

GOUGH'S CAVE, CHEDDAR, SOMERSET: QUATERNARY STRATIGRAPHY

by

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ABSTRACT

The Quaternary stratigraphy of Gough's Cave is reviewed and summarised. The earliest deposits known are the Main Sands (new name) probably deposited when the cave was the main resurgence for the karst drainage of the area. The Conglomerate marked a departure from the normal pattern of sedimentation, being probably deposited by a stream entering the cave from Cheddar Gorge. The succeeding Creswellian Cave Earth was deposited by intermittent floods and yielded the flint industry which gives it its name. This occupation lasted for around 1500 years. The Creswellian Cave Earth is capped by the stalagmite which marks a period of seasonal flooding which left a sequence of alternations of clayey sediment and carbonate. The youngest deposit was the Upper Cave Earth (new name) which marks a return to brief floods. Eventually deposition ceased in the outer part of the cave. Early Iron Age and Romano-British finds from the Upper Cave Earth probably resulted from later contamination or human or animal disturbance.

INTRODUCTION

Gough's Cave, Cheddar, Somerset is a site of major importance for its prolific Late Upper Palaeolithic flint industry, which has at last been fully described (Jacobi, 2004) and human skeletal remains which have been minutely analysed in a series of papers in the *Bulletin of the Natural History Museum* (Stringer 2000, with list). The history of the discovery of the cave and the archaeological work have been described in detail (Irwin, 1985; Jacobi, 1985, 2004) and will be noted briefly as far as they concern the deposits in the cave.

From the 1890s the then lessees, the Goughs, removed considerable portions of the Creswellian Cave Earth (see below) in order to make a pathway into the cave for tourists. In doing so they saved flint tools and flakes and animal (and human?) bones. However, the cave was subject to periodic flooding. They observed that the flood waters rose from and drained away in the side branch now known as Cheddar Man fissure (or Skeleton Pit) and cut a trench through the deposits in this fissure in the hope of providing better drainage. In doing so, in December 1903, they found human bones, a nearly complete skeleton now known as Cheddar Man. This led H.N. Davies, a fellow of the Geological Society of London, to visit the cave and record what he could of the stratigraphical context of the discovery, and details of the bones themselves (Davies, 1904). Davies did not say when or how often he visited the cave. It seems unlikely that he did so before the discovery of the skeleton, but we do not know. For his section of the deposits in the main passage (1904, fig. 2) he would have had to rely on information from the Goughs plus what he could see of deposits still in place. By contrast, his sections of the deposits in the Cheddar Man fissure (Davies 1904, figs. 4, 5), where Gough had cut his drainage trench, are probably accurate.

Excavations from 1927 for about five years were commenced in order to improve access to the cave, but R F Parry extended them so as to remove (apparently) most of the remaining deposits in the outer 45 m or so of the cave. Parry published only one stratigraphical section (Parry 1929b, insert between pp. 104 & 105). Its exact location was not stated; presumably somewhere within the then excavated area (fig. 1b). Or it may have been

Figure 1. *Plans of the outermost part of Gough's Cave brought to approximately the same scale. a) Davies 1904, fig 1. Scale unknown (the stated scale is wrong). The diagonal ruling indicates areas left unexcavated by the Goughs. b) Parry 1929. The diagonal ruling indicates areas excavated in 1927-28. c) Parry 1931. Dates of excavation of different areas by Parry are indicated. d) Survey made for Cheddar Caves in 1935. A - E are the areas excavated in the 1950s and reported by Donovan (1955). G shows the position of the section seen in 1989 (Fig. 2 of this paper). H is the section partly illustrated by Donovan (1972, fig. 16, upper section). J is the approximate site of the section illustrated by Tratman (1972, fig. 15). K is the section shown by Donovan (1972, fig/ 16, lower section).*

generalised. Although later he appears to have excavated extensively he gave no further information about the deposits, except to write (1931, p. 46) that 'We may take the stratification there shown [i.e. in 1929b] as being constant throughout the whole excavation.' His 1929 section showed rock floor about 2.3 m (recorded as 15 6-inch layers) below path level. This was the path that existed when excavations were made in the 1950s (Donovan, 1955), Parry (1929a) recorded that in the 1929-30 season rock floor was reached at three places, two at 4.27 m and one at 4.42 m [below the original surface of the deposits]. The positions of these soundings was not recorded.

