Donald A. McFarlane and Joyce Lundberg - The 19th century excavation of Kent's Cavern, England. *Journal of Cave and Karst Studies*, v. 67, no. 1, p. 39-47.

THE 19TH CENTURY EXCAVATION OF KENT'S CAVERN, ENGLAND

DONALD A. MCFARLANE

W. M. Keck Science Center, The Claremont Colleges, Claremont CA 91711, USA. dmcfarlane@jsd.claremont.edu

JOYCE LUNDBERG

Department of Geography and Environmental Studies, Carleton University, Ottawa, ON K1S 5B6, CANADA

Between 1858 and 1880, William Pengelly developed revolutionary new techniques for the archeological and paleontological excavation of cave deposits. His work at Brixham Cave and Kent's Cavern, England, yielded tens of thousands of specimens from the mid-Pleistocene to the Holocene, settled the intellectual debate over the co-existence of humans and extinct mammals, and accumulated an unparalleled resource for continued study. Although the Brixham Cave work was thoroughly summarized in print, Pengelly never published the plans of his much more thorough and extensive excavations at Kent's Cavern. Here we present a reconstructed plan of the Pengelly excavations that we hope will be a valuable resource for future analyses of the archaeological and paleontological collections.

In the mid-19th century, the preeminent philosophical question facing the emergent archaeological and paleontological community was the contentious issue of the "Antiquity of Man", and the controversial but apparent co-occurrence of anthropogenic artifacts with the remains of extinct mega-faunal mammals. As early as 1771 Johann Esper had found human bones intermingled with those of cave bear (*Ursus spelaeus*) in the excavations at Zoolithenhöhle, Burggaillenreuth, Germany (Esper 1774). In 1792, John Frere reported stone hand-axes deeply buried in gravels at Hoxne, England, commenting that [these axes] *may tempt us to refer them to a very remote period indeed; even beyond that of the present world* (letter to the Society of Antiquities, London, quoted in Daniel 1959).

Since the publication of James Hutton's *Theory of the Earth* (1785), informed scientific opinion had consistently pushed the presumed age of the Earth back in time, whereas the tenure of *Homo sapiens* was still widely considered to be constrained by the Ussherian timescale of ~6000 years which had been the foundation of Thomas Burnet's influential *Sacred Theory of the Earth* (1681).

When William Buckland published *Reliquiae Diluvianae* (Buckland 1823), he advanced an influential case for the traditional Catastrophist view, interpreting cave deposits as direct evidence of the Noachian Flood that had incorporated the bones of those doomed "antediluvian" species swept away in the great Catastrophe. Buckland's own excavations had uncovered human remains; most famously the "Red Lady" of Paviland Cave, but Buckland argued that "she" (now known to be "he"; North 1942) was...*clearly not coeval with the antediluvian extinct species*... (Buckland 1823, p. 89). Similarly, Buckland interpreted human remains from a cave at Burrington, England, as the remains of ...*wretches that perished in it, when the country was suffering under one of our numerous military operations.* (Buckland 1823, p. 164). Nevertheless, by 1838 Boucher de Perthes had reported "antediluvian" artifacts from gravels in the Somme Valley of northern France (de Perthes 1838).

Between 1825 and 1829, Father John MacEnery of Torre Abbey conducted a series of excavations in Kent's Cavern, a well known site in Wellswood (now a suburb of Torquay), England. MacEnery broke through a laterally extensive flowstone floor and recovered bones of extinct mammals and flint artifacts from the "cave earth" beneath. Because the flowstone floor sealed the bones from modern intrusions, MacEnery recognized that their co-occurrence with flint tools was significant. Buckland, however, disagreed, considering the tools to have entered the cave earth in post-Diluvian times through "oven pits" dug through the flowstone by Celtic inhabitants (Kennard 1945). In light of MacEnery's lack of experience in geology and cave excavation, and the fact that the Great (entrance) Chamber of Kent's Cavern had been extensively modified by centuries of use and souvenir hunting, MacEnery's views carried little weight and did not appear until 1859 (MacEnery 1859), 18 years after his death and by then superseded by work at Brixham Cave.

William Pengelly became intrigued with the problem of the "antiquity of Man" in the mid-1800s, and conducted some additional excavations at Kent's Cavern under the auspices of the Torquay Natural History Society in 1846. However, in 1858 the discovery of Brixham Cave provided him–and the British geological community–with a unique opportunity. The cave, which had no open entrance, was discovered during quarrying operations on January 15, 1858. The owner, John Philp, enlarged a small hole through which a quarryman's "jumper" (crow-bar) had been lost and entered a cave with a pristine flowstone floor which was embedded with a reindeer (*Rangifer tarandus*) antler. Breaking the floor, Philp discovered more fossil bones and within days had secured the site with a locked gate and opened it as a tourist attraction. When Pengelly visited the site shortly afterwards he recognized the potential for an excavation through a largely undisturbed flowstone floor in a previously sealed cave: any artifacts that might be recovered from the bone stratum would be undeniably

coeval with the extinct fauna already known to be present. Finding Mr. Philp...*not disinclined to dispose of his Cavern, or rather the right of working it, to any person prepared to pay him well for it* (Pengelly 1858), Pengelly sought to lease the site for excavation. In due course, the Geological Society of London established a Cave Committee and obtained Philp's lease fee of 100 £ from the Royal Society.

THE EXCAVATIONS

Pengelly assumed local oversight of the excavation, and employed Henry Keeping, a professional fossil collector, and local laborers to conduct the actual digging. Excavation began on July 15, 1858. Of great importance, Pengelly devised and introduced a fundamentally new approach to cave (and archaeological) excavation. The standard method of excavation in the mid-1800s was to sink multiple vertical shafts through the deposits, to locate the richest accumulations of bones or artifacts. Little attention was paid to stratigraphy, so that the specimens from different levels were intermingled by the time they reached the museums. Pengelly began with a survey of the cave. Next,

It was decided to remove the stalagmitic floor, then the entire bed immediately below (if not of inconvenient depth) horizontally throughout the length of the cavern, or so far as practicable; this accomplished, to proceed similarly with the next lower bed, and so on until all the deposits had been removed.

