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THE AVELINE'S HOLE 9 CRANIUM: A PARTIAL SOLUTION TO A LONG STANDING ENIGMA

by

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ABSTRACT

Aveline's Hole is both one of the best-known sites with early human skeletal material in Britain and one of the most problematic in its history. First discovered and explored at the close of the 18th century, it yielded an estimated burial count of at least fifty individuals. Twentieth century work suggested a Late Upper Palaeolithic date for the material, in a context that might be called Creswellian. A recent dating programme places the human remains into the early Holocene and confirms the site as a Mesolithic cemetery in all senses of that word. Though a number of partial studies of the material have been published, no full description was attempted or published prior to the destruction of much of the collection in 1940. Recently one of us published a full study of the site history and a description and analysis of the surviving material. However, that study did note the small number of intact but undated crania that have been attributed to the site at various times. This study looks at one of these, denoted as AH9 and never previously described, in the aftermath of direct radiocarbon dating. Both direct dating and indirect analyses indicate that it is highly unlikely that this skull was part of the Mesolithic assemblage from this site.

INTRODUCTION

In considerable contrast to much of Western Europe, Upper Palaeolithic and Mesolithic human skeletal material is rare in Britain. The only site with multiple well-preserved Mesolithic remains has been the limestone cave site of Aveline's Hole in the Mendip Hills, Somerset, discovered at the end of the eighteenth century. For a variety of reasons the large collection of material was only partially described, with the vast majority of the material recovered in the most recent excavation campaigns of the 1910s and 20s destroyed during the bombing of Bristol in 1940. However, the site is of major importance both archaeologically and anthropologically, as recently reviewed in a series of papers (Boycott and Wilson, 2010; 2011; Donovan, 2005; Jacobi, 2005; Marshall and van der Plicht, 2005; McLaughlin, 2005; Meiklejohn *et al.*, 2011; Schulting, 2005 and contributions therein).

THE SITE

Aveline's Hole is a limestone cave in Burrington Combe in the Mendip Hills of Somerset (51.324° N; 2.753° W), a region with considerable evidence of late glacial and early postglacial human occupation. The site was first discovered accidentally in 1797, and then excavated several times, as has been published elsewhere (see Schulting, 2005; Boycott and Wilson, 2010; 2011). The main elements may be summarized as follows. When originally discovered the presence of skeletal material from ca. fifty individuals was reported. The Reverend John Skinner worked at the site between 1819 and 1824, and there is evidence that much material was removed at this time. William Buckland mentions the site in his *Reliquiae Diluvianae* (Buckland, 1823, pp. 164–5), though whether he ever excavated there is far less clear.

Davies (1921, p. 62, see also Balch 1937, pp. 102–3) claimed that he did but Boycott and Wilson (2011) found no confirmation of either an excavation or a visit. This perhaps raises further questions about the report by Boyd Dawkins (1864) that material removed by Buckland was already missing in the 1860s, leaving only a few remaining pieces. One of them was the specimen reported later as Calvarium "O", described by Buxton (1925) and again attributed, via Davies, to Buckland's activities at the site — also identified as AH1 by Oakley (1971, p. 17) — and now housed at the Natural History Museum, London. This is one of the specimens that have played a role in the enigma of the find under consideration here. Oakley (1980) also thought that it was part of the material excavated by Buckland in 1823. Almost no other skeletal material from the earlier work survives.

Figure 1. *Skull AH9, frontal view.*

Later in the nineteenth century additional excavations were undertaken by a number of people including William Boyd Dawkins (1864). However, much of the extant collection discussed and described by Schulting in his (2005) review stems from work by the University of Bristol Spelaeological Society from 1912 to 1914 and again from 1919 to 1931. A series of partial reports were published in the Society Proceedings; see J.A. Davies (1921; 1922; 1923; 1925), Edward Fawcett (1920; 1921; 1925), Sir Arthur Keith (1924), L.H. Dudley Buxton (1925) and E.K. (Edgar Kingsley) Tratman (1923; 1924). However, the full collection was not studied prior to its partial destruction during World War II.

THE AVELINE'S HOLE 9 SKULL - DESCRIPTION

The AH9 skull is important because of its state of completeness. If demonstrated to be of Late Upper Palaeolithic or Mesolithic age it would be the most complete specimen from Britain other than the skull associated with the Cheddar (Gough's New Cave) skeleton. The latter has been directly dated to the early Mesolithic and in fact is roughly the same age as the dated Aveline's Hole material (Meiklejohn *et al*., 2011).

The following brief description is based on examination of the specimen (at the University of Bristol) in May 1983, together with observations made during the writing of this paper (Figures 1-4). The cranium partially preserves most of the external braincase, but much of the base is damaged or absent. Some though not all of the material shows stalagmitic encrustation. Most bones of the face are largely complete (intact or at most, slightly damaged), including frontal, maxilla, both zygomatics, both nasals, and palatine. The margins of the nasal opening and nasal cavity show damage, and both the nasal opening and orbits have some calcite encrustation. The remaining base is represented by the upper part of the greater wing and adjacent body of the sphenoid with surficial secondary calcite. Of the remaining calotte the right parietal is largely complete, as is the upper pole of the occipital. The left parietal and right temporal are missing, though the latter at least was present in an earlier photograph (Figure 5). Part of the left temporal is attached to the sphenoid, but the tympanic region is missing. The roofs of the orbits show pitting characteristic of *cribra orbitalia* (Figure 6), a condition usually attributed to iron deficiency anaemia (Stuart-Macadam, 1992), though this connection has recently been questioned (Walker *et al.*, 2009). The condition is not uncommon in prehistoric material, and has been noted on two other individuals more securely attributed to Aveline's Hole (Schulting and Wysocki, 2005, p. 199).

