-century, a simple counterpart of e.g. the gold ring with a setting from the Sully (Cardiff) hoard of coins running down to c. 296 (Grueber 1900). Cf. also Charlesworth (1961 a) and Henkel (1913).
3. Fig. 10.c, Pl. 4. Bronze finger-ring, found in place on a right index finger, inner diameter 17-18mm., much worn. It is of unusual design. The front of the hoop is demarcated by an almost imperceptible moulding to either side of the triangular protuberance (with a casting flaw at the base), above which there is a pierced excrescence. The most obvious comparison, with finger-ring keys for caskets etc., is wrong, for the bits on these are mostly squarish and waisted at the junction with the hoop. The Wookey ring is an example of the ultimate devolution of a different type, for which the finger-ring key may yet have been the inspiration. In this type the excrescence is in the form of a pair of panthers resting forepaws, like heraldic supporters, on a vase between them, e.g. Charlesworth (1961 b) from Corbridge. Another Corbridge ring (*ibid* 1961 c)



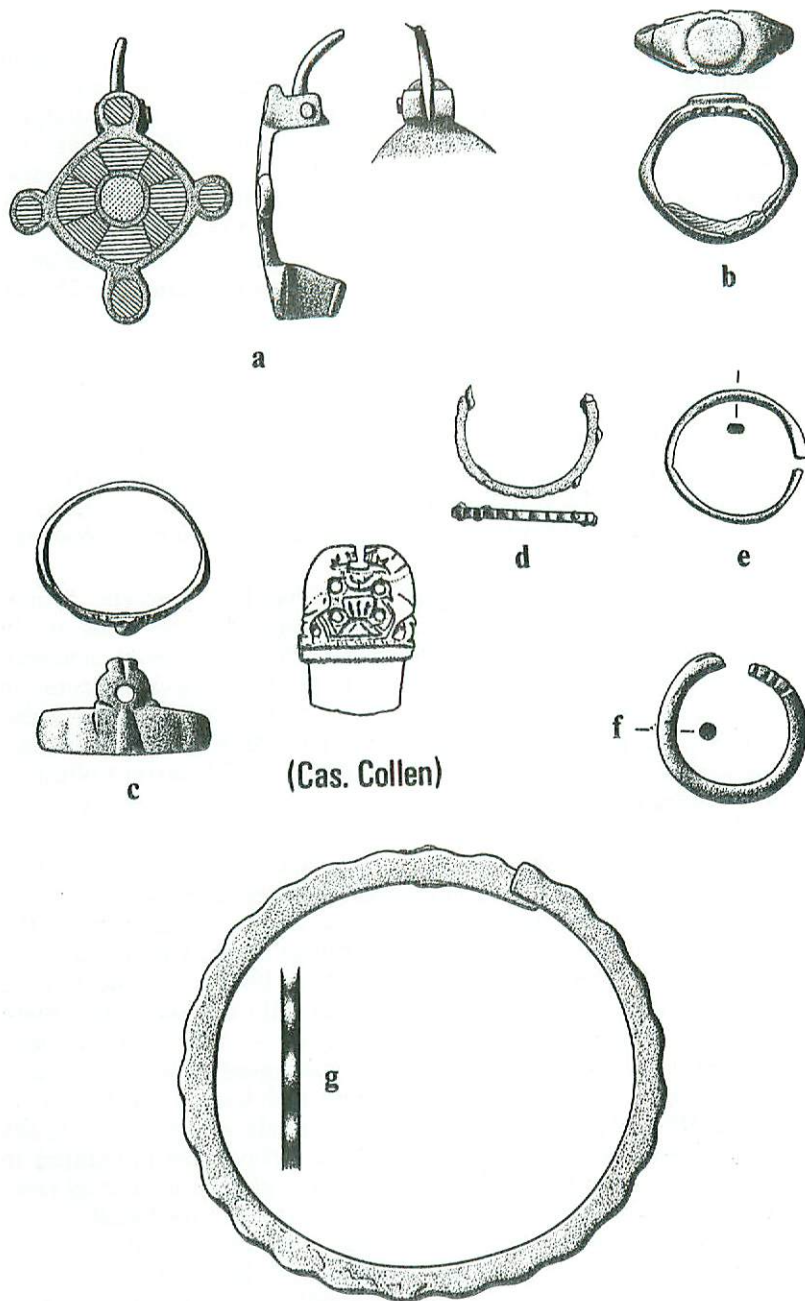


Fig. 10. Metal objects.