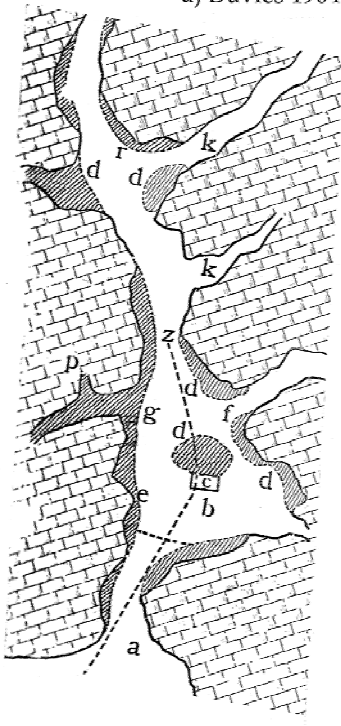
It is probably impossible now to reconstruct the areas excavated in detail. The areas and depths dug by the Goughs are unknown. Parry in his diagram (1931, fig. 1) does not take account of them. Hence my attempt to show the areas excavated (Donovan, 1955, fig. 12), based on Parry and my own observations, cannot be very accurate. If the present paper is full of ifs and buts and alternative explanations, this is because of the inadequacy of the surviving information.

Parry's failure to record and publish the details of his excavations, and further sections through the deposits, was a major tragedy for Somerset archaeology, given the importance of the site which must even then have been apparent. The local standard was not high: at Glastonbury Abbey the excavator, F. Bligh Bond had been dismissed in 1922 following his claim to be guided by automatic writing and spirits (Rahtz and Watts, 2003). At least the supernatural did not intervene at Gough's Cave, so far as we know. When I wrote my 1955 paper I was somewhat critical of Davies (1904) for not recording in more detail. Re-study of his work has increased my appreciation of what he was able to do, while the inadequacies of those involved in 1927-1931 have been forced upon me.

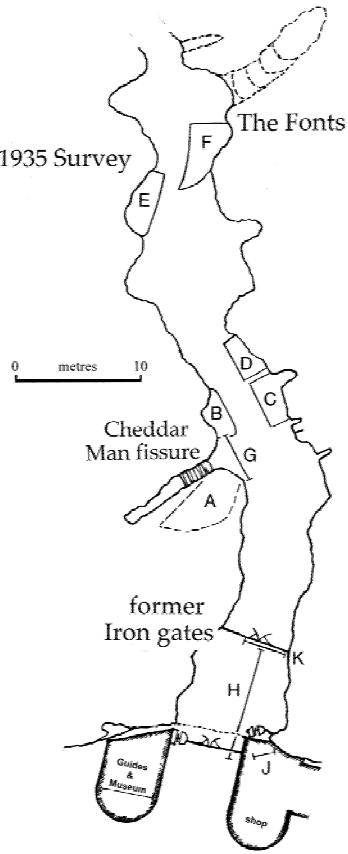
Parry's method of excavation (which was actually done by the cave guides during the slack winter periods) was to remove the deposit in 6-inch spits. Finds were labelled with the number of the spit or layer. However, it becomes apparent that there are serious deficiencies in the recording which makes the layer numbers of very limited usefulness.

I attempted to decipher the stratigraphy of the deposits in the cave, inadequately recorded by previous excavators (Donovan 1955). The present paper reassesses the stratigraphy in the light of evidence obtained since 1955. The result is bound to be unsatisfactory because so little of the deposits has been properly studied and recorded. Even more uncertain is the attempt to account for the origin of the sediments. Studies of sedimentology and pedology by Collcutt (1985) and by Macphail and Goldberg (2003) are very useful but they only had access to a small number of samples, and none from the areas which yielded the bulk of the finds.