Figure 2. *Skull AH9, left lateral view.*

The upper dentition is represented on the right side by both premolars, the first molar and the root of the second molar. On the left side are the first and second molars; the incisors, canines and left premolars were all lost postmortem. The state of the two third molars cannot be judged from the specimen. The left second molar exhibits a large carious lesion distally at the cemento-enamel junction (CEJ).

The mandible is largely complete on the left side. The right side consists of the damaged ascending ramus and interior of the posterior portion of the body. The right condyle is absent. The anterior alveolar region is considerably damaged. The lower dentition lacks all teeth other than the molars, which are all present except for the right third molar. Both left and right first molars exhibit large carious lesions lingually at the CEJ, together with a third early-stage caries on the right second molar (Figure 7).

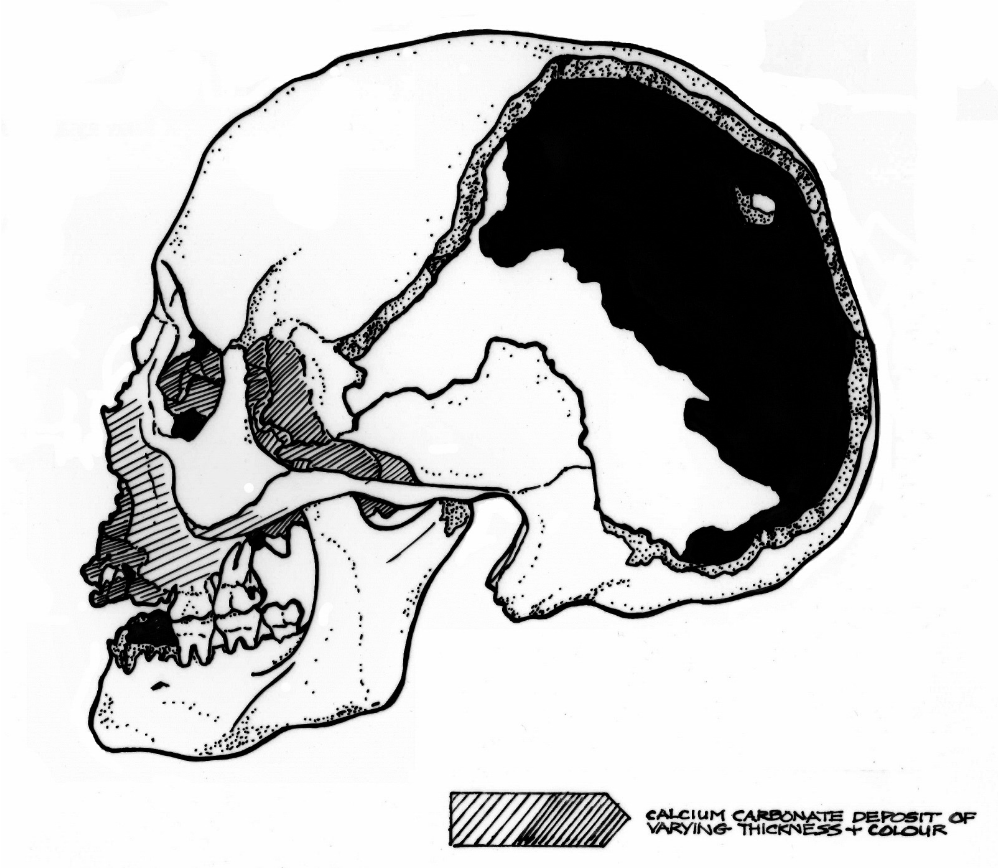

Figure 3. *Left lateral sketch of skull AH9.*
Drawing: Lyla Pinch Brock.

Carious lesions are rare in the Mesolithic of north-west Europe, though not entirely absent (Meiklejohn and Zvelebil, 1991). None were reported, for example, from the relatively large Mesolithic skeletal assemblages of Vedbæk-Bøgebakken (ibid), or the Dnieper Rapids (Lillie and Richards, 2000), while Alexandersen (1988) reported a rate of only 0.37% for Skateholm I and II combined (5 of 1339 teeth). For mid-latitude Europe only Téviec and Hoëdic have reported a relatively high prevalence of caries (15 of 485 teeth – 3.1%, Meiklejohn and Zvelebil, 1991, p. 144). However, AH9 stands out with what would be an unprecedented four or more lesions (not all teeth are represented, and additional early-stage caries may be present). None of the other 141 teeth from Aveline's Hole exhibit caries (Schulting and Wysocki, 2005, p. 200).

The individual appears to be female. Even without a clear population comparison the skull is very small (see also below). This extends to visible features such as the glabella, brow ridges and mastoid processes. In terms of age the relatively unworn state of the dentition suggests that the individual is a young adult – though this assumes that the individual is indeed Mesolithic, or at least prehistoric, and so subject to high dental attrition. As shall be seen, this assumption is unjustified, leaving the individual's age difficult to determine (rates of dental wear being population-specific).

