A GEOGRAPHIC INFORMATION SYSTEMS APPROACH TO THE 19TH CENTURY EXCAVATION OF BRIXHAM CAVERN, DEVON, ENGLAND

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ABSTRACT

The oldest known spatially-explicit archaeological excavation, conducted in Brixham cave, Devon, in 1858, is reconstructed using geographic information systems technology. Two dimensional plots of individual fossil taxa and flint artefacts demonstrate the utility of the technique for elucidating taphonomy and palaeobiology. The cave served as a den for hibernating brown bears, as a den for hyena and cave lion, and as a reliquary for their prey.

INTRODUCTION

Brixham Cave (also known as Windmill Hill Cavern) is a small solutional fissure cave located in the town of Brixham, Devon, England (Latitude 50.394 N, Longitude 3.513 W, altitude 25 m). The cave was closed to the surface in modern times, until it was uncovered during limestone quarrying operations on January 15th 1858. The landowner, a Mr John Philp, noticed the presence of an antler lying on top of a flowstone floor some 23m into the cave, and the discovery was communicated to William Pengelly shortly thereafter. Pengelly recognised that the excavation of a pristine cave containing paleontological remains might resolve one of the most important scientific and philosophical questions of the mid-19th century – the contentious question of the “antiquity of Man”.

Scientific study of European “bone caves” can be said to have been placed on a firm footing with the publication of William Buckland’s Reliquiae Diluvianae (1824) in which he noted at least eight instances in which human remains were found in cave strata apparently coincident with the bones of extinct mammals. This juxtaposition challenged the prevailing Natural Theology that had developed over the preceding century from the intercalation of Biblical scripture and the emergent field of geology. Buckland, in keeping with his deference to Scripture and a young age for the human species, argued that the bones in these cave deposits were “....not of the same antiquity with those of the antediluvian animals that occur in the same caves with them” (Buckland, 1824, p.169). Others disagreed. John MacEnery began sporadic excavations in nearby Kent’s Hole (now Kents Cavern; latitude 50.467 N, longitude 3.503 W, altitude 58 m) in the summer of 1825, inspired by Buckland’s work and initially in the company of Buckland himself (Kennard, 1945). By 1826 MacEnery had apparently satisfied himself that flint implements and extinct mammals were contemporaneous, but he deferred to Buckland’s opinion that they were emplaced in oven pits by recent Celtic occupants of the cave, and withheld his manuscript on the subject from publication. The work was eventually published posthumously in 1859 (MacEnery
The significance of Brixham Cave in the spring of 1858 lay in its pristine condition and the intact capping of flowstone that sealed the presumed ancient bones and tools from historic-era intrusions. Convinced that the site could provide a definitive test of the contemporaneity of the human artefacts and extinct mammals, the Geological Society of London established a Brixham Cave Committee and obtained a grant from the Royal Society to secure a lease to the cave (Gruber, 1965; van Riper, 1993).

The excavations, under Pengelly’s supervision, set a new standard for the science. Whereas previous cave excavations had focused on simple collection of the materials, Pengelly devised a system to associate each fossil and artefact with its spatial location in the cave. Brixham Cave consists of a network of mostly narrow, rectilinear fissures developed along the joints of the limestone bedrock. Pengelly’s excavation system was two dimensional – position was recorded horizontally along the axes of the fissures, and vertically through the strata. Axial position was defined as distance along a survey line from the origin (the modern entrance) or the opening of subsequent galleries (fissures) from the first fissure (the “Reindeer Gallery”; Figure 1). Some original survey line markings remain in

![Diagram of Brixham Cave](image-url)
the cave. Position left or right of the survey line was not recorded, probably because of the narrowness of the fissures. When Pengelly began work on Kents Cavern seven years later, the larger passages necessitated that he develop his system into a true three-dimensional methodology (McFarlane and Lundberg, 2007), which became the foundation of modern archaeological and paleontological excavation practice.

Although the Brixham Cave excavations convinced the excavators and their collaborators that human artefacts were indeed buried in the cave coexistent in age with extinct “antediluvian” species, an abundance of caution in London delayed formal publication of the results until 1873, by which time more spectacular evidence had been reported from Continental Europe (van Riper, 1993; Rudwick, 2008) and Brixham Cave slipped into relative obscurity. Nevertheless, the thoroughness of the excavation records and notes that have survived (Pengelly, 1873; unpublished Pengelly notebooks, 1858, Torquay Museum) permit a re-examination of the spatial aspects of the data using a geographic information systems (GIS) approach.