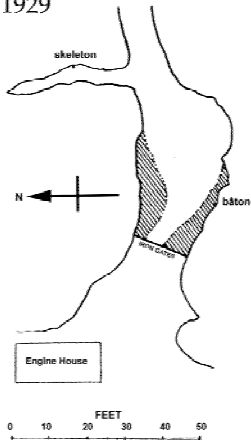
a) Davies 1904



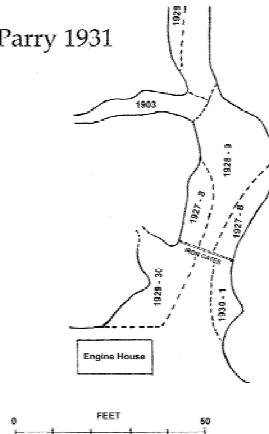
d) 1935 Survey



b) Parry 1929



c) Parry 1931



NEW INFORMATION SINCE 1955

Gough had lowered the floor of the cave at the entrance only enough to give reasonable clearance for human beings, so that visitors climbed steps up from the road and then walked downhill into the cave, as shown in Figure 3. In 1957 it was decided to make a level entrance into the cave. The present bridge over the entrance represents the original level. A section through the Creswellian Cave Earth was revealed which was partially published by Donovan (1972). Complete information has been incorporated in Figure 3.

I think that the lowering of the path here was dug by hand, but I am not certain. If so, it is odd that no finds were reported from my section or the one recorded by Tratman (1972, fig. 14).

In 1959 the cave floor between the location of the (former) iron gates and the Fonts was lowered by about 0.6 m, rather more at the Cheddar Man fissure. Information has been incorporated in the present account.

In 1968 alterations were made to the building on the south side of the cave entrance. Among other things human remains were recovered from a post-palaeolithic context. Another section through the Creswellian Cave Earth and Breccia was exposed and recorded by Tratman (1972, fig. 15) and the present writer (unpublished). Tratman recorded cave earth resting on the rock floor. The basal layer was an almost stone-free clayey silt. There followed layers of clayey sand (16 cm) succeeded by sandy clay with increasing amounts of limestone fragments, the top part being recorded as 'masses of shattered limestone boulders' by Tratman. The total thickness exposed was about 2.5 m, but it is not clear how much of this was Creswellian Cave Earth. Tratman's section shows an apparent dip towards the south or south-east.

In 1986 a small excavation west of Cheddar Man fissure and adjacent to the north wall of the cave was begun by R M Jacobi, and partially reported by Currant, Jacobi and Stringer (1989). The work was continued under the auspices of the Natural History Museum until 1992, resulting in important finds including a third *bâton*. These excavations were briefly mentioned by Stringer (2000) but have not been fully reported.

In 1989 further changes were made to the arrangements for viewing Cheddar Man fissure and a section was exposed near its mouth (Figure 3). This is here referred to as section G in continuation of sections A – F recorded in 1955. The section proved about 1 metre thickness of the Conglomerate and small thicknesses of deposit below and above. Sedimentological features are recorded below under the respective units. Lowering of floor level in 1957 had revealed a very large limestone boulder at the western end of the section.

About 1990-1991 a hole was dug by the guides against the south wall of the cave about 27 m inside the present gates, i.e. about 16 m from the cave mouth. It is still partly open. No useful section can be seen beneath the concrete floor. As far as is known there is no record and no finds were made (information partly from A.R Farrant).

FLOODING OF GOUGH'S CAVE

Some of the deposits described below are attributed to periodic flooding of the cave, hence a brief account is given here. Stanton (1986) wrote '... after exceptionally heavy rain, Gough's Cave becomes a resurgence.' Because the cave slopes downwards from the entrance to a lowest point at the Fonts, about 50 m from the entrance, flood water drains internally to the lower-level water-filled passages (Farrant, 1991).

The earliest mention of flooding is by Skinner (MS, 1816, quoted by Irwin 1986) reporting ‘.. the guides, who say, in Winter, there is so much water in the cave, they cannot enter it’ which suggests long-term winter flooding. Davies (1904, 339) describing the situation that caused the Goughs to excavate Cheddar Man Fissure in 1903, merely writes that ‘the chambers and passage were often flooded’. Parry (1930, 26) referred to the ‘recent great flood’ of the winter 1929-30. He does not give details but evidently the water remained for long enough for sediment to settle. Parry measured the thickness of the deposit left behind and found that it varied from 3.2 mm (recorded as 1/8 inch) to 22.2 mm (recorded as 7/8 inch), the thickest deposit being where the water had been deepest.

In recent years the cave has flooded on average once or twice a year. About every five to ten years the water level has been high enough to flow out past the entrance turnstiles, as it did in 1981, 1985, 1995 and 2000. Major floods persist for up to 48 hours, and in the case of the 1968 flood (see below) for 3 days. The floods leave a deposit of muddy, sandy silt (A R Farrant, *pers. comm.*).