Scale 1/1.

shows a simplified motif. Summary in execution too is the Castell Collen (Rads.) fragment shown in our fig. 1 (Boon 1973), third century A.D., a date which would suit other rings of the same kind; cf. especially Henig (1977) with a further discussion of the type. Those quoted so far are recognizably close to the prototype; cf. now a bronze ring from Kenchester (Walton 1951) where the panthers have taken on a grub-like shape, which is well on the way to the extreme stage of degradation seen in the Wookey specimen. On this all we see are their curved backs and heads, divided by a filed line, and underparts outlined by the hole; the vase has gone. Somewhat similar is a Camerton specimen, dated c. 250-380 (Wedlake 1958 d).

- 4-6. Fig. 10.d,e,f. Three simple bronze finger-rings, 15-16mm. inner diameters, the last probably made from a bracelet; the cogged edge of No. 4 resembles that of the bracelet, No. 7; No. 5 is made from a strip with butted ends.
7. Fig. 10.g, Pl. 4. Bronze bracelet, very much worn, found around the forearm bones of a young woman. The pattern is well known in late contexts, e.g. Gatcombe (Cunliffe 1967 a) or Camerton (Wedlake 1958 b).
8. Fig. 11.a. Heavy cast and filed bronze handle, complete, 50mm. long, 18mm. wide, having a flat cleft socket 3.5mm. thick at the base, in which the base of an iron or steel blade has been clenched, as the sole method of attachment. There is ring-and-dot decoration and the mouth of the socket is scalloped on both sides; there is also a little nicking on one edge and around the end of the grip. The best parallel known to me is a plainer handle in the Silchester Collection at Reading Museum (fig. 11.b) and another, not so close, is shown by L. Jacobi (1897).

The mode of attaching the blade shows that no heavy pressure was to be placed upon it; the comparison therefore is not with any form of paring-knife or chisel but with razors. The same clenching of the blade is found for example in the Osprunge razor, with a handle in the form of a bust of Minerva (Whiting 1923 a) — the type is common and a list (very incomplete) will be found in Hilary Walton's paper cited under No. 3 above — which has a blade 147mm. long and 50mm. wide at the cutting-edge. This edge is at right-angles to the plane of the blade and handle, so that such razors differ almost in principle from the modern barber's type; but very similar ones, of Roman and Punic origin, are illustrated in Daremberg and Saglio. There is a plain one-piece iron or steel razor with such a blade and a grip not unlike the bronze handle under discussion in the Silchester Collection. This type is indeed shown on a cutler's monument in the Vatican (Brit. Mus. 1929) but on an Ostian terracotta relief (Meiggs 1960) we additionally see a different type with curved blade and Y-shaped handle, fitting into the palm and clasping more of the base of the blade. This second