The more effectually to guard against the chance of error, the materials were first carefully examined in situ, after which they were taken at once outside the cavern, where they underwent a further inspection. In no instance were they removed, for even temporary convenience, from one part of the cavern to another.

Whenever a bone or other article worthy of preservation was found, its situation (that is to say, its distance from the mouth or entrance of the gallery in which it occurred, as well as its depth below the surface of the bed in which it lay) was carefully determined by actual measurement. In order to [facilitate] *their identification, the specimens were all numbered; those that were found in the same place received the same numeral, and were packed in one and the same box, so that at the close of exploration the number of boxes indicated the number of localities in which fossils had been found; the boxes were distinguished by numbers, each bearing that which each specimen within it bore. Finally an entry of each box was made in a journal, in which were registered the number and situation of the specimens it contained, with the date on which they were found, and occasionally a few remarks respecting them*. (Pengelly *et al*. 1873, p. 482).

Pengelly's survey of the cave, which appears in detail in the Royal Society report of 1873 (Pengelly *et al*. 1873), divides the cave into 8 galleries and 2 chambers. His notation system was based on horizontal distance from the entrance of each gallery or chamber; although only in the case of the first (the Reindeer Gallery) can this point of origin be fixed with reasonable confidence.

Following completion of the Brixham cave project, Pengelly focused his attention on the much larger Kent's Cavern in nearby Wellsworth, Torquay. Kent's Cavern was well known locally and much visited: inscriptions carved into flowstone bosses in the cave date from as early as 1571. Moreover, MacEnery had proven the site to be productive of extinct fauna and human artifacts. Pengelly appreciated that any lingering doubt as to the co-occurrence of humans and extinct species could be dispelled only with a major and very tightly controlled excavation. There must be no doubt as to the exact provenance of each excavated specimen.

Having obtained the provisional consent of the landowner, Sir Lawrence Palk, Pengelly was able to enlist the financial support of the British Association for the Advancement of Science for a sustained campaign. On the September 20, 1864, the British Association passed a resolution establishing the Kent's Cavern Committee, consisting of Sir Charles Lyell, Professor Phillips, Mr. John Lubbock, Mr. John Evans, Mr. E. Vivian, and Mr. William Pengelly, *...for the purpose of promoting researches on special points not yet sufficiently explored in the Kent's Hole, Torquay, provided satisfactory arrangements can be made for the final disposition of specimens; that Mr. William Pengelly be the Secretary; and that the sum of £100 be placed at their disposal for this purpose* (Pengelly1858). The project would eventually occupy Pengelly and his excavators six days a week for 16 years.

The Cavern Committee held its first meeting on November 23, 1864, in the rooms of the Geological Society, London, and Pengelly went to work making the necessary formal arrangements with the landowner and hiring labourers. On March, 19, 1865, Pengelly hired Charles Keeping (brother of Henry Keeping, the Chief Workman at the Brixham Cave excavation), and on March 27, 1865 he engaged George Smerdon. Smerdon was to remain in the employ of the Cavern Committee for its duration, eventually receiving a small pension and assuming the custodianship of the cave, which had become popular with adventurous visitors. Smerdon's son-in-law, Francis Powe, took over the custodianship of the cave from Smerdon and purchased the property in 1903; it has remained in the Powe family to the present day.

Pengelly's excavation system was to become one of the foundations of the modern scientific archaeological method. At Brixham Cave, Pengelly had developed a system to relate the origin of each fossil or artifact to its horizontal position along the length of the relevant gallery, and to its vertical level. In the Brixham cave context, where the passages are rectilinear and quite narrow, this was adequate for Pengelly's purposes. At Kent's Cavern, however, Pengelly faced a much more complex situation. Kent's Cavern is more than 900 m long (although much of that was unknown when Pengelly started work), and several chambers were wide enough that a truly three-dimensional system of documentation was needed.