However, Stanton (1986) wrote ‘Possibly the flooding is a recent phenomenon caused by the several dams that have been built between the resurgence and Cox’s Cave within the last three or four hundred years, which must have raised the underground water levels by several metres.’

Under the present climatic regime, every few decades when exceptionally heavy rain falls in the area, the underground drainage is overloaded and a stream briefly flows down Cheddar Gorge (1927, 1968; Hanwell & Newson 1970).

STRATIGRAPHY

There is no recognised convention for the formal naming of sedimentary units in caves in Britain. In the present case one referee has commented that ‘Main Sands’ is not very informative and that ‘Cave Earth’ could cover almost anything. I agree, but have decided to keep existing names as far as possible for the sake of consistency.

The following sequence is now recognised:

Upper Cave Earth (new)
 Stalagmite (Davies, 1904)
 Creswellian Cave Earth & Breccia (Donovan 1955)
 Conglomerate (Donovan 1955)
 Main Sands (new)

The Main Sands

This name is introduced here for the sediments beneath the Conglomerate. The unit can only be recognised with certainty where the Conglomerate is present. It has been seen only in excavations B, C and D reported by Donovan (1955), over a distance from about 25 m to 33 m from the mouth of the cave, and section G seen in 1989 (Figure 2). It was absent nearer the cave mouth where the Conglomerate is separated from the rock floor only by 15 cm of ‘clayey red loam and sand’ (Parry 1929a, b). Parry’s excavations must have found the Main Sands as they extended further into the cave, but there is no mention in the very brief later reports (Parry, 1930, 1931).

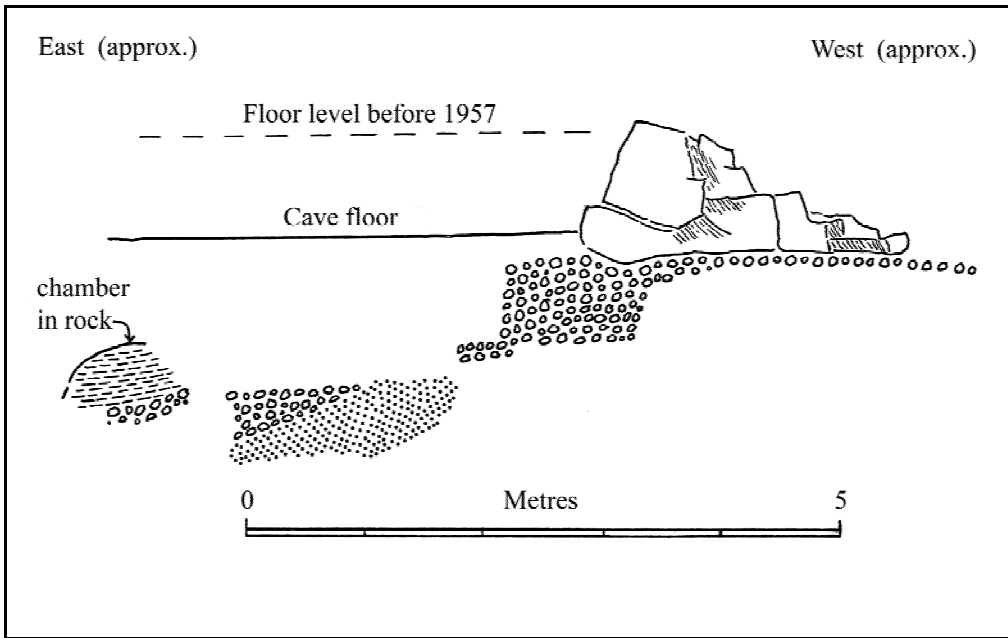


Figure 2. Section of deposits exposed west of Cheddar Man fissure, 1989. Drawn as seen looking south. Note the details have been reversed on figure 3 which is drawn as if looking north. Symbols for sediments as in figure 3. Vertical and horizontal scales are the same.

A maximum (incomplete) thickness of about 3 m was proved in excavation D. The lower member here was about 0.9 m (seen) of coarse red sand, with a modal grain size of about 0.5 mm. It was well sorted, silt and clay fractions being only 2.9% of the total. This was succeeded with an abrupt junction by laminated sand with the majority of grains between 0.02 and 0.2 mm diameter (Mackney in Donovan 1955, Appendix ii, pp. 103-104).