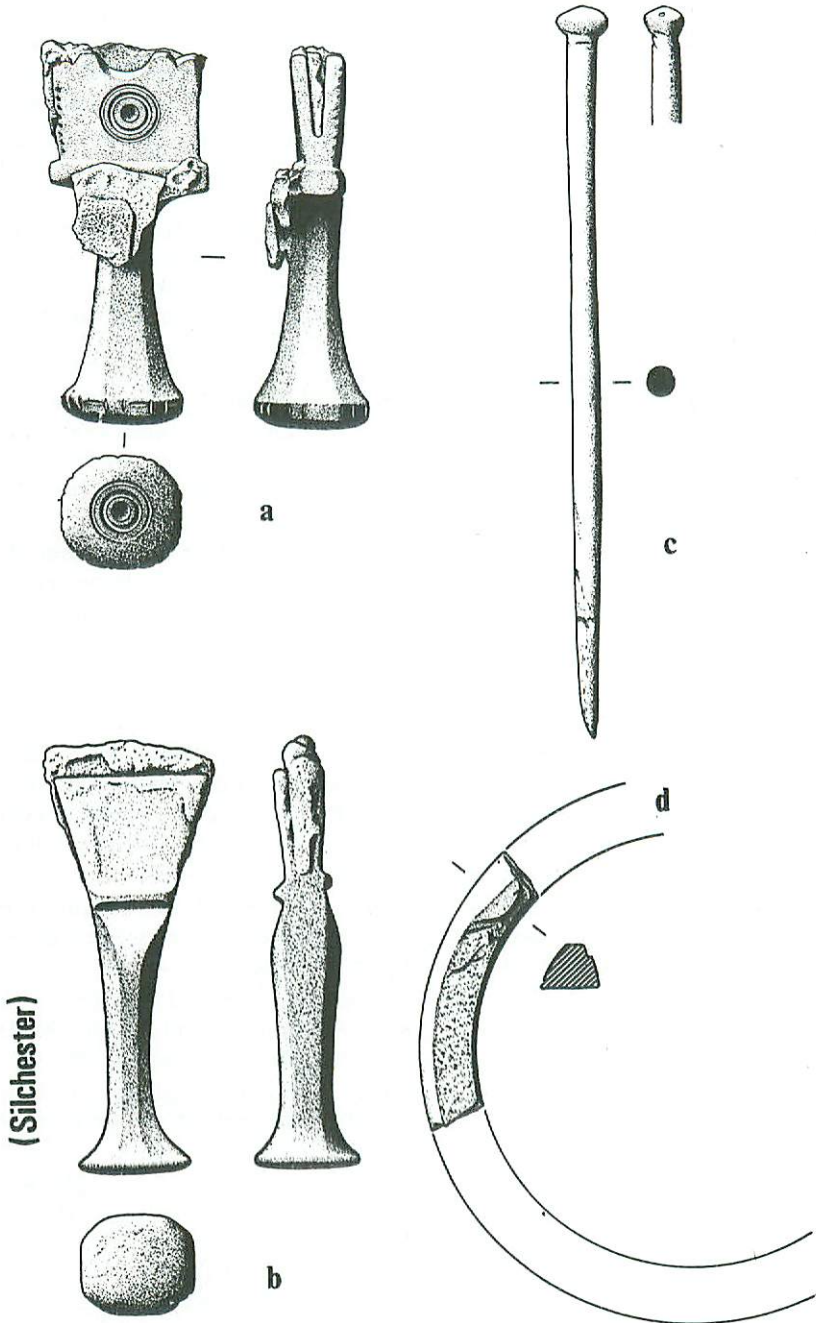


Fig. II. Artefacts.

Scale 1/1.



type has been studied by M. E. Mariën (1971-1973) and appears to have been much more common than the other in the north-west provinces of the Roman Empire. The character of the decoration of the Wookey specimen is typical of the later third or fourth century.

9. Fig. 7. Iron latch-lifter, length 22cm.m common type, Iron Age and Roman, e.g. from Wookey Hole itself (Balch 1914 b) and Verulamium (Manning 1972).
10. Pl. 5. Over forty domed or conical-headed studs from shoe-soles, thoroughly corroded, some in lumps in the sandy matrix, some singly. The illustration (from a radiograph) shows something of the original arrangement on the sole. Shoes, when not of the one-piece "sandal" type, usually had stout soles built up of several layers of fragments or offcuts between the inner and outer soles. The nails therefore helped to hold these together, as well as protecting the outer sole. The dead were frequently buried in their shoes and many accounts refer to the presence of such nails at the feet, e.g. Crook (1946), Rahtz and Grinsell (1956). Nails also occur with cremation-burials (Boon 1974 b).
11. Not illustrated. Two short pieces of squared iron, as from the shanks of nails, 80mm. long, joined by rust into a T-shape resembling the hilt of some instrument; one other length of thicker bar, featureless.