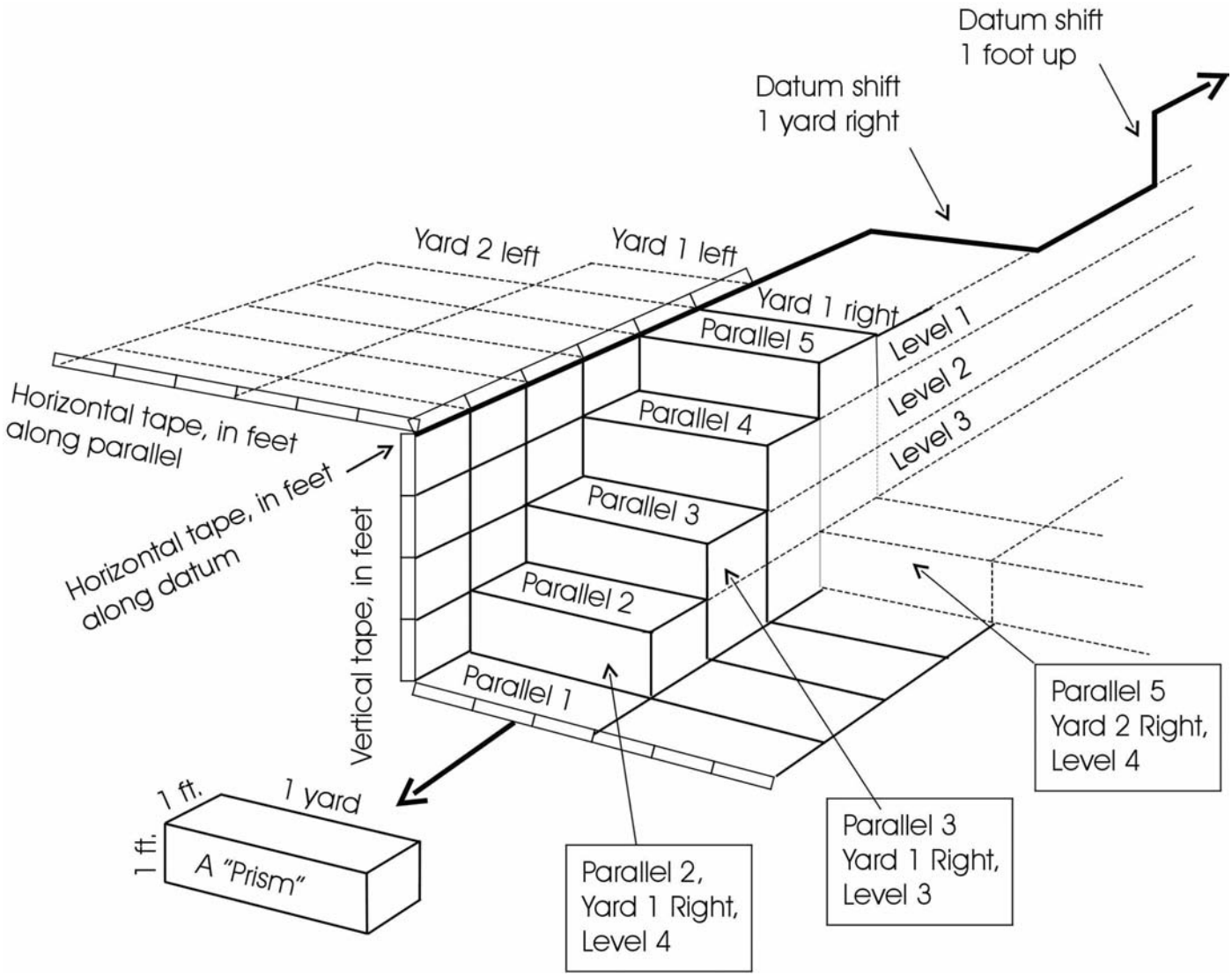


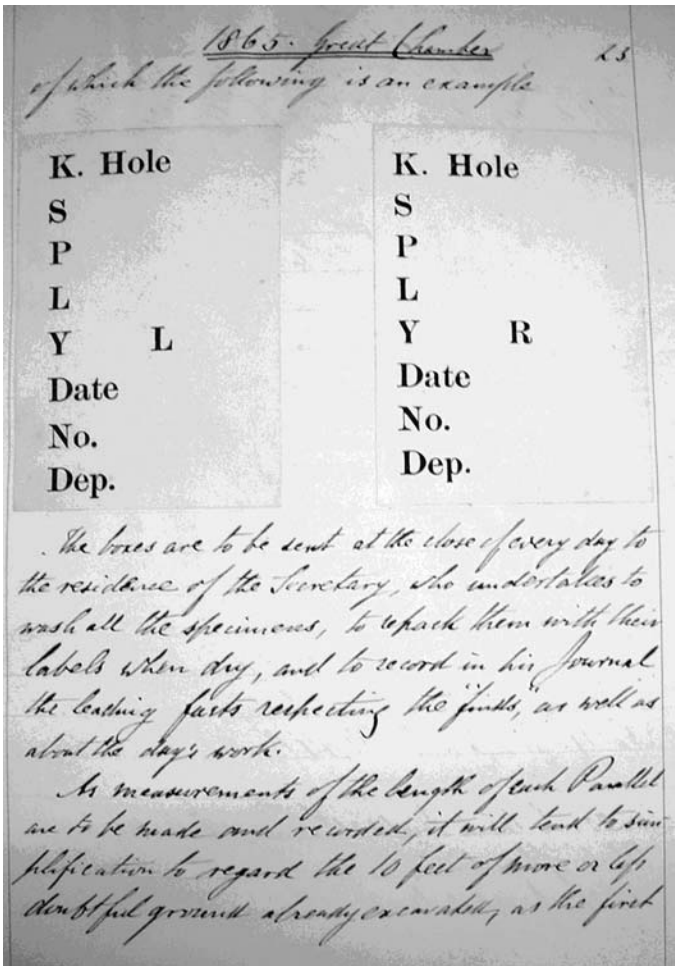
Figure 1. The Pengelly excavation system.

Pengelly's solution was to create a system (Fig. 1) of *Series*, each consisting of a leveled *Datum* line suspended over the cave floor. *Series 1* was tied to the masonry at the South Entrance, and extended 62 ft (19 m)[1] across the Great Chamber to the far wall on a bearing of 275° magnetic (Appendix 1). Each *Series* was intersected by lateral *Parallels* at 90° to the *Datum*, and set 1 ft (0.3 m) apart. Each *Parallel* extended in successive 1 yard (0.9 m) segments perpendicular to the left and right of the *Datum*. Finally, Pengelly added vertical control; he removed surficial deposits and any flowstone capping and then excavated in 4 one-foot (0.3 m) *Levels* (extending this to 9 *Levels* in the Long Arcade). Thus, material was removed in units measuring 1 ft x 3 ft x 1 ft deep (0.3 m x 0.9 m x 0.3 m deep), which Pengelly called *Prisms*. In order to follow the meanderings of the cave passages, Pengelly periodically shifted his Datum line, always at 90° left or right (and/or up and down), by the appropriate number of feet or inches. In Pengelly's own words:

We make a vertical section down through the deposits, say at ten feet from the entrance, at right angles to a datum line drawn horizontally from a point at the entrance to another at the back of the first chamber, in the direction as it happens, of W.5° N. We draw a line at right angles to the datum at eleven feet from the entrance, so as to define or mark off a new "parallel" a foot wide. Along this entire belt or parallel we take off the Black Mould from side to side of the chamber and examine it carefully by candlelight in situ. (Pengelly 1875, p. 16).