The only information additional to that in Donovan (1955) is from section G near the Cheddar Man Fissure. About 0.7 m of sand was seen immediately below the Conglomerate. Dr John Cater who visited the cave with me noted ‘sands and gravels with abundant cut and fill scours’. The bedding is mainly erosive-based trough cross bedding. Dr Cater concluded from the present attitude of the cross bedding that the whole outcrop (and presumably the overlying Conglomerate) had been tilted down towards the Cheddar Man fissure by c. 15°. This was presumably due to subsidence into the fissure.

In contrast to these more recent observations the bedding noted by me (1955) was mainly horizontal. However, I did record in exposure B that ‘The bedding was approximately horizontal except in the uppermost layers, which showed minor contortions probably due to differential compaction.’ To my untutored eye these ‘contortions’ could equally well have been sedimentary structures of the kind noted by Dr Cater.

Petrological examination by Donald Mackney showed that a minor constituent of the coarse sand was fragments of silicified fossils derived from the Carboniferous Limestone. However, the dominant constituent of the Main Sands is quartz sand. The only credible source of this is the Portishead Formation (formerly Upper Old Red Sandstone) which outcrops in the core of the Blackdown anticline. This was shown by an adit at Burrington to comprise

lithologies ranging in grain size from conglomerate to shale (Hepworth and Stride, 1950). The Maesbury and Ellick soils are largely derived from the Portishead Formation, the dominant constituent recorded as loam or sandy loam (Findlay, 1965). Surface transport via the (now) dry valleys and Cheddar Gorge is improbable, and is likely that the sediment was transported through the cave systems. Three major swallet caves, GB Cave, Longwood Swallet and Manor Farm Swallet lie due south of the Portishead Formation outcrop of Blackdown and were feeders to the Cheddar springs (Stanton, 1977). There is the remains of a sandy fill to the swallet entrance of the GB Cave stream, and abundant sediments derived from the Portishead Formation are present in GB Cave (Ford, 1964) and Longwood Swallet.

Dr Cater noted thin (1 mm) short (3 – 4 cm) wood fragments which he thought must have come in from outside the cave.

The Main Sands is interpreted as a stream deposit of the time when Gough's Cave fed an active resurgence. Stanton (1965) located the main feeder to the Gough's system in the terminal Boulder Chamber where excavation (for an extension to the cave which did not materialise) revealed laminated silty clay, a presumed flood deposit, penetrated by a channel filled with sand and coarser clastic material which had evidently been the route by which water entered under pressure from below. The Boulder Chamber is the terminal chamber of the known air-filled cave and lies about 300 m, measured along the cave passage, from the entrance. The water evidently left the Boulder Chamber by the 'western creep' (Stanton, 1965, dig 5) where coarse sand overlying laminated silt and clay showed cross bedding indicating westward flow. Subsequently Farrant (1991) has identified several additional inlets.

The abrupt change, in excavation D (Donovan, 1955, 81, 82), from coarse sand to laminated sand indicates a reduction in stream power. Could this have been when the cave ceased to be the main resurgence? The sedimentary structures noted in the top 0.7 m at section G (and possibly B) indicate a return to higher-energy conditions. They mark the final phase in the long history of sediment transport through the cave in the Last Interglacial (Stanton, 1986). The absence of this phase in excavations C and D is due to the uneven erosion of the sands by the overlying Conglomerate.

The Conglomerate

The Conglomerate consists of rounded pebbles of Carboniferous Limestone with a small amount of sandstone from the Portishead Formation. In the exposures seen by me in the 1950s (Donovan, 1955) the pebbles were mostly about 2.5 cm (recorded as one inch) in diameter, and seldom more than 7.5 cm (recorded as three inches). John Cater who saw exposure G (Figure 2) in 1989 wrote that 'The distance of transport was sufficient to produce well-rounded edges but not to break platy and irregular-shaped cobbles into higher-sphericity clasts.' The deposit is clast-supported with sandy matrix, and Cater thought that "the sandy matrix was most likely introduced by sieving down from above. No great length of time need be postulated between deposition of the framework and infiltration of the matrix; it could have been a more or less continuous process."

In section G the Conglomerate was seen to have an erosive base, and in excavations B, C and D recorded in 1955 the base was sharp, with a relief of at least half a metre due to erosion of the underlying Main Sands.