#### OTHER RELICS

12. Fig. 11.c. Well-made bone pin, complete and well preserved, length 91mm.; highly polished by use, especially near the head. Cf. Balch (1914 c), lower, for others similar. Possibly used to fasten a garment or shroud, or possibly a hairpin, as in the well-known case at York, where two jet pins were found in place in a knot of hair (Home 1924). One further bone pin was found (not illustrated).
13. Fig. 11.d. Section of a plain, lathe-turned bracelet of Kimmeridge shale, split; inner diameter about 58mm. This size is average, cf. A. J. Lawson (1976) on the Silchester bracelets.
14. Fig. 12.a. Small glass bead, milky-blue, squared section, 5mm. long. Common late Roman type; several for example in the fourth-century necklace from a grave at Verulamium (Wheeler 1936).
15. Fig. 12.b. Small glass bead, black, of wound construction, 4mm. diameter. Common late type, found for example in the Winchester (Lankhills) cemetery.
16. Fig. 12.c. Small, flat, oval glass bead, about 8.5 by 6.5 by 2.5 mm., black with a central band of turquoise-blue; the piercing is through the short axis. A rare type: Mrs. Margaret Guido kindly cites two others, somewhat larger, of the same design (black with opaque white or turquoise-blue band) from Housesteads fort and Bracknell (Berks.) respectively, the latter in the Beck Collection at Cambridge (No. 2247). These beads are of Central European ("Sarmatian") origin and belong to the third or fourth century.

## ADDENDA

Not illustrated: (a) small glass bead, opaque turquoise-green, about 3.3 by 2.5mm. cf. No. 14 above; and (b) cylindrical jet bead, much worn, 17.5mm. long, 3.3mm. in diameter; divided by circumferential grooves into seven rings; cf. the necklace of over 150 such in single, double or multiple segments up to five, found at Ospringe in Group 13 (Whiting 1925 b and 1931), late second or third century. These two beads were found by Mr. E. J. Mason in association with cervical vertebrae in the Fourth Chamber some years ago. Unfortunately they were reduced to dust during their passage through the post and it was only with difficulty that sufficient was pieced together (in the laboratory of the Dept. of Archaeology, Nat. Mus. of Wales) to provide the above details in conjunction with Mr. Mason's measurements.

## POTTERY

1. Fig. 12.d. Several sherds of a bowl with base-ring, Oxfordshire ware, slightly micaceous, orange fabric, darker red core, softish; dull light red slip. There is a decoration of impressed demi-rosettes. Cf. Porchester (Fulford 1975 a) where finds suggest that Form 36 began to be exported from the Oxfordshire kilns c. A.D. 325 but the stamped varieties come in later, c. 345. This piece could go well in date with the numerous coins of the House of Valentinian from Wookey Hole, recorded by Balch. Similar bowls from Somerset include Camerton (Wedlake 1958 c) and Lufton villa, Yeovil (Hayward 1972).
2. Fig. 12.e. About half a one-handed flagon in warm dark grey ware, somewhat sandy, with a lighter grey to black surface, smoothed at neck and shoulder, where faint burnished lines appear; there is a rough reserved zone below and the remainder has been wiped while on the wheel or turntable. Much used. A similar piece but less bulbous was in Pagans Hills well (Rahtz and Harris 1958 a), late third to early fourth century; the type is common in the New Forest potteries, and on Porchester evidence is datable c. 270-350 (Fulford 1975 b). Balch (1914 d) shows somewhat similar vessels but they are ill-drawn.
3. Fig. 12.f. Wide-mouthed jar in many small fragments; warm light grey ware with light grey core and traces of a very thin warm black slip on both sides. Not much used. About the same date as No. 2 above, cf. a Pagans Hill well specimen (Rahtz and Harris 1958 b) with a less hooked rim. An earlier version from Gatcombe is described by Cunliffe (1967 b).
4. Fig. 12.g. Jar with everted rim (one sherd; and a body-fragment with burnished parallel lines, not drawn), in very hard warm light-grey ware and dark buff core. Third or fourth century.
5. Fig. 12.h. Eleven fragments, sooty, of a plain dish of black burnished ware. Same date.