The finds from each *Prism* were placed together in their own box, and given a single identifying number. By the time excavations in the cave ended on June 19, 1880, 7340 boxes

[1]Editor's note: English units followed by metric were allowed in this article for historic reasons.


1865. Great Chamber 25
of which the following is an example

K. Hole
S
P
L
Y L
Date
No.
Dep.

K. Hole
S
P
L
Y R
Date
No.
Dep.

The bones are to be sent at the close of every day to the residence of the Secretary, who undertakes to wash all the specimens, to unpack them with their labels when dry, and to record in his Journal the leading facts respecting the finds, as well as about the day's work.

As measurements of the length of each Parallel are to be made and recorded, it will lead to simplification to regard the 10 feet of more or less doubtful ground already excavated, as the first

Figure 2. An original Pengelly specimen label (Torquay Museum).

had been accessioned, many containing dozens of individual bones, bone fragments, teeth, and artifacts. Each numbered box contained a standardized label (Fig. 2) locating the origin of its contents in three-dimensional cave-space (*Series, Parallel, Yard, and Level*). Pengelly produced monthly progress reports to the Cavern Committee, an annual report to the British Association, the latter being published (Pengelly 1868, 1869, 1871, 1878, 1884), and copious diary notes.

The Pengelly excavation was pioneering in its exactitude, which was not replicated in subsequent cave excavations in Kent's Cavern or anywhere else for decades thereafter; for example, the Torquay Natural History Society excavations in Kent's Cavern, 1926–1940 (Dowie 1928; Benyon *et al*. 1929; Smith 1940). The value of Pengelly's meticulous work in a modern context is enhanced by the fact that Pengelly's diary, more than 900 pages of hand-written notes, survives in the Torquay Museum archives, together with the majority of the specimens. Most of the remaining important specimens (particularly anthropogenic artifacts) went to the British Museum, and the remainder were disbursed in small lots to 15 other museums in Britain, to the Jardin des Plantes in Paris, and to the Smithsonian Institution in Washington D.C. Only Pengelly's charts and maps of the excavation are missing.

Kent's Cavern is now recognized as one of Britain's oldest archaeological sites, having yielded artifacts from all the recognized stages of the Paleolithic. Paleontologically, Kent's Cavern is no less important, having preserved a rich fauna spanning multiple full glacial-interglacial cycles. Remarkably, there has been only a single attempt to utilize the full potential of the archived spatial data. Campbell, in an exercise preparatory to the publication of his *Upper Paleolithic of Britain* (Campbell 1977), attempted to plot the origin of critical specimens excavated from the Great Chamber–South West Gallery area of the cave on a portion of Lake's survey (Lake 1934) of the cave (Campbell and Sampson 1971). Although Campbell's conclusions, based on the vertical distribution of specimens, remain valid, he apparently made some errors of transcription. Since Pengelly's system is always referenced back to the origin of Series 1, any error is propagated through all subsequent Series.

Pengelly's notes and published accounts do not contain any diagrams, maps or stratigraphic sketches. We do know that at least one survey was made, because the costs appear in the financial accountings, but this and other graphical materials have not survived in any known collection. Therefore, we have transcribed the entire sequence of Pengelly's grid system records (78 Series), and plotted them in their entirety for the first time. These records are preserved in multiple manuscript volumes in the collections of the Torquay Natural History Society, usually as daily entries. We have also overlain the resulting "Pengelly grid" on the 1989 survey of the cave (Proctor & Smart 1989) to identify both errors of transcription in Pengelly's records, and the cumulative error implicit in Pengelly's survey technique—undertaken by candle light, in constricted or choked passages not yet cleared of sediment.

METHODOLOGY AND RESULTS

Pengelly's system is referenced to his 1st Series, which began as follows;

A line, termed the "Datum line" was stretched horizontally from a fixed point on the external face of the masonry at the Entrance to another point at the back of the Great Chamber…The direction of this line, carefully ascertained by compass was W.5°N magnetic." (Pengelly diary entry, April 11, 1865).

Because the exact position of the starting point is slightly ambiguous, we used the stated length of the first datum line, "62 feet" (19 m), in conjunction with a laser rangefinder and an obvious projection on the west wall of the Great Chamber to reconstruct the first datum ("Series 1"). Pengelly's compass bearing of "W.5°N magnetic", equivalent to 275° $N_{mag1865}$ in modern terminology, is indistinguishable from our reconstruct-