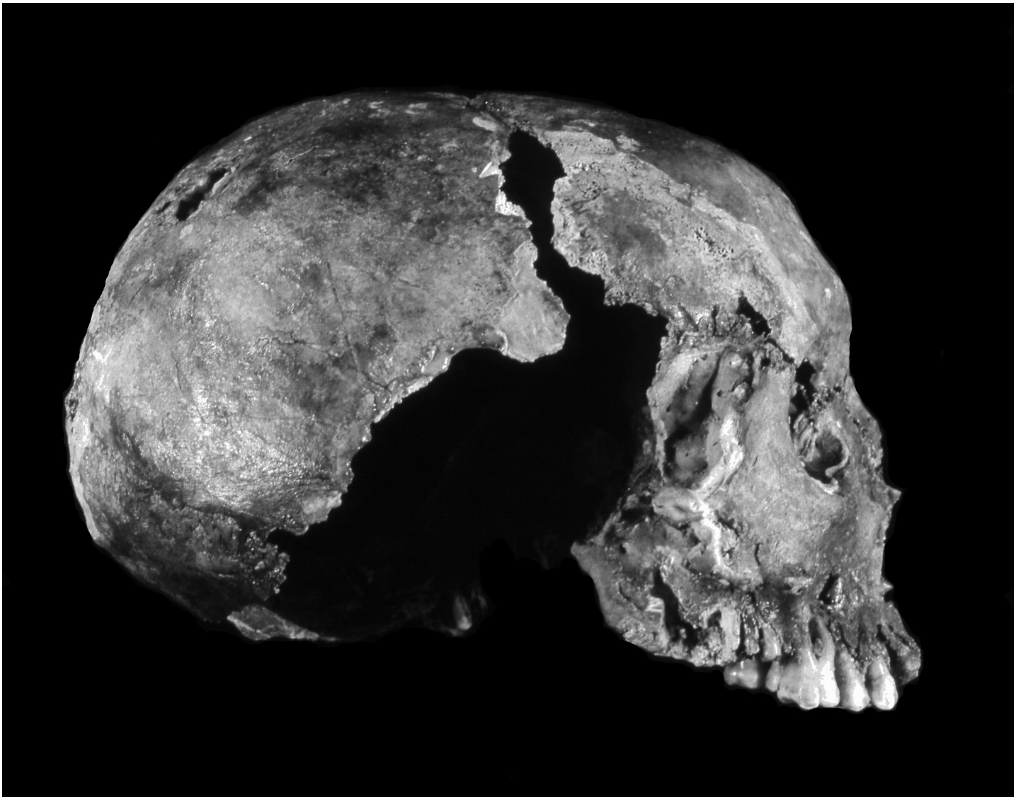

Figure 4. *Skull AH9, right lateral view.*

THE AVELINE'S HOLE 9 SKULL – THE PROBLEM

Following its brief mention by Balch (1937, see below) and a photograph published by Palmer (1957) the Aveline's Hole 9 (AH9) skull next appears in the inventory of Oakley (1971, p. 18). He later attributed it to the Bristol Spelaeological Society excavations of 1914 (Oakley, 1980). Since then it has presented problems regarding its provenance, in part related to the question of the chronological age of the Aveline's Hole collection. Beyond this were questions

Figure 5. *Skull AH9 photographed in 1957, prior to removal of calcite encrustation.*
Photograph: L.S. Palmer By courtesy of Wells and Mendip Museum.

over whether the skull was, in fact, from Aveline's Hole. Oakley was cautious (see footnote in Oakley, 1971, p. 18) but Newell *et al.* (1979, p. 93) accepted the attribution at face value. As discussed below this attribution is now in considerable doubt.

The vast majority of the collection having been destroyed in 1940, together with all the archival files, interest turned in the 1970s to the surviving collection of the University of Bristol Spelaeological Society; especially as technology developed for direct radiocarbon dating of human bone. To briefly summarize Meiklejohn *et al.* (2011), in 1971 the first direct determination indicated an early Holocene and therefore Early Mesolithic age (Barker *et al.*, 1971). Though slightly later than predicted (ApSimon *et al.*, 1961), it appeared to be confirmed by a date derived from the calcite encrustation on cranium "O" in the Oxford collection (see e.g. Newell *et al.*, 1979; Oakley, 1980). These, and four further dates from the Oxford and Belfast laboratories, are now superseded by the extended set published as part of the review of the site (see above), tightly distributed between ca. 10200 and 10400 calBP or ca. 8330 calBC (Marshall and van der Plicht, 2005). These clearly confirm both the early Holocene age of the primary collection, and a very restricted period of burial.

With the Aveline's Hole skeletal material now firmly dated to the early Holocene the status of AH9 becomes critical. At this point, however, the situation becomes greatly complicated, in part because the air raid in 1940 also destroyed the archival files. So what do we know? It is immediately clear that no one in the last half century is really certain about the provenance of the specimen. As already noted, Oakley's last opinion (1980) was that it came from the excavations of 1914, though the basis for this opinion is not stated. E.K. Tratman, who was involved in the later part of the twentieth century excavations, and who described the teeth (1923; 1924), probably knew as much about the site as anyone alive after 1970 (he died in 1978). Parts of his correspondence are critical to putting together this note. However, Tratman himself confused some of the specimens as he stated that he believed that the stalagmite date (GrN-5393) was from AH9 (*in litt* to J. Musgrave, 8 Oct. 1976), whereas we know it was from the cranium "O". Tratman also states in the same letter that it was "... found or dug out of the cave at an unknown date when the cave was known as 'THE CAVE'" (emphasis Tratman). Although its name of Aveline's Hole was bestowed by Boyd Dawkins, ca. 1860, there was some confusion in the early part of the twentieth century regarding the nomenclature of the caves in Burrington Combe owing to an error on some Ordnance Survey maps and this name seems to have been in use until about 1920 (Fawcett, 1920; Davies, 1920). This does not contradict Oakley's dating of the finding of the skull to the twentieth century.