- 6-11. Not illustrated (6), base of flagon (?), six fragments, ware as No. 2 above; (7), half the base and part of the wall of a large grey jar, four fragments; (8), small basal and another fragment of a similar vessel but coarser ware; (9), two conjoining sherds from a globular jar, ware much as No. 3 above, with burnished grooves; (10), body and basal sherds in dull black ware similar to black-burnished ware, same vessel(?); (11), two sherds from the same (?) black-burnished cavetto-rim cooking-pot, one showing the obtuse-angled narrow lattice band of third or fourth century vessels of the kind.

### POST-ROMAN RELICS

(not illustrated)

1. Twelve brass pins with spirally coiled globular heads, two or three with traces of tinning, 23 to 30mm. long and one 43mm. The mode of manufacture is described by Tylecote (1972). The first large-scale manufactory was established at Gloucester in 1625 (Longman and Loch 1911) and the wire used will have been made at Stapleton near Bristol or even at Cheddar (Rees 1968). The Bristol and Gloucester area became an important seat of manufacture (Day 1973) until the Birmingham trade, producing pins of the modern form, destroyed it. Machinery for making the coiled-head pins can be seen in the old pin-works at Gloucester (now Bishop Hooper's Lodging Museum), where it was in use from 1743-1850. Tylecote observes that the heads of the Gloucester pins tended towards a conical form about the end of the 18th century; the Wookey pins are therefore probably earlier. How much earlier it is difficult to say; from about 1461 (3 Edw. IV cap. 4 1) there were attempts to protect home manufacture by forbidding the importation of foreign-made pins. About half the pins are more or less bent, probably because they were used as votive offerings. Pins are among the commonest of such offerings. For other finds see Balch (1914e).
2. Thin brass sheath, 23mm. long: a lace-tag, still containing fibres. Probably 17th century and not from a shoe-lace, for shoes were then buckled. It is a tag from the "points" by which a bodice was fastened and gives those "points" their name.
3. Pipe-stem fragment of large bore, about 2.5mm. According to Hamilton's (1967) original diagram of 1954 c. 1620-80.

### REFERENCES

- |              |      |  |
|--------------|------|--|
| BALCH, H. E. | 1914 | <i>Wookey Hole its Caves and Cave Dwellers</i> . Oxford Univ. Press. |
|              | a    | p.135-6.   |
|              | b    | Pl. 8,9.   |
|              | c    | Pl. 27.  |
|              | d    | Pl. 11.  |
|              | e    | p.77, pl. 15.  |



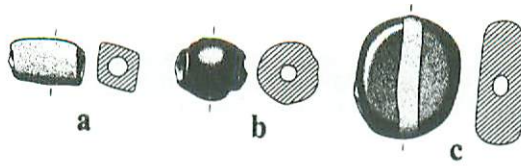
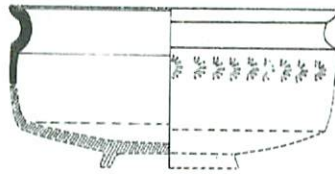
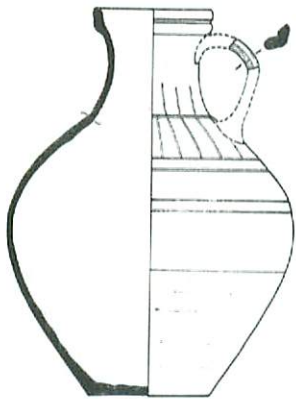


Fig. 12. Beads.