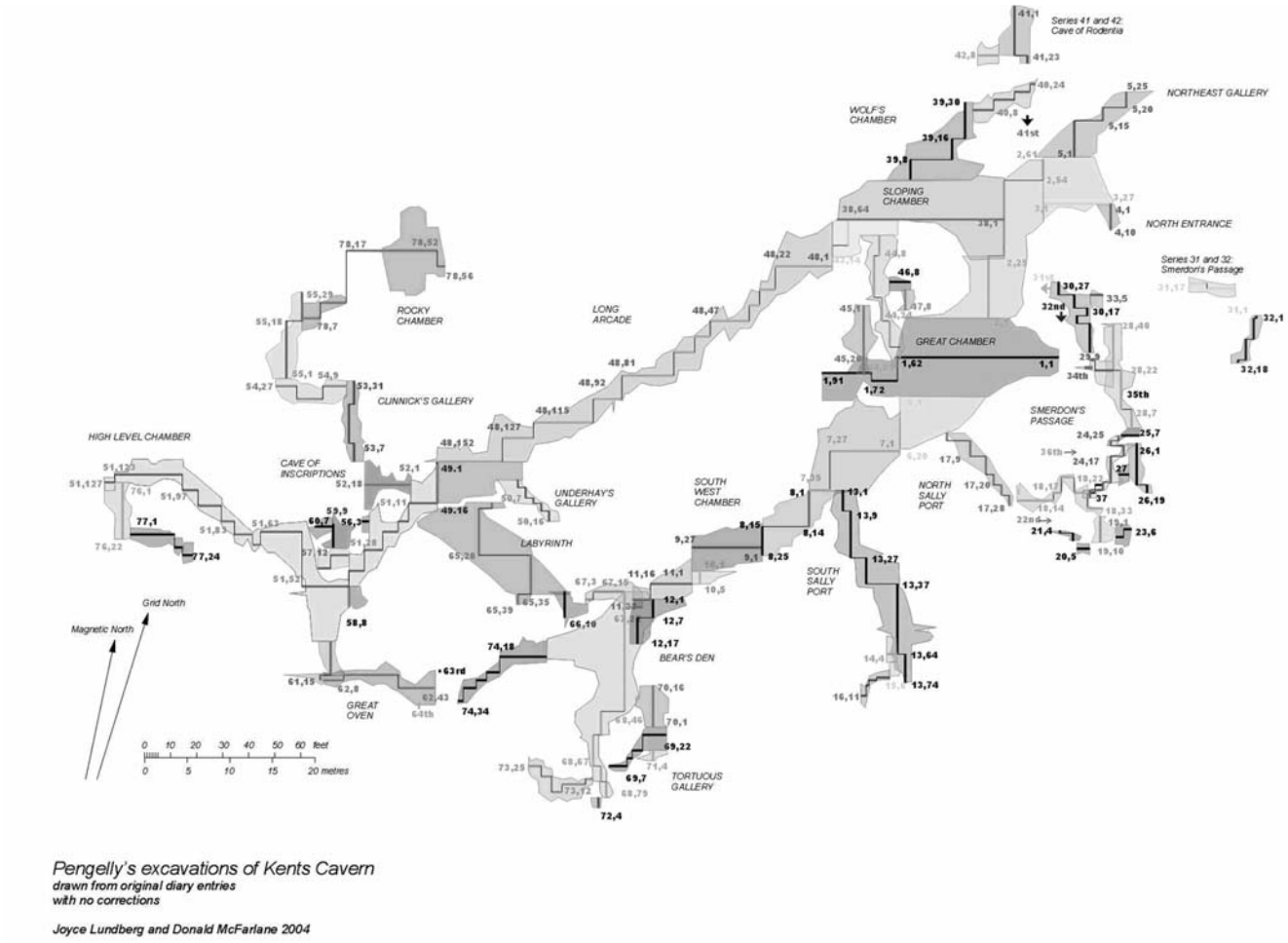


Figure 3. The Pengelly excavations, as recorded without corrections.

ed Series 1 bearing of 252° $N_{mag1989}$ (see Appendix 1). From Series 1, all subsequent series and their parallels were plotted using the datum origins and shifts recorded in Pengelly's diaries. A plot of these data, as transcribed, appears in Figure 3.

We used a modified version of the Proctor and Smart survey of Kent's Cavern, completed in 1989 with a traverse closure error of ~0.5% (Proctor & Smart 1989), and overlaid the Pengelly excavation plot, identifying a number of significant errors. We carefully examined the locations of these errors in the cave, and then made conservative corrections to the Pengelly plot to achieve the best fit with the Proctor and Smart survey (Fig. 4[1]). The apparent errors resulted from (a) occasional misplacement of the origin ("Parallel") of a datum shift, (b) occasional omission of a datum shift from the manuscript record, and (c) most commonly, a cumulative error in establishing offset datums at 90° to their origin. Apparently, after Series 1, datum offsets were set by eye or set-square rather than by compass bearing. A listing of our corrections appears in Appendices 2 and 3.

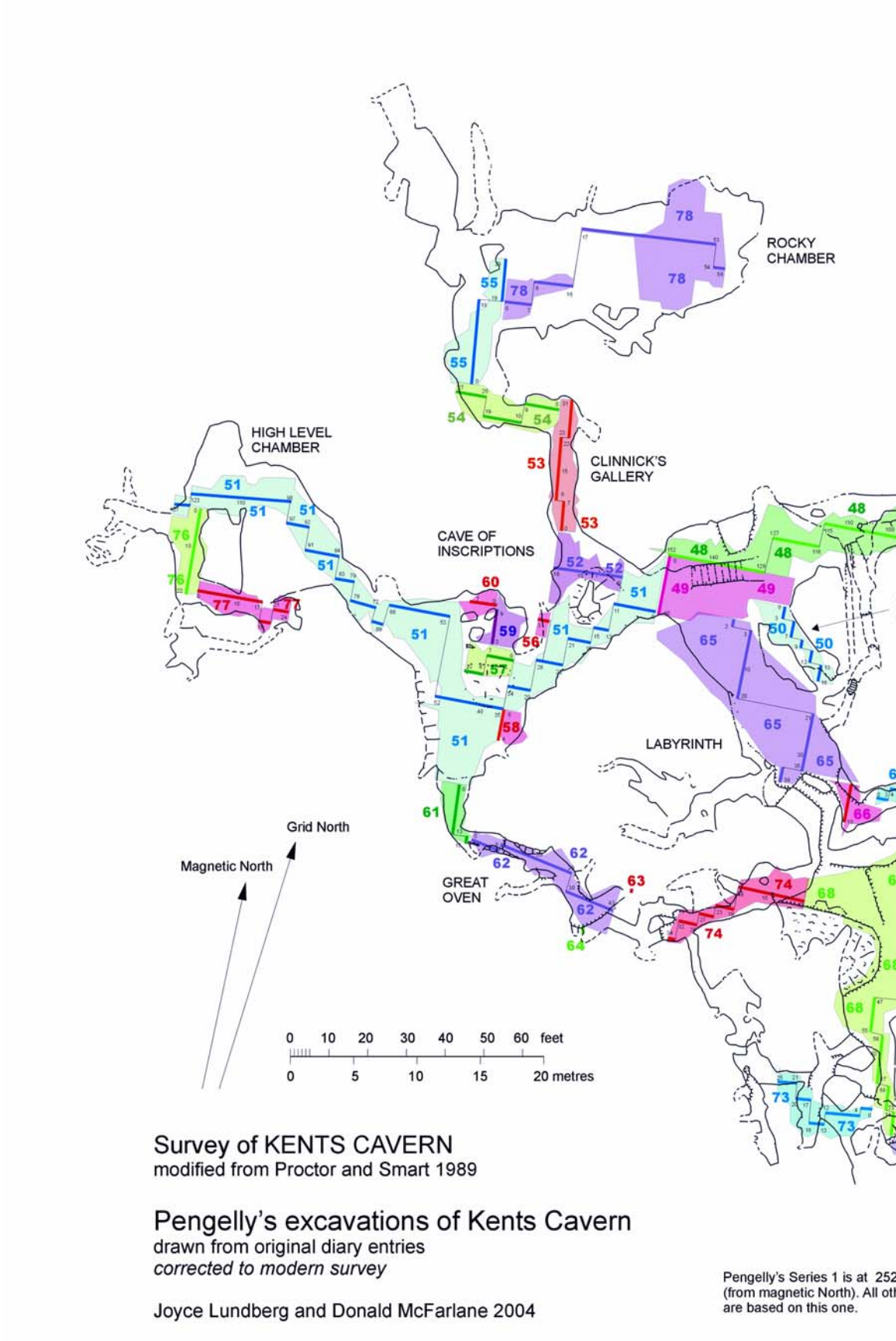
[1] Available in digital form from the authors, or from the NSS archives.