METHODS

The original cave survey (Pengelly et al., 1873) was digitized and imported into ArcGIS v9 (ESRI, 2009) as a shapefile. Specimen data from Pengelly et al. (1873) was transcribed into an Excel (Microsoft Corporation, 2007) spreadsheet and also imported into ArcGIS v9. Specimen locations which were originally recorded as distance along each gallery (in feet) were plotted by fitting a central survey line (with a beginning measurement and end measurement) along each gallery and geocoding (interpolating) the specimen data (address/foot) in a manner analogous to geocoding street addresses.

The distribution of the total specimen inventory (all species), and each individual taxon was examined using a fixed kernel density plot (Figure 2) with a 2m search radius (Bayer, 2004).

RESULTS AND DISCUSSION

The distributions of flint artefacts and of the 13 animal taxa are shown as kernel density plots with the midpoint of occupied locality “cell” marked as solid circles (Figures 3a-3d). Although Brixham Cave was entered through a single excavated entrance (the modern entrance, at the north end of the Reindeer Gallery. The entire system is very shallow and, in the course of the 19th Century excavations, four additional entrances were excavated from the inside of the cave, out. It is apparent from the kernel density plot of total specimen distribution (Figure 2) that the modern entrance was not the point of access for the paleontological materials. It would appear that these remains entered the cave from the now-sealed entrance into West Chamber, and were distributed along the Flint Knife Gallery and then north and south along the Reindeer Gallery. Very few specimens passed through Pen Gallery into the Southern, Kings and/or Keepings’ Galleries, and none into Maunday’s Gallery, the latter at least being sealed with sediment.

Brown bear (Ursus arctos) remains are the most abundant (n=354; Figure 6a) faunal remains recovered from Brixham Cave, accounting for approximately one half of the total identifiable recoveries. The spatial distribution of these remains is almost identical to those of the next most abundant taxon, the reindeer Rangifer tarandus (Figure 5d). Bears of all ages are represented, including juveniles with milk dentition, with bones of some individuals found in close association or near-articulation (Pengelly et al., 1873),
circumstances consistent with the use of the cave as a den and hibernaculum. Spotted hyena
(Crocuta crocuta; Figure 4c) are the third most abundant taxon in Brixham Cave. The taxa
Bos primigenius, Capreolus capreolus, Cervus elaphus, Coelodonta antiquitatis, Equus
ferus, and Mammutus primigenius all have similar distributions constrained by the simple
cave layout and were presumably brought into the cave as prey of hyenas. The cave lion,
Panthera leo spelaea, is present in the sparsely fossiliferous Pen Gallery, and may be

Figure 2. Density map of all 1873 excavated specimens. Points represent the mid-
point of excavated sections. Kernel density plots use a 2m search radius.
Figure 3a-3d. Density plots of individual taxa. Points represent the midpoint of excavated sections. Kernel density plots use a 2m search radius.
Density plots of individual taxa. Points represent the midpoint of excavated sections. Kernel density plots use a 2m search radius.

Figure 4a-4d. Density plots of individual taxa. Points represent the midpoint of excavated sections. Kernel density plots use a 2m search radius.
Figure 5a-5d. Density plots of individual taxa. Points represent the midpoint of excavated sections. Kernel density plots use a 2m search radius.
associated with mammoth remains in Southern Chamber, which apparently did not see hyena activity. The artefacts are concentrated close to the West entrance and perhaps indicate the site of human occupation, with additional material moved into the lower Reindeer Gallery by sediment flow.