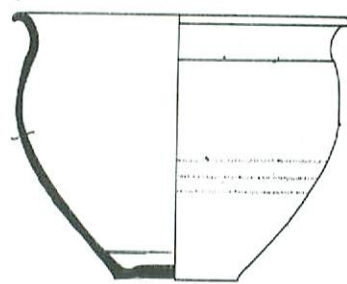
Scale 2/1



d



e



f



g



h

Fig. 12. Pottery.

Scale 1/4

- BOON, G. C. 1974 *Silchester, the Roman Town of Calleva*.  
 a Fig. 19.3.  
 b p. 185.  
 1969 *Archaeologia*, p. 48, Fig. 6.10.  
 1973 *Trans. Rads. Soc.* 13, 18.2.
- BRITISH MUSEUM 1929 *Guide to Greek and Roman life*, Figs. 166-7.  
 CHARLESWORTH, D. 1961 *Arch. Ael.* Series 4, 39.  
 a Pl. 2.17.  
 b Pl. 4.12.  
 c Pl. 9.1.
- CROOK, M. 1946 A Roman Coffin found at Kelston, nr. Bath. *Proc. Univ. Bristol Spelaeol Soc.* 5 (3), 189.
- CUNLIFFE, B. 1967 Excavations at Gatcombe, Somerset. *Proc. Univ. Bristol Spelaeol Soc.* 11 (2), 126.  
 a p. 150, Fig. 41.9.  
 b p. 149, Fig. 40.181.
- DAREMBERG AND SAGLIO 1973 *Dictionnaire des Antiquités* 4, 1. Figs. 5334-5.
- DAY, J. 1973 *Bristol Brass*, p. 90.
- FULFORD, M. 1975a In B. Cunliffe, *Excavations at Porchester*, 1, 282-6, 391-20, Figs. 175-6.  
 b New Forest Pottery. *B.A.R.* No. 17, type 20.  
 1900 *Numismatic Chron.* Series 3, 9, Pl. 3.9.
- GRUEBER, H. A. 1967 *Post. Med. Arch.* 1, 91, Fig. 27.
- HAMILTON, J. C. 1972 Roman Villa at Lufton, Nr. Yeovil. *Som. Arch. & Nat. Hist. Soc.* 116, 68, Fig. 6.7.
- HAYWARD, L. C. 1977 In R. Birley, *Vindolanda*. 1, 35.6.
- HENIG, M. 1913 *Die römischen Fingerringe der Rheinlande* Taf. 4.78 (gold), 19.386 (silver), 39.907 (bronze).
- HENKEL, F. 1924 *Roman York*. Fig. 179.  
 1968 *Archaeological Journal*, 124, Fig. 22.201.
- HOME, G. 1897 *Das Römerkastell Saalburg*. Taf. 61.11.
- HULL, M. A. 1967 *Archaeologia*. 105, 248.9.
- JACOBI, L. 1911 *Pins and Pincushions*, p. 19.
- LAWSON, A. J. 1972 In S.S. Frere, *Verulamium* 1, 182-73.
- LONGMAN, E. D. and LOCH, S. 1971/73 *Helinium* 11, 213-7 and 13, 71-7.
- MANNING, W. H. 1960 *Roman Ostia*. Pl. 27a.
- MARIËN, M. E. 1956 *Trans. Bristol and Glos. Arch. Soc.* 75, 196.
- MEIGGS, R. 1958 The Temple Wall and Other Buildings at Pagans Hill, Chew Stoke. *Som. Arch. & Nat. Hist. Soc.* 101-102.  
 a p. 50, Fig. 4.1.  
 b p.50, Fig. 4.7.
- RAHTZ, P. A. and GRINSELL, L. 1968 *Industry before the Industrial Revolution*. 2, 589.
- RAHTZ, P. A. and HARRIS, L. G. 1972 *Post. Med. Arch.* 6, 183-90.  
 1951 *Trans. Woolhope Club* 33(2), 192-6, Fig. 4.  
 1911 *The Roman Era*, Fig. 74 A.
- REES, W. 1958 *Excavations at Camerton, Somerset*. Camerton Excavation Club.  
 a Fig. 54.57.  
 b Fig. 58.25.  
 c Fig. 47.643.  
 Fig. 57.12R.
- TYLECOTE, R. F. 1972 *Proc. Som. Arch. & Nat. Hist. Soc.* 126, Fig. 6.7.
- WALTON, H. 1936 *Verulamium Report*. 214, Fig. 47.
- WARD, J. W. 1923a *Arch. Cant.* 36, 66, Pl. 55 left.  
 b p. 78-80, Pl. facing 65.
- WEDLAKE, W. J. 1931 *Ospringe Report*. Pl. 5.