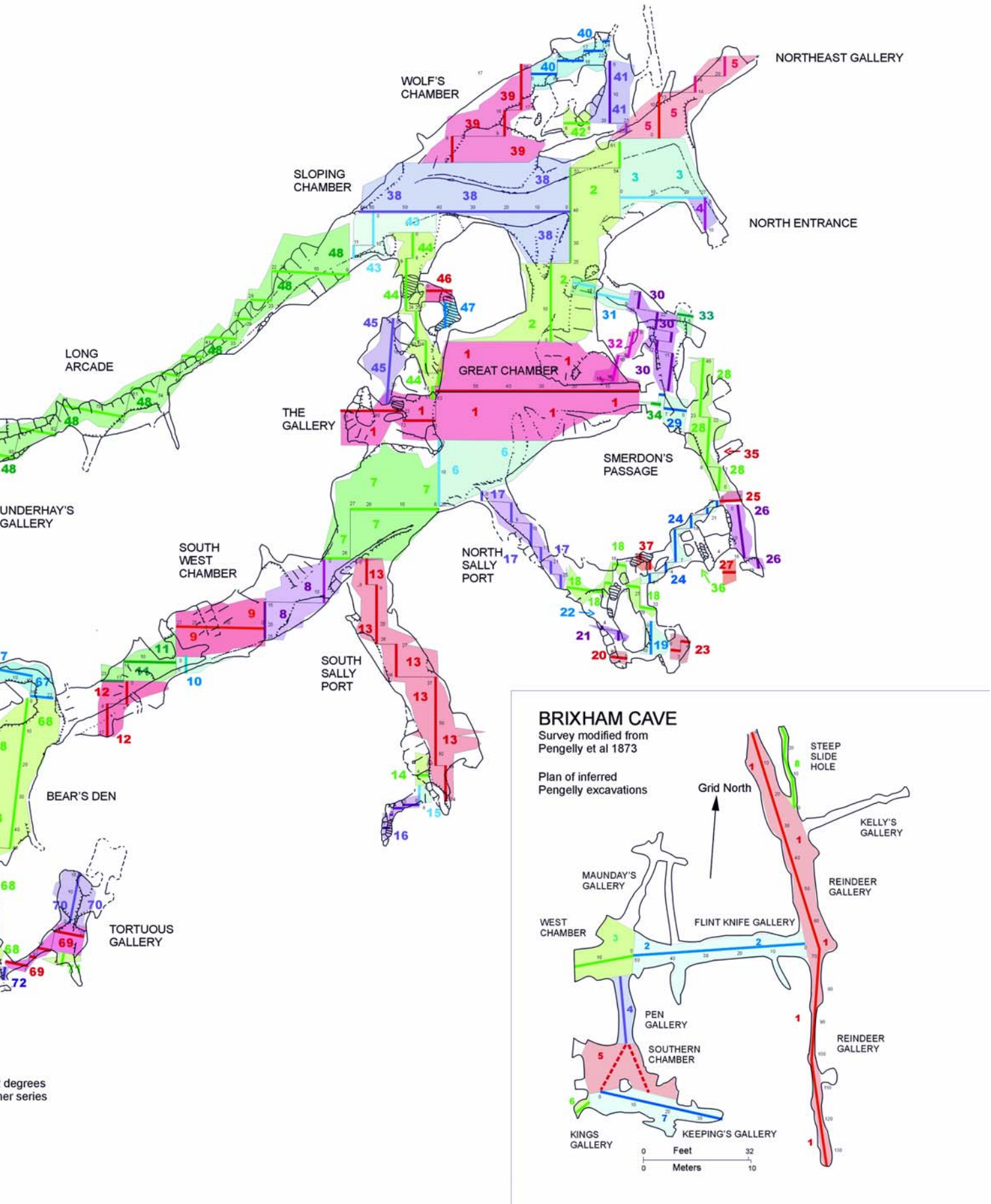
Discussion

In recent syntheses of archaeological methodology, the origin of modern archaeological excavation techniques in Britain has sometimes been credited to Lieutenant General A. Pitt-Rivers, whose *Excavations at Cranborne Chase* (1887, 1888, 1892, 1898) introduced three-dimensional grids and levels to the excavation of surface barrows (Renfrew & Bahn 2004). However, as Warren and Rose (1994) have pointed out, credit for these innovations is more properly due to William Pengelly, who developed them two decades before Pitt-Rivers began work at Cranborne Chase, and with whose work Pitt-Rivers was demonstrably familiar. Curiously, Pengelly has been more directly credited with the development of these methods in French and American archaeology (Browman 2003).