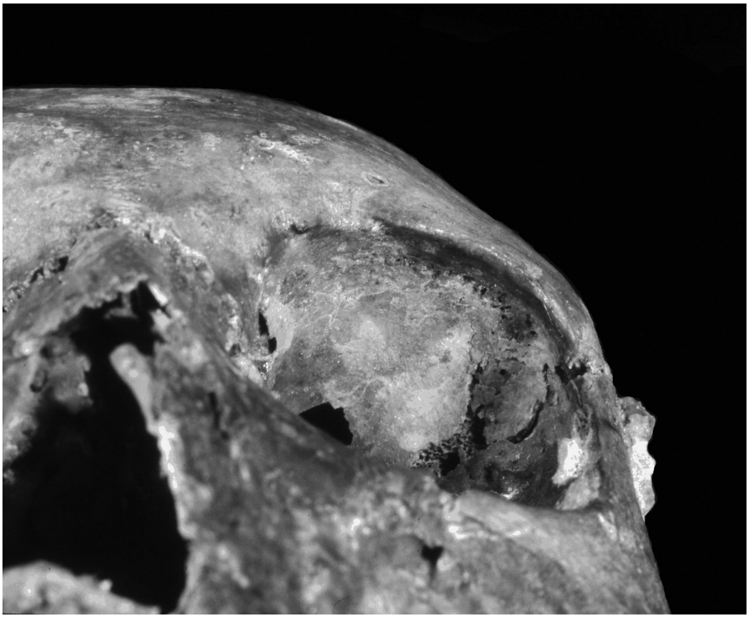

Figure 6. *Skull AH9, left orbit showing* cribra orbitalia.

It seems clear that this skull never formed part of the main collection from the site. The earliest reference is by H.E. Balch (1937, p. 103) who states "I may have one skull from Aveline's Hole in the Museum at Wells, its source cannot be proved, but its condition strongly suggests it, and it had been in Bruton School for many years, in [John] Rutter's area". No connection with Bruton can now be demonstrated; enquires at King's School, Bruton, only show knowledge of a different skull, from a Beaker burial at Windmill Hill Quarry, Wincanton. Both that skull and its associated Beaker are now in Taunton Museum (Steve Minnitt *pers. comm.*). It is strange that Balch, who was the founder of Wells Museum and its curator until 1958, was so unclear as to how this skull came into his possession.

The skull remained in Wells until the 1960s. As noted above, Leo S. Palmer, then curator of Wells Museum, published a photograph in 1957 (Palmer, 1957), but no study was made at this time. It is clearly not one of the three skulls described by Keith (1924). Given its completeness, it certainly would have been published had it been known and attributed to the site at this time.

In 1964, Tratman (*in litt*) wrote to Don Brothwell at the Natural History Museum suggesting that he study it. As he wrote "[i]t has special importance for Aveline's Hole material in that the facial skeleton is more or less intact and the specimen is thus the only one in which this part survives. Further, the fact that the mandible, though broken, is still in place implies that the body was put into the cave as a body, a point that it was never possible to demonstrate with the other material." However, although the skull does seem to have been sent to London (Tratman *in litt*, 1976) no study was done and the skull was returned to Wells. Tratman then sent it, again, to Jonathan Musgrave at the University of Bristol, sometime prior to his letter of October 1976. A publication by JM and Tratman was suggested but the idea was curtailed by Tratman's death on August 21, 1978. Shortly afterwards one of the authors (CM) examined the specimen at Bristol in 1978/79, and in more detail in 1983, when access to the unpublished material reported here occurred. More recently, in the early 2000s, another of us (RJS) examined the skull as part of the reassessment and dating of the surviving Aveline's Hole collection (Schulting, 2005). Indeed, because of its completeness, and despite reservations about its attribution to the Mesolithic (see above), AH9 was used in a photo shoot reporting the results of the AMS ^{14}C dating programme, appearing prominently in an article by Simon de Bruxelles in *The Times* of 24 September 2003. We can now set the record straight.

Figure 7. *Lingual view of left mandibular molars; note CEJ caries on first molar.*

What we now know is that the skull is first mentioned in reference to its apparent presence in Bruton, though new evidence questions whether it was ever there. There is no evidence that it was seen by any of those who looked at Aveline's material after 1918, and it is clearly not one of the three skulls described by Keith in 1924, as noted above. Tratman, in his 1976 letter, associates the stalagmitic covering as indicating that the piece came from the final "stage of use of the site" (*ibid*). His explanation of this in undated notes written prior to April 1978 was that:

> "It is necessary to distinguish between the main occupation and the terminal stage when the cave was used for multiple burials followed by closure of the cave with an abrupt alteration of the micro-climate, which lead [*sic*] to the formation of massive layers of stalagmite. All the human material described by Keith and Fawcett and Buxton belong to this final stage. So also does [AH9]".

However, if this were the case we would expect direct dating of the find (see below) to give an early Holocene age. This is patently not the case. Consequently it is highly probable that the source of the find is not Aveline's Hole, especially as there is no evidence of any late prehistoric or historic activity in the cave, as a result of its having been sealed, possibly intentionally, by a large stone slab (Schulting 2005, p. 244).

An attempt to source the skull in the 1980s was unsuccessful. It followed from a letter from Guy Rogers of the University Museum, Oxford (*in litt*, July 26, 1980), who was planning to do a chemical analysis of the stalagmite in the "O" skull and wrote to one of the authors (JM) requesting a tufa sample from AH9, which he mentions with reference to Balch (see comment above), or from any remains from Aveline's Hole. However, when one of us tried to follow up this lead in the mid-1980s, Rogers was no longer at Oxford. It is interesting that he suggested that "There is of course every possibility that this skull ("O") may have come from another source, e.g.: the petrifying spring at Matlock, Derbyshire." This is where the situation stood when the skull was finally directly AMS ^{14}C dated.

At some time between 1964 and 1976, the majority of the calcite encrustation covering the exterior of the skull was removed, producing its current appearance (compare Figures 4 and 5). Three small sections of this calcite encrustation were placed in the UBSS Museum and it was their existence that suggested the possibility of the uranium series dating which has recently also been conducted to determine a *terminus ante quem* age (see below and Richards *et al.* this issue).