## THE CONCENTRATION OF COPPER, LEAD AND ZINC IN SEDIMENTS IN WOOKEY HOLE CAVE, SOMERSET

by  
R. D. STENNER

### SUMMARY

The River Axe in Wookey Hole Cave drains a large area of Central Mendip. Three of the tributary streams enter St. Cuthbert's Swallet after flowing through disturbed land, where lead mining was carried out from pre-Roman times until the early twentieth century (Gough 1967). Analyses of sediments collected from an excavation in the Fourth Chamber of Wookey Hole were compared with those from elsewhere, to permit an assessment to be made of the extent and magnitude of contamination by the former lead industry.

### EXPERIMENTAL

Samples of sediments were collected from the excavation of a Romano-British cemetery in the Fourth Chamber of Wookey Hole in August 1973, 1974 and 1975. Other samples were from the first five chambers and the passage, now closed, from Wookey Hole Nine to the surface. Samples were also collected from St. Cuthbert's Swallet and three other Mendip caves. From other surface sites a further 150 samples were taken, to provide more comparative data, which were all analysed using identical procedures.

The samples were dried, screened, digested with nitric acid and analysed for copper (Cu), lead (Pb) and zinc (Zn) by atomic absorption spectrophotometry. Full practical details of this method will be presented in a future publication (Stenner 1978). In 90 samples analysed in duplicate the mean of each metal had a Standard Error of approximately 5.5%. The maximum enhancement of lead by calcium was 50 parts per million (p.p.m.). The three sets of results from the Wookey Hole Fourth Chamber excavation were compatible with one another and a summary of these results is presented in Table 3.



TABLE 3

Thickness of sample analysed cm. (approx.)	Thickness of deposit, cm.	Description of deposits	Metal concentration, p.p.m.		
			Cu	Pb	Zn
		Surface			
1 _____ ) ) 8 (approx) )			18	7200	1100
2 _____ ) ) 7 (approx) )		soft, unstratified	25	11000	1600
0.9 _____ ) 0.8 _____ ) 1.6 _____ ) 0.5 _____ ) 0.9 _____ ) 15 approx. 0.6 _____ ) 0.5 _____ ) )		hard, stratified, many strata containing charcoal or bone fragments	71 38 29 38 37 31 34	26000 24000 5200 5100 4800 3600 5100	1600 2100 1800 1700 780 860 1500
5 _____ ) 4 _____ )			53 50	4700 3000	680 820
_____ ) _____ ) 15 _____ ) 2 _____ ) _____ ) _____ ) 15 _____ ) 2 _____ )		compact, unstratified	36	480	760
_____ ) 2 _____ )			75	750	1050
_____ ) 2 _____ )	16	muddy gravel	28	1100	810
		bed rock.			