The very large collections of paleontological and archaeological material from Kent's Cavern have, for the most part, survived and remain an irreplaceable resource for the study of the British Pleistocene; indeed, research continues as new technologies become available (e.g., Bocherens & Fogel 1995). Nevertheless, application of the wealth of information

Figure 4.
The Pengelly excavations, with corrections.




NORTHEAST GALLERY
WOLF'S CHAMBER
SLOPING CHAMBER
NORTH ENTRANCE
LONG ARCADE
GREAT CHAMBER
THE GALLERY
SMERDON'S PASSAGE
UNDERHAY'S GALLERY
SOUTH WEST CHAMBER
NORTH SALLY PORT
SOUTH SALLY PORT
BEAR'S DEN
TORTUOUS GALLERY
degrees
ner series
BRIXHAM CAVE
Survey modified from
Pengelly et al 1873
Plan of inferred
Pengelly excavations
Grid North
STEEP SLIDE HOLE
KELLY'S GALLERY
REINDEER GALLERY
MAUNDAY'S GALLERY
WEST CHAMBER
FLINT KNIFE GALLERY
PEN GALLERY
SOUTHERN CHAMBER
REINDEER GALLERY
KINGS GALLERY
KEEPING'S GALLERY
0 Feet 32
0 Meters 10

preserved in Pengelly's records has been hindered by the difficulty of extracting this information in the absence of a summary report and plan of the excavations. The presentation of such a plan in this study opens up new possibilities for the analysis of the spatial information in the Kent's Cavern collections.

ACKOWLEDGEMENTS

We would like to thank Mr. Nick Powe, owner and manager of Kent's Cavern, and Mr. Barry Chandler, Assistant Curator, Torquay Museum, for their support, encouragement, and unfettered access to the site and records under their care. Messrs Duncan Coe and Ian Morrison of English Nature kindly arranged for the necessary permissions at the national level. Dr. Andrew Currant of the Natural History Museum, London, assisted in the early planning. P. J. Watson and an anonymous reviewer provided useful comments on the manuscript. The project was funded in significant part by a grant to McFarlane through a Mellon Foundation faculty development grant to Scripps and Harvey Mudd Colleges, and we thank Lisa Sullivan and Michael Lamkin for their support in this context.

REFERENCES

Benyon, F., Dowie, H.G., & Ogilvie, A.H., 1929, Report on the excavations at Kent's Cavern: Proceedings of the Torquay Natural History Society, v. 5, p. 237.

Bocherens, H. & Fogel, M.L., 1995, Trophic structure and climatic information from isotopic signatures in Pleistocene cave fauna of southern England: Journal of Archaeological Science, v. 22, p. 327–340.

Browman, D.L., 2003, Origins of Americanist stratigraphic excavation methods, *in* J. Truncer, ed., Picking the Lock of Time: Gainesville, University Press of Florida, p. 22–39.

Buckland, W., 1823, Reliquiae Diluvianae; or, observations on the organic remains contained in caves, fissures, and diluvial gravel, and other geological phenomena, attesting to the action of an universal deluge. Murray, London, 303 p.

Burnet, T, 1681, Telluris Theoria Sacra; orbis nostril originem & mutations generales, quas aut jam subiit, aut olim subiturus est, complectens. G. Kettilby, London.

Boucher de Perthes, J., 1838, De L'Homme Antèdiluvian et ses oeuvres Treuttel, Paris.

Campbell, J.B., 1977, The Upper Paleolithic of Britain. A study of man and nature in the Ice Age, vols I and II: Clarendon Press. Oxford.

Campbell, J. B. & Sampson, C. G., 1971, A new analysis of Kent's Cavern, Devonshire, England: University of Oregon Anthropological Papers, No.3, 40 p.

Daniel, G E., 1959, The idea of Man's antiquity: Scientific American, v. 201, p. 167–176

Dowie, H.G., 1928, Note on excavations in Kent's cavern: Proceedings of the Prehistoric Society (East Anglia), v. 5, p. 306–307.

Esper, J.F., 1774, Ausführliche Nachricht von neuentdeckten Zoolithen unbekannter vierfüsiger Thiere, und denen sie enthaltenden, so wie verschiedenen andern, denkwürdigen Grüften der Obergebürgischen Lande des Marggrafthums Bayreuth: Knorr. Nuremberg. 148 p.

Hutton, J., 1785, Theory of the Earth; or an investigation of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe: Transactions of the Royal Society of Edinburgh, v. 1, p. 209–304.

Kennard, A.S. 1945, The early digs in Kent's Hole, Torquay. Proceedings of the Geologists Association 56, p. 156–213.

Lake, P.M.B., 1934, Map of Kent's Cavern, *in* Rogers, E.H., Stratification of the cave earth in Kent's Cavern: Proceedings of the Devonshire Archaeological Exploration Society 1954-1955, p. 1–25.

MacEnery, J., 1859, Cavern Researches. Simpkin, Marshall. London.

NOAA, 2004, National Geophysical Data Center. http://www.ngdc.noaa.gov/seg/potfld/declination.shtml

North, F.J., 1942, Paviland Cave, the "Red lady," the deluge and William Buckland: Annales of Science v. 5(2), p. 91–128.

Pengelly, W., 1858, Manuscript notebook: Torquay Museum, England.

Pengelly, W., 1868, The literature of Kent's Cavern, Part 1: Transactions of the Devonshire Association for the Advancement of Science, Literature and Art, v. 1, p. 469–522.

Pengelly, W., 1869, The literature of Kent's Cavern, Part II: Transactions of the Devonshire Association for the Advancement of Science, Literature and Art, v. 3, p. 191–482.

Pengelly, W., 1871, The literature of Kent's Cavern, Part III: Transactions of the Devonshire Association for the Advancement of Science, Literature and Art, v. 4, p. 467–490.

Pengelly, W., 1875, Manuscript notebook: Torquay Museum.