DATING THE AVELINE'S HOLE 9 SKULL

A radiocarbon determination returned on bone of the AH9 sample is cal AD 1494-1648 (OxA-19839: 307 ± 25 BP, $d^{13}C$ = -19.3‰). While, for the reasons given above, a Mesolithic age was not necessarily expected, this is surprisingly late. Nevertheless, there is no indication from the bone chemistry that anything is amiss with the result. That being said, the bone surfaces do appear to have been treated with a consolidant at some point in the specimen's history: not unusual for material that has been in museum collections for decades. The Radiocarbon Laboratory for Archaeology and the History of Art, Oxford, was alerted to the high probability of contamination, and a harsher pretreatment was employed. The C:N ratio of 3.2 is within the range for well-preserved collagen, though this would also be the case if the consolidant used was an animal hide or bone glue. The yield of 6.8% is more useful as a check in this case, as it is considerably lower than the ca. 30% found in *in vivo* bone collagen. It is still well within the range of acceptable yields for archaeological bone, but at the same time indicates that the material being dated was not entirely modern. While there is no guarantee that all contaminants were removed, and thus the date may be too recent by some centuries, a

Mesolithic attribution of AH9 can be ruled out, as indeed can a prehistoric age of any period. This finding is also consistent with the statistical analysis that shows that the AH9 cranium is a clear outlier when compared to a European Mesolithic database (see below).

To further constrain the age of AH9, two calcite coatings were presented for uranium-series dating at facilities of the Bristol Isotope Group, University of Bristol. U-Th methodology provides robust age constraints on speleothems for a wide variety of applications (Richards and Dorale, 2003) and can match the precisions achievable for ^{14}C methods in many cases. The secondary calcite coatings available provided an opportunity to supplement the dating work already referred to above, and also test the feasibility of dating potentially very young material with high detrital content.

One speleothem sample was from the selection of three available at the UBSS Museum and considered highly likely to have been separated from the cranium in the 1960s or 70s, the other was a small fragment from the alveolar process of the inner maxilla of AH9, very close to the second molar. The calcite in both cases is dense, creamy-white, but contains a significant amount of detrital material in places, especially near the bone-calcite contact. U-Th isochron methodology (Luo and Ku, 1991; Ludwig and Titterington, 1994) was used to constrain the age and initial U and Th isotopic signal.

Uranium concentrations are high and range from 0.83 to 2.53 µg g^{-1} and observed $^{232}Th/^{238}U$ (where high values indicate greater detritally contaminated and hence more initial ^{230}Th) show a wide range. Nine sub-samples of ~20-50 mg were analysed and the effective correction for initial Th is large in most cases: derived ages for each sub-sample, uncorrected for initial ^{230}Th, range from 0.15 to 7.2 ka (thousands of years before AD 1950). This situation is ideal for isochron methodology and a reasonably linear array was achieved using the nine sub-samples such that a detritus-free end-member age could be calculated. While there is some excess geological scatter in the data, an isochron age of AD 1824 to 1954 (2σ, without accounting for scatter) is determined. We are confident in this data because the U-Th age determined for the least contaminated sub-sample is 0.210 ± 0.002 ka (uncorrected for initial ^{230}Th), 0.182 ± 0.014 ka (correcting for bulk earth $^{230}Th/^{232}Th$ activity ratio) and 0.13 ± 0.04 ka (using a more radiogenic $^{230}Th/^{232}Th$ activity ratio suggested by the isochron methods here). These ages do not provide further constraint on the radiocarbon age of the bone, but they are consistent with this age and add further weight to the contention that this sample is not Mesolithic. In addition, the derived ($^{234}U/^{238}U$) initial activity ratio of 2.47 ± 0.05 (2σ) is the same for both sample coatings and this provides extremely convincing evidence that the UBSS sample is indeed from AH9. It is tempting to use the U isotope ratio as a tool for provenance, because particular drip waters and precipitating speleothems can have consistent or predictable ($^{234}U/^{238}U$) initial activity ratios with time (e.g. Corchia Cave, Drysdale *et al*, 2009), but local and regional variations are typically too great to ascribe a single value to a cave system.

The tentative attribution to Matlock, Derbyshire, by Guy Rogers is interesting given the recent date, but is indirect as his reference was to the "O" skull. Moreover, the basis of his statement is not known. It could simply be that he was noting that sites like Matlock could produce human remains with calcium carbonate deposits. Nevertheless, such an attribution for AH9 may well be justified. Matlock Bath was famous in Victorian times for its 'dipping wells', in which any object could be placed and be quickly coated with calcium carbonate (Adam, 1838). Another contender would be the 'petrifying well' at Knaresborough, North Yorkshire, associated with the soothsayer Mother Shipton (ca. 1488–1561), and where all kinds of objects would be 'turned to stone' after being suspended in the water (Burrell, 1896). It might also be noted here that the appearance of the calcium carbonate deposits on AH9 differs from that noted on other material from Aveline's Hole, both in colour and in texture.

In rejecting the Mesolithic attribution of AH9, we have also resolved the puzzle of an individual with so many carious lesions, atypical for the period. Conversely, poor dental health was not at all uncommon in Britain in the sixteenth and seventeenth centuries. AH9 thus joins a number of other cases of human remains that, when directly dated, have proven to be of a very different age than expected, though few are as extreme as the present example. The Galley Hill skeleton, for example, was considered a type-fossil for the Palaeolithic (Keith, 1915), yet questions were already raised in 1948 when newly developed fluorine relative dating tests indicated that it was probably intrusive into the gravel terrace in which it was found in 1888 (Oakley and Montagu 1949). Radiocarbon dating subsequently placed it in the Bronze Age (BM-86, 3310 ± 150 BP: 2010–1220 cal BC) (Barker and Mackey, 1961). Putative Palaeolithic human remains from Badger Hole, Somerset, instead returned Mesolithic (OxA-679, 9060 ± 130 BP: 8610–7830 cal BC; OxA-1459, 9360 ± 100 BP: 9120–8300 cal BC) and Anglo-Saxon dates (OxA-680, 1380 ± 70 BP: cal AD 536–854) (Stringer, 1986). Numerous other examples might be cited, including the dating of supposedly Aurignacian human remains from Vogelherd, Germany to the Late Neolithic (Conard *et al*., 2004), and, most recently, the dating of the supposedly early Upper Palaeolithic skull from Combe Capelle, France, to the Mesolithic (Hoffmann *et al*., 2011).