In section G overlying the Conglomerate John Cater noted "moderately well-sorted granule-grade [i.e. 2 – 4 mm] sandy gravels interbedded with better-sorted silty fine [sand] ... bedding is on a mm-scale, consisting of graded cross beds grouped into sets with erosive set bases. The bedding is mainly erosive-based trough cross-bedding. Some crude larger-scale

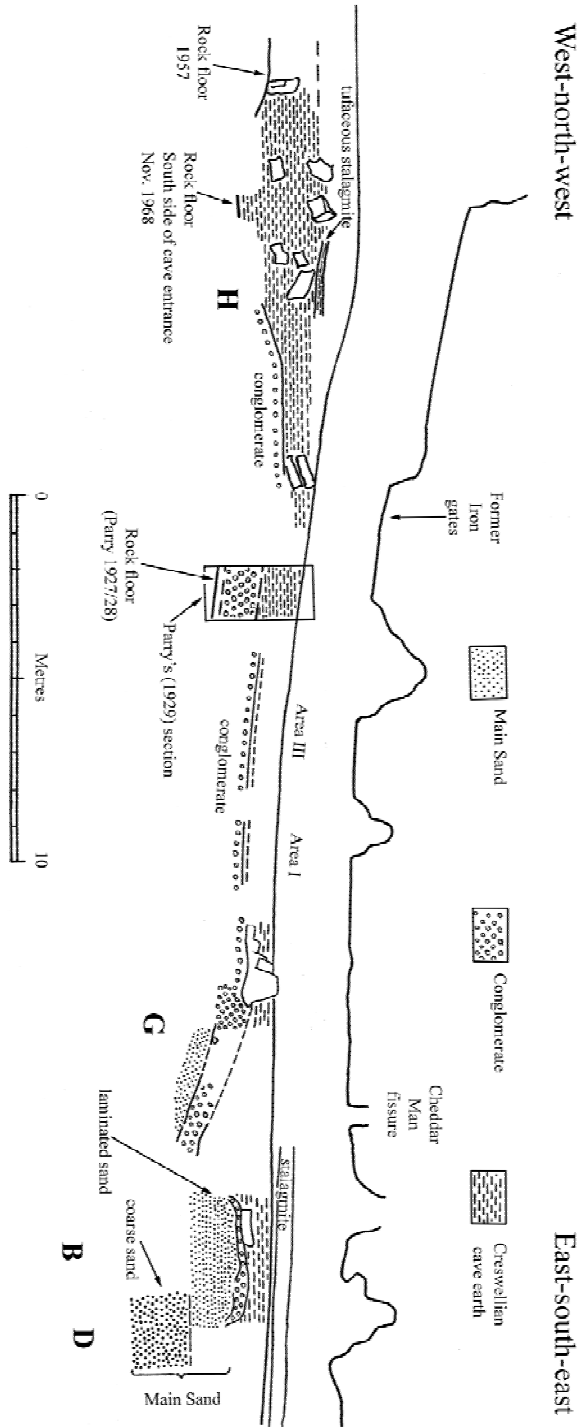


Figure 3. Longitudinal section of Gough's cave showing the sedimentary units discussed in the present paper. The cave floor is shown as it existed before the alterations of 1957, and is based on levels surveyed in 1951. The present cave floor is not shown. Bold capitals B, D G and H refer to sections the positions of which are indicated on Figure 1d.. Vertical and horizontal scales are the same.

fining-upward sequences are present, comprising all or part of a single cross-set. Tabular cross-bedding is also present. Many of the erosion surfaces are deep (c. 5 cm) steep-sided scours with the cross beds draping the sides (i.e. typical cut-and-fill structures). The sand/gravel sequence passes sharply up from the underlying pebble-and-cobble Conglomerate.”

The exposure described in the last paragraph recalls the fact that Davies in his sections of the deposits in the Cheddar Man fissure (1904, fig. 4, 5) draws his “bed of sand and pebbles ...” resting on rock floor with the pebbles below and the sand above. Total thickness in the fissure was 20 to 30 cm. Davies (1904, p. 340) noted that “The deposits of the main cavern passed into [the Cheddar Man fissure] without break.” It is probable that the sand seen at the eastern end of section G should be grouped with the Conglomerate rather than with the Creswellian Cave Earth.