Pengelly, W., 1878, The literature of Kent's Cavern, Part IV: Transactions of the Devonshire Association for the Advancement of Science, Literature and Art v. 10, p. 141–181.

Pengelly, W., 1884, The literature of Kent's Cavern, Part V: Transactions of the Devonshire Association for the Advancement of Science, Literature and Art, v. 14, p. 189–434.

Pengelly, W., Busk, G., Evans, J., Prestwick, J., Falconer, H., & Ramsay A., 1873, Report on the exploration of Brixham Cave, conducted by a committee of the Geological Society, and under the superintendence of Wm. Pengelly, Esq., FRS., aided by a local committee; with descriptions of the animal remains by George Busk, Esq., F.R.S., and of the flint implements by John Evans, Esq., F.R.S., Joseph Prestwich, F.R.S., F.G.S., &c., Reporter: Philosophical Transactions of the Royal Society of London, v. 163, p. 471–572.

Pitt-Rivers, A.H.L.F., 1887, Excavations in Cranborne Chase. Vol 1: Privately Printed.

Pitt-Rivers, A.H.L.F., 1888, Excavations in Cranborne Chase. Vol 2: Privately Printed.

Pitt-Rivers, A.H.L.F., 1892,. Excavations in Cranborne Chase. Vol 3: Privately Printed.

Pitt-Rivers, A.H.L.F., 1898, Excavations in Cranborne Chase. Vol 4: Privately Printed.

Proctor, C.J. & Smart, P.L., 1989, A new survey of Kent's Cavern, Devon: Proceedings of the University of Bristol Spelaeological Society, v. 18(3) p. 422-429.

Renfrew, C. & Bahn, P., 2004, Archaeology, Theories, Methods, and Practice, 4th Ed: Thames and Hudson Press.

Smith, R.A., 1940., Some recent finds in Kent's Cavern: Proceedings of the Torquay Natural History Society, v. 8 p.59–73.

Warren, C.N. & Rose, S., 1994, William Pengelly's techniques of archaeological excavation: Torquay Natural History Society, Publication No. 5. 40 p.

Appendix 1. Series 1 Bearings

Pengelly 1865 "W. 5°N magnetic."

Magnetic declination at Kent's Cavern in 1865 was -22.333° (pers. comm. Susan MacMillan, British Geological Survey), making Pengelly's bearing equivalent to 252.67° NGrid. Our plot of Series 1 from Pengelly's notes and in-cave ground truthing is 252° Ngrid

Magnetic north on our survey is plotted for 1989, as per the Proctor and Smart (1989) survey. Nmag1989 was -5.816°, or 354.18° Ngrid (NOAA 2004).

Appendix 2.

Corrections to the Pengelly Plot.

Series 1 drawn at 252 N° magnetic.

At 12th Series there is a cumulative offset of ~2 ft (0.6 m); Series 8 through 12 corrected +1.2°.

Series 11and 12 shifted North 3 ft (0.9 m).

Series 14-15 overlap Series 13; Series 14-16 corrected with a shift 3.6 ft (1.1 m) southwest.

North Sally Port.
Origin of the 17th Series in the 6th Series is too far east. Corrected with a shift of Series 17 through 35 of 5 ft (1.5 m) West (changes 6S/14P from an offset of 18 ft (5.5 m) to offset of 13 ft (4.0 m))

Parallelogram shift of 17th Series by 6° S. (no change in E/W). This ends 17th Series at the correct known landmark.

18th Series moved 3 ft (0.9 m) South.

Smerdon's Passage–each series individually tied to passage.

24th Series; penultimate datum shifts recorded as Left (west) but MUST be Right (east).

Exact position of 37th Series relative to its origin in the 24th Series is very ambiguous in Pengelly's notes; we have fitted it to available unexcavated passage on left of 24th Series.

No obvious modification possible to 28th Series to make it fit. UNRESOLVED.

38th Series (and subsequent connected series) shifted 1.5 ft (0.5 m) North to eliminate overlap of excavations with 2nd Series.

Origin of 48th Series is ambiguous, leading to an error (impossible zig-zag in excavation) at 48th Series. Possible unrecorded datum shift at 48th Series, 47th Parallel. We have inserted a datum shift of 3ft (0.9 m) South.

Rocky Chamber offset, listed as 20 feet left, is too wide for passage (25 ft (8 m) max) – reset to 15ft (5 m).

77th Series, final datum shift switched from Right to Left.

65th Series 1st datum shift moved 5 ft (1.5 m) left instead of right.

68th Series, 2nd datum shift switched from left to Right to bring end into passage and connect line with 69th Series.

48th Series (Long Arcade) progressively deviates from the curvature of the passage; we have corrected for this mis-alignment which therefore affects all subsequent series.

29th Series has to start in the 23rd Parallel instead of 22nd Parallel.

37th Series; origin and directions ambiguous; fitted to passage.

41st series moved to 24th Parallel, 7 ft (2.1 m) right (from 22nd Parallel, 9 ft (3 m) right)

46th direction not indicated in Pengelly notes- must be East

Appendix 3.

Since the position of each Series is dependent on the position of each preceding Series in the sequence, we list these sequences here. {Example; an error or correction in the 9th Series would affect the 10th, 11th and 12th Series but not the 13th Series whose origin is in Sequence 3.} Series underlined and boldfaced are points of origin for subsequent Series.

Pengelly's Series sequences:

1-2-3-4-5

1-**6**-**7**-8-9-10-11-12

7-13-14-15-16

6-17-**18**-19-20-21-22-23

18-24-**25**-26-27

25-28-29-30-31-32-33-34

2-**38**-39-40-41-42

38-**43**-44-45-46-47

43-48-**49**-50-**51**-76-77

51-52-53-54-55-78

51-56

51-57-59-60

51-58

51-76

51-58

51-61-62-63-64

49-65-66-67-**68**-69-70-71-72

68-73

68-74