MORPHOLOGICAL ASSESSMENT OF THE AVELINE'S HOLE 9 SKULL

One question arising during the analyses reported here was whether the AH9 cranium differed morphologically from individuals confirmed as dating to the Mesolithic. In other words should the morphology have suggested to us, prior to direct dating, that we were dealing with a non-Mesolithic individual? Within this framework JB and CM undertook Principal Component Analysis to see whether the piece fitted within the distribution of known Mesolithic specimens or whether it could be identified as an outlier.

For those unfamiliar with statistical approaches in the biological sciences, broadly defined, Principal Component Analysis (PCA) is a multivariate technique that looks at the relationships between individual specimens defined by an interrelated series of measurements. The resulting database is a matrix with size defined by the number of individuals being examined and the number of measurements taken on each. In this case the size of the matrix (excluding AH9) is 43 (the number of individuals) by 12 (the number of cranial measurements used). The task is to characterize the nature of the interrelationships and reduce the dimensionality of the data set. The analysis does so by defining a series of orthogonal axes (vectors) that show graphically the variance within the matrix. It is based on the covariance matrix, covariance being the study of how change in one variable corresponds to change in other variables in the matrix. It begins by defining what is called the first principal component (PC1), an equation explaining the maximum amount of variability within the matrix as a linear function of all the measurements used. Different measurements will show different amounts of correlation with this component. From this equation all of the measurements on any given individual in the analysis are reduced to a single point that can be plotted on the component or axis. The programme then proceeds to look for a second component or axis (PC2) that explains the maximum amount of variance remaining in the matrix, but is orthogonal (at right angles) to the first axis and, in similar fashion, the measurements on each individual are reduced to a single point. Plotting the first two components produces a scatter of points showing where each individual lies relative to others. The programme then proceeds to a third axis (PC3) that accounts for the maximum variance remaining after removing PC1 and PC2. Again, this is orthogonal to the first and second axes. The resulting three-dimensional plot produces a cloud of points, each denoting the place of an individual; the closer together in the cloud the more closely related they are. A PCA analysis continues to produce further components to explain all the variance in the matrix, the maximum number being the smaller of the two dimensions in the matrix, in this case 12. To examine all components together in multidimensional space is mathematically but not visually possible. Moreover, in most biological analyses the first three or four axes explain the vast majority of the total variance in the matrix; in this analysis 79.6%

Greatest Length (M1/GOL)	170
Maximum Cranial Breadth (M8/XCB)	((132))
Minimum Frontal Breadth (M9/WFB)	90
Maximum Frontal Breadth (M10/XFB)	(113)
Bistephanic Breadth (M10b/STB)	(98)
Biasterionic Breadth (M12/ASB)	(105)
Frontal Arc (M26)	116
Parietal Arc (M27)	114
Occipital Arc (M28)	(92)
Frontal Chord (M29/FRC)	103
Parietal Chord (M30/PAC)	102
Occipital Chord (M31/OCC)	(80)
Frontal Subtense (FRS)	23
Parietal Subtense (PAS)	21
Occipital Subtense (OCS)	(19)
Bifrontal Breadth (M43a/FMB)	93
Nasio-Frontal Subtense (M43b/NAS)	16
Biorbital Breadth (M44/EKB)	95
Bizygomatic Breadth (M45/ZYB)	((123))
Bijugal Breadth (M45(1))	107
Bimaxillary Breadth (M46b/ZMB)	93
Zygomaxillary Subtense (M46c/SSS)	(22)
Upper Facial Length to Prosthion (M48)	((66))
Upper Facial Length to Prosthion anterior (NPL)	((63))
Interorbital Breadth (M50)	23
Orbital Breadth (M51a/OBB)	37 (L)
Orbital Height (M52/OBH)	34 (L)
Nasal Breadth (M54/NLB)	(21)
Nasal Height (M55/NLH)	(46)
Simotic Chord (M57/WNB)	10
Maxillo-Alveolar Length (M60/MAL)	((57))
Maxillo-Alveolar Breadth (M61/MAB)	(64)
Palatal Breadth (M63/PAB)	((40))

Table 1. *Total set of measurements made on AH9; the first twelve variables were used in the PCA analysis. '()' indicates approximate measurements.*