We can for the first time, in the new longitudinal section (Figure 3), see the extent of the Conglomerate. The section exposed at the entrance to the cave in 1957 showed cave earth/breccia resting on Conglomerate from the (former) iron gates westwards for 4.4 m. At this point the Conglomerate disappeared below the base of the exposed section. A further 5.5 m to the west Creswellian Cave Earth was seen resting on rock floor (this was not shown in my section published in 1972). The westward limit of the Conglomerate therefore lies between these two points. The eastward limit was seen in sections B, C and D of Donovan (1955, figs. 13-15), where the Conglomerate is represented by discontinuous fragments. Although the outcrop could have been modified after deposition, this is not very likely on any scale on account of the large particle size. I believed that the extant distribution essentially represents the original depositional form.

The east-west length of the Conglomerate is about 30 m. The greatest recorded thickness was about 1.07 m (recorded as 3 ft 6 ins. but measured only to the nearest 6 in) recorded by Parry (1929b) somewhere inside the former iron gates. However, Parry (1929b) also noted that the gravel (i.e. the Conglomerate) was ‘slightly thicker’ in the central part of the cave dug in the autumn of 1928. The thickness was about 1 m in the disturbed section G seen in 1989 at the entrance to the Cheddar Man fissure.

The Conglomerate is clearly a high energy deposit. Stanton (1986, 127) thought that the Conglomerate marks the stage when the cave was opened to the Gorge, “somewhere between the present entrance and Cox’s Cave. A mass of coarse stream-borne debris would have entered the cave through the hole in its roof and formed a lenticular deposit thinning out up and down the passage.” This was also suggested by John Cater (*in litt.* 12 Sept. 1989) who interpreted the Conglomerate “as of fluvial channel origin. A major increase in flow power eroded away part of the underlying sand unit and brought in coarse clasts from outside the cave.”

The apparent lack of internal stratification could indicate that the Conglomerate was a debris flow. However so little of it has been seen that this is not a safe conclusion.

An alternative view is put forward by Macphail and Goldberg (2003, p. 53, 54) who wrote that ‘the formation of the Conglomerate can perhaps be best related to cryoclastic activity and high energy phreatic flow occurring near the last glacial maximum.’ A R Farrant makes the same suggestion, writing that the Conglomerate may have been ‘formed by the *in-situ* rounding of frost shattered debris from the cave roof close to the entrance by water resurging out of the cave mouth, either during flood events or following an amelioration of the climate and reactivation of underground drainage.’

In the absence of better evidence the matter remains in doubt. The presence of sandstone (Portishead Formation) pebbles is a difficulty for the *in situ* origin, as is (to my mind) the erosional base of the deposit. On the other hand the fact that the Conglomerate wedges out

just inside the present cave mouth appears to be against an external origin, which might produce a deposit extending inwards from the former cave mouth some distance west of the present one. On balance I favour an external origin. It may be noted that remains of a similar deposit appear to have been found, in a similar stratigraphical position, in Aveline's Hole, Burrington Combe (Donovan, 2005), on the north side of the Mendips.

Finds in the Conglomerate

The 1927-28 excavations at the sides of the cave yielded 20 flint artefacts from the Conglomerate, and the total from all of Parry's digs was 75 (Jacobi 2004 fig. 4). Jacobi is inclined to accept Parry's idea that these finds were not originally in the Conglomerate but were carried down [from the Creswellian Cave Earth] by retreating water after floods, close to the walls of the cave; none were found in the digs in the central part of the cave (Parry, 1931). However, the record of almost half the total number (36) in the topmost 6-inch layer of the Conglomerate suggests that faulty recording was also a factor, the diggers failing always to recognise the boundary between Conglomerate and cave earth.

The Cave Earths

Parry (1929b, section between pp 104 & 105) recorded 2.44 m (recorded as 16 6-inch layers) of cave earth. The upper part of his section contained Early Iron Age and later material, the lower part yielded Upper Palaeolithic flints. It is not possible to draw a dividing line in Parry's section because layers 7, 8 and 9 yielded both Early Iron Age finds and Palaeolithic flints. The zone of overlap was between just over 15 cm (6 inches) and 45.7 cm (18 inches) thick. The most likely explanation is that the six-inch layers by which finds were recorded did not exactly follow the stratification. Over the length of about 9 m which Parry excavated in 1927-28 a divergence of the layers from the stratification by about two degrees would be enough to create this error. If the EIA finds were indigenous there must be a major stratigraphical gap between the two parts which are here referred to as the Creswellian Cave Earth and the Upper Cave Earth. This problem is further discussed below.