Surprisingly, the Brixham Cave paleontological deposits have never been subjected to radiometric dating. The main faunal assemblage, which was emplaced below the stalagmite floor in Pengelly’s ‘Layer 3’, is consistent with the “Pin Hole mammal assemblage” of Currant and Jacobi (2001). This assemblage is dated to MIS 3 (24 ka – 56 ka; Bassinot et al., 1994). However, the first paleontological specimen to attract notice at Brixham Cave was a reindeer (Rangifer tarandus) antler that lay above the flowstone floor; “On a shelving stalagmitic terrace in the interior we saw from a distance a pair of large Cervine horns horizontally imbedded in the stalagmite;” (Pengelly et al., 1873; p473). Eventually, excavations would yield 72 ‘determined specimens’ of reindeer, the majority from “layer 3” below the flowstone floor, but some lying on and partially embedded, in it. If we accept that layer 3 is indeed MIS 3 in age, then the age of the flowstone floor and its superimposed reindeer are of interest. Stalagmitic deposition was essentially non-existent in England during MIS 2 (Gascoyne et al., 1983) due to the prevailing extreme periglacial conditions, so that the flowstone floor was almost certainly deposited during the early Holocene and is probably contemporaneous with the extensive deposition of the “granular stalagmite” in Kents Cavern, which began approximately 11,000 yrs BP (Lundberg and McFarlane, 2007). Comparable tufaceous flowstone layers of early to mid-Holocene age are known.
from many other British cave sites, including Broken Cavern and Three Holes Cave, Tor-
bryan Caves (15 kms NNW of Brixham Cave; Currant 1998), Potter’s Cave, Wales
(Davies, 1989), Symond’s Yat East Rockshelter, Herefordshire (Barton, 1994), Pin Hole
Cave, Derbyshire (Jacobi et al., 1998), and Stump Cross Caverns, Yorkshire (Baker et al.,
1996). A Holocene flowstone floor in Brixham Cave requires that reindeer were present in
southern England in early Holocene times.

Based on an account in the 13th Century Orkneyinga Saga (Anon., 1200), it has often been
argued that reindeer were hunted in Caithness, Scotland, into the Middle Ages. The evi-
dence has been considered in detail by Clutton-Brock and McGregor (1988), and shown to
be unsupported by modern archaeological evidence. The youngest carbon-dated reindeer
remains from Britain come from Reindeer Cave, Creag nan Uamh, Inchnadamph, Scotland
(latitude 58.128 N, 860 kms north of Brixham Cave) dating to 9032 -9478 BP (2σ, SRR1-
2105; Clutton-Brock and MacGregor, 1988; recalibrated4 to Reimer et al., 2004). Speci-
mens from Kitley Shelter Cave, Devon (35kms from Brixham Cave) date to 10,700-11,252
BP (2 , Coard and Chamberlain, 1999; recalibrated4 to Reimer et al., 2004). A newly re-
ported date of 12,329-13,063 BP (2σ ,OxA-180754, Stevens et al., 2010; calibrated
from Aveline’s Hole, Mendip Hills (latitude 51.324 N, longitude 2.753
W, altitude 129 m; 116 kms NNE of Brixham Cave), further demonstrates that reindeer
were present in southern England post-Last Glacial maximum. Stevens et al. (2010) com-
ment that the great rarity of reindeer in postglacial Mendip archaeological deposits poses
the question of where Upper Palaeolithic human hunters obtained their prey. The presence
of an apparently post-glacial reindeer in Brixham Cave raises the possibility that the spe-
cies may have persisted into the Holocene on the uplands of Dartmoor, some 25 kms west
of the cave, as first suggested by Coard and Chamberlain (1999) in the context of the
Kitley Shelter Cave specimens.

CONCLUSION

The Brixham Cave excavation was the earliest known archaeological and/or cave site to be
excavated according to a protocol that preserved the spatial relationships of the materials.
The 19th century spatial data is robust enough that it can be readily entered into a geo-
graphic information system format for display and analysis.

Basic analysis suggests that the paleontological remains primarily result from the activities
of three taxa; brown bears using the cave as a hibernaculum, and hyenas and cave lion us-
ing the cave as a den, both accessing the cave from the western entrance in MIS 3 time.
The origin of the apparent Holocene Rangifer antler, located at a point in the Reindeer Gal-
elry remote from the western entrance is more obscure; it is unlikely that the modern
(north) entrance was ever open in Holocene time prior to its excavation in 1858.

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1 NERC radiocarbon Laboratory, East Kilbride, Scotland.
2 http://calib.qub.ac.uk/calib/calib.html
3 http://calib.qub.ac.uk/calib/calib.html
4 Oxford University Radiocarbon Unit.
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