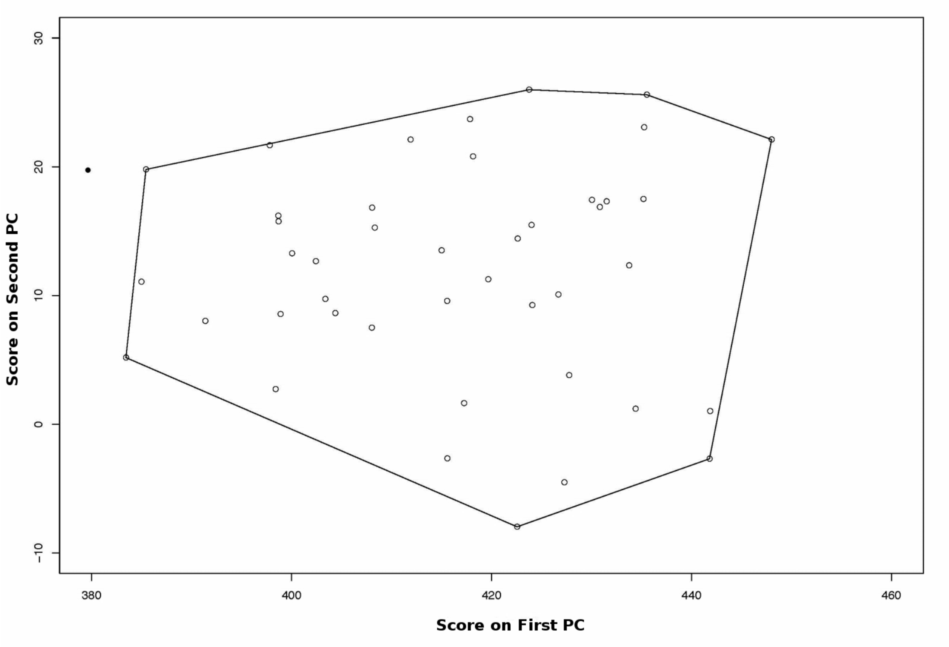

Figure 8. *Scatterplot of Scores on First and Second PCs of Covariance Matrix.*

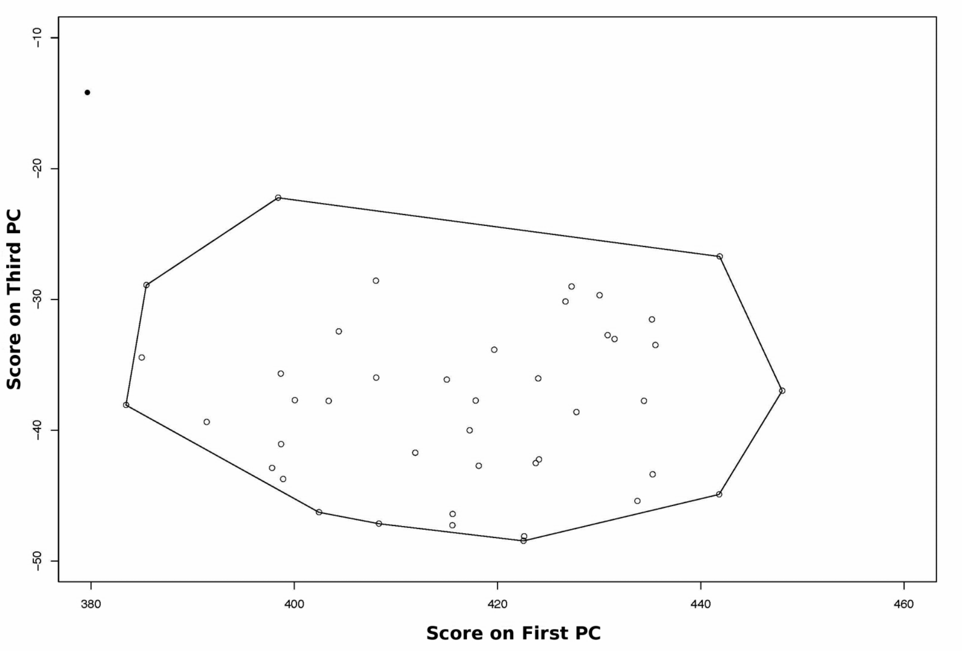

Figure 9. *Scatterplot of Scores on First and Third PCs of Covariance Matrix.*

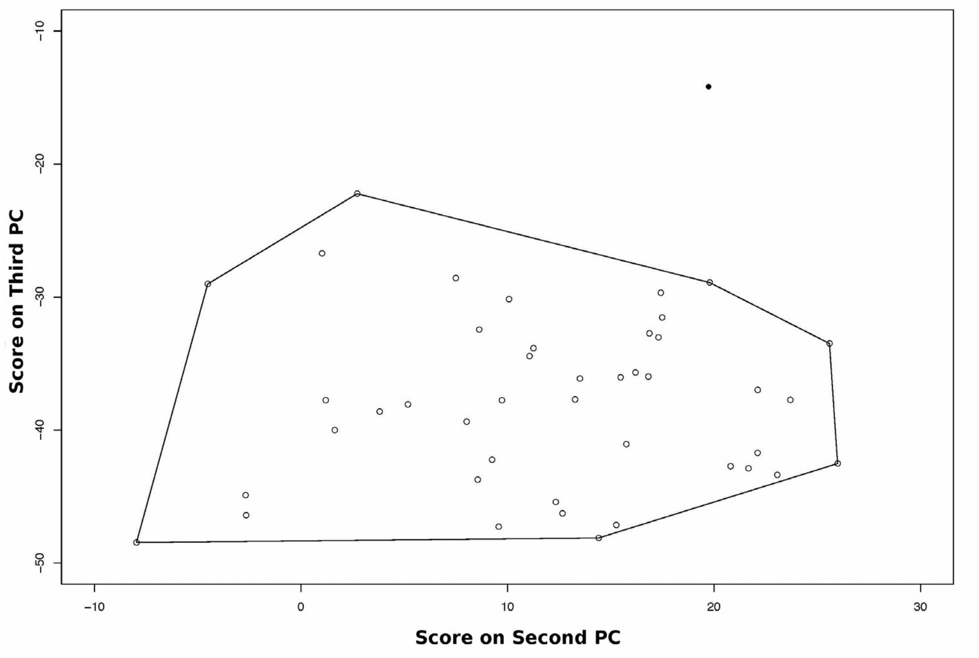

Figure 10. *Scatterplot of Scores on Second and Third PCs of Covariance Matrix.*

of the total variance is accounted for by the first three axes, 87.2% by the first four. The remaining eight axes, explaining the remaining 12.8% of the variance, are of little importance.