The concentration of copper, lead and zinc in sections through a mud bank in the Fourth Chamber of Wookey Hole containing archaeological material, given by samples collected in August 1973, 1974 and 1975.

## DISCUSSION

Table 3 shows conclusively that the higher levels of lead in Wookey Hole Cave sediments are un-natural and are a consequence of the lead

industry. Analysis of sediments from St. Cuthbert's Swallet also led to the conclusion that the high level of lead contamination was un-natural and was the result of pollution by the lead industry (Stenner 1978).

The analysis of nine samples from the river bed in Wookey Hole Chambers 1 to 5 gave figures similar to the soft unstratified deposits in the Fourth Chamber, set out in Table 3. The mean was 8,500 (S.D. 2,400) p.p.m. Pb. Eight samples from stream passages in St. Cuthbert's Swallet had a mean for Pb of 31,000 (S.D. 15,000) p.p.m., while eight samples from the three feeder streams to the swallet had a mean for lead of 44,000 (S.D. 8,000) p.p.m. Further down the Axe at Loxton four samples from the river bed contained a mean of 90 p.p.m. Pb.

The analysis of 16 samples from caves with no known association with contaminated streams gave figures for copper, lead and zinc of 22 (S.D. 9), 140 (S.D. 90) and 170 (S.D. 120) p.p.m. respectively. These figures suggest that the sediments in St. Cuthbert's Swallet and Wookey Hole, which pre-date the lead mining industry, do indeed contain more lead than other similar cave streams. Values for Pb lay within the range 300 to 900 p.p.m., with the exception of the deepest sample from Wookey Hole Four, shown in the Table. This sample was slightly contaminated by drainage from upper levels.

Of 120 soil samples analysed 61 contained less than 500 p.p.m. and only six contained more than 5,000 p.p.m. Pb. The samples included many from intensively mined land and this serves to emphasize the unusual magnitude of the levels found in the sediments in the streams which sink into St. Cuthbert's Swallet. This swallet has a catchment of 1.2 km<sup>2</sup>. compared with the total revised area of 46.2 km<sup>2</sup>. for Wookey Hole (Smith and Drew 1975). The swallet thus contributes only a small fraction of the total flow from the resurgence. The possibility of sediments being carried by water percolating through intensely mineralized rock and old workings was considered. However the poor ability of small streams to transport sediments must be contrasted with the high transport potential in St. Cuthbert's stream, with its notably fast flow-through time to Wookey Hole (Atkinson, Drew with High 1967). The well-documented lead pollution at Wookey Hole caused directly by the operations at St. Cuthbert's Leadworks were another consideration (Gough 1967). The author's opinion is that the facts are consistent with a hypothesis, that the lead which contaminates the Wookey Hole sediments was transported via St. Cuthbert's Swallet.

#### ACKNOWLEDGMENTS

The author wishes to thank the Royal Society for sponsoring his research and his supervisor, Dr. G. Nickless, for the necessary practical facilities and valued critical advice. He also wishes to thank Dr. W. I. Stanton, Dr. E. K. Tratman and the management of Wookey Hole Caves for making it possible for him to collect samples from within the cave.

## REFERENCES

- ATKINSON, T. C., 1967 Mendip Karst Hydrology Research Project, Phases  
DREW, D. P. with HIGH, C. 1 and 2. *Wessex Cave Club Occ. Publ. Ser. 2 (1)*.
- GOUGH, J. W. 1967 *The Mines of Mendip*. 2nd Ed. David and Charles.
- SMITH, D. I. and 1975 Limestone and Caves of the Mendip Hills. David  
DREW, D. P. (Eds.) and Charles, 183 and 200.
- STENNER, R. D. 1977 The concentration of some heavy metals in sedi-  
ments in some Mendip Caves and an assessment of  
the significance of un-natural contamination. *Proc.*  
*7th. Internat. Cong. of Speleology, Sheffield, Eng.*,  
183-4.
- 1978 (In preparation).