As noted above, the current analysis compared AH9 with 43 confirmed Mesolithic crania on 12 craniometric variables (a subset of a much larger database, n=325, chosen to provide the largest possible number of individuals with the maximum number of available measurements, since PCA analysis will not accommodate missing data points). The total set of measurements made on AH9 is shown in Table 1, with the twelve variables used in the PCA analysis highlighted with grey fill. The comparative sample is from a database of Mesolithic cemetery sites. The 44 individuals (i.e., including AH9) are those with all variables used and include adult males and females, there being some uncertainty over the sex of AH9. Six sites were included: Cabeço da Arruda and Moita do Sebastião (Portugal), Höedic and Téviec (Brittany), Skateholm I (Sweden) and Grotta dell'Uzzo (Italy).

Prior to analysis the data record for AH9 was set aside and PCA (Jolliffe, 1986) was conducted on the sample covariance matrix of the 12 variables for the remaining 43 specimens. As already noted, the first three principal components (PC1, PC2, and PC3) collectively accounted for 79.6% of the total variance. Table 2 lists the coefficients of these principal components, along with the proportion of total variance attributable to each PC. The fourth component (PC4) provided no additional information and is not discussed further.

All coefficients for PC1 are positive and it is a weighted mean of the 12 variables. All contribute to roughly the same degree. Thus PC1 is indicative of overall size; according to Jolliffe (1986, p. 51) an interpretation very typical for anatomical measurements. The second, PC2, provides a contrast between two sets of variables one weighted negatively, and especially M10 (maximum frontal breadth) and M28 (occipital arc), the other positively, especially M26, M27, M29 and M30 (frontal and parietal arcs and chords). PC2 therefore shows a pattern where frontal breadth and occipital length become smaller as frontal and parietal length become larger. The third, PC3, contrasts two breadth measurements, M8 and M12 (maximum cranial and biasterionic breadth) and four length measurements, M27, M28, M30 and M31 (parietal and occipital arcs and chords). In other words, as the cranium becomes broader the middle and posterior portions of the cranium decrease in length.

	Coefficients for the principal components		
Variable	PC 1	PC 2	PC 3
M1	0.396	0.052	0.047
M8	0.289	-0.210	0.335
M9	0.270	-0.038	0.158
M10	0.298	-0.809	0.087
M10b	0.346	-0.041	0.126
M12	0.231	-0.189	0.353
M26	0.384	0.343	0.075
M27	0.203	0.403	-0.417
M28	0.287	-0.583	-0.466
M29	0.276	0.314	0.120
M30	0.183	0.329	-0.384
M31	0.211	-0.286	-0.392
Proportion of total variance	0.563	0.147	0.086
Cumulative proportion of total variance	0.563	0.710	0.796

Table 2. *Summary of Principal Component Analysis on the Covariance Matrix*.

The scores of each specimen for PC 1 through PC3 were obtained and are plotted as open circles for pairs of PCs in Figures 8–10 (1 vs 2, 1 vs 3, 2 vs 3). For each figure, the convex hull of the points is superimposed and the position of AH9 indicated by a black dot, plotted after the calculation of the PC values and thus not part of the core data matrix. What becomes clear is that for PC1 and PC3, AH9 falls outside the range of variation of the core sample, and in the plot of PC1 vs PC3 (Figure 9) the individual is outside the expected Mesolithic range on both axes. For figures 8 and 10 AH9 is within the Mesolithic range for PC2. In all three plots AH9 falls well outside of the convex hull on at least one axis and is a strong outlier. Interpreted morphologically, AH9 is smaller than any of the individuals in the Mesolithic sample (PC1) while it is also both narrow and short (PC3) in the same comparison.

For each of the 12 variables, Table 3 lists the sample mean, sample standard deviation, and observed value and Z-score for AH9. AH9 was excluded in calculating the sample mean and standard deviation values. A Z-score indicates the relationship of the individual value and the mean for the sample and may be negative or positive. It is also an indicator of the distance of the value from the sample mean in terms of standard deviation. For AH9 all Z-scores are negative and data values for the specimen are more than 2.5 standard deviations below the sample mean for variables M27, M28, M30 and M31. One final question, where AH9 fits in relationship to other post-Roman British skeletal series lies beyond the scope of this paper but is being explored separately by three of us (CM, JB, RJS, *in prep.*).

Variable	Mean	Standard deviation	Values for AH9	Z-score for AH9
M1	183.628	7.483	170	-1.821
M8	135.302	6.285	132	-0.525
M9	96.326	5.668	90	-1.116
M10	113.395	5.534	113	-0.071
M10b	110.326	6.465	98	-1.907
M12	112.233	6.164	105	-1.173
M26	125.395	7.672	116	-1.225
M27	129.558	6.150	114	-2.530
M28	118.860	7.686	92	-3.495
M29	108.302	5.926	103	-0.895
M30	115.488	5.360	102	-2.516
M31	99.721	5.329	80	-3.701

Table 3. *Determination of Z-scores for AH9.*

CONCLUSION

This examination of the skull referred to as Aveline's Hole 9 has determined that its actual source is unclear. Besides providing new information on the history of the find, we report the results of radiocarbon analysis, demonstrating that it does not date to the Early Mesolithic, or to the Mesolithic at all, but rather is comparatively recent (AD 1494-1648, though this may be slightly too recent due to contamination, i.e., on the order of a few centuries). Further analysis by U-series methods is consistent with these results and suggests a much later time for emplacement in a karst setting. Given the apparent closing of the cave entrance after its use for burial, whether intentionally or accidentally, and the absence of any post-Mesolithic activity, it is unlikely that the skull derives from Aveline's Hole. This sharpens the focus on the tortuous history behind this previously undescribed specimen, sometimes viewed as one of the most complete pre-Neolithic skulls from Britain. We have clearly shown that the AH9 skull is no longer of importance for any study of Mesolithic populations, further demonstrating, should this be necessary, the importance of directly dating human remains from uncertain contexts, or of questionable attribution.

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