The Creswellian Cave Earth and Breccia

Davies (1904) described the Creswellian Cave Earth and Breccia as "a deposit of reddish mud from 3 to 8 feet deep, containing angular masses of limestone, large and small, which have ... fallen from the roof; and boulders of the same rock, well-rounded at the edges, evidently transported by flood-waters." Both he and Parry noted that stratification was often evident, Parry writing that "... it has a laminated appearance caused by alternating bands of cave earth and sand."

Donald Mackney did a grain size analysis of the Cave Earth from excavation D of Donovan 1955 (D 1955 p. 103):

Coarse sand (2.0-0.2 mm)	7.25%
Fine sand (0.2-0.02 mm)	45.5%
Silt (0.2-0.002 mm)	15.3%
Clay (<0.002 mm)	20.1%
total	88.2%

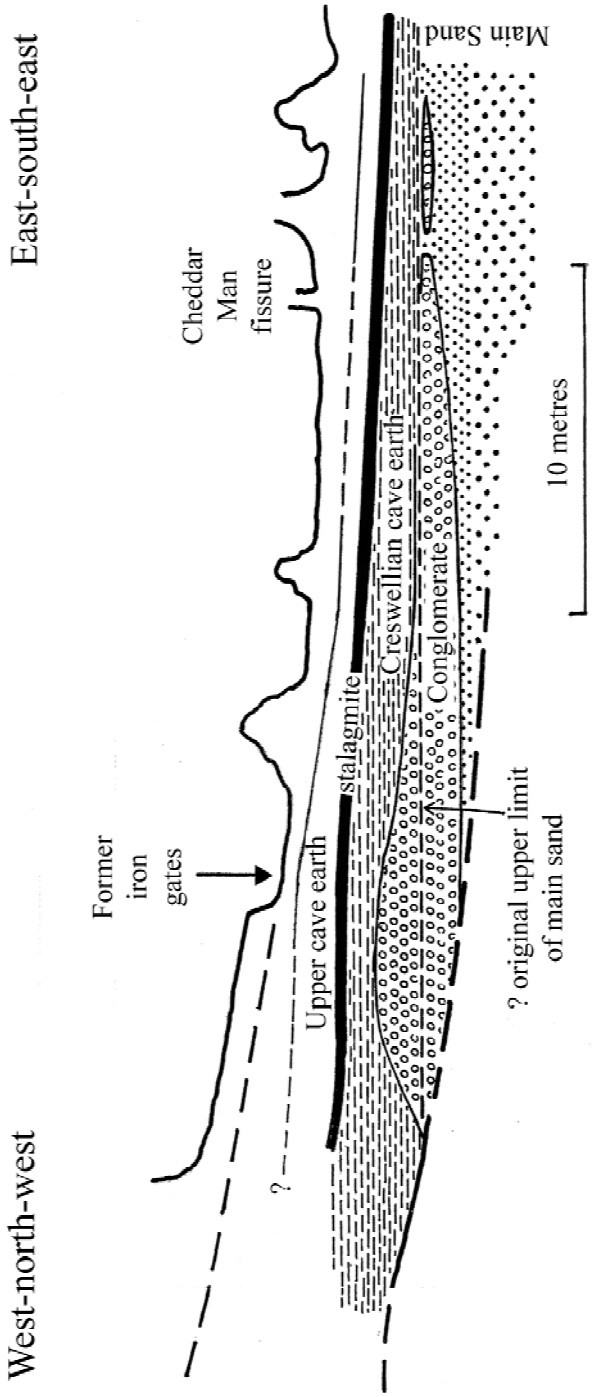


Figure 4. *Attempted reconstruction of the Quaternary sedimentary units before excavation. Later cave floor levels are not shown. Vertical and horizontal scales are the same.*

This was a bulk sample so that it is possible that layers of different grain sizes were mixed together. Collcutt (1985) also studied samples from the 1950s excavation and wrote that the sediment can be described as a badly sorted silty sand.

A few metres north-west of this exposure the Creswellian Cave Earth was exposed, resting on Conglomerate, in excavations I and III of Jacobi and the Natural History Museum. Macphail and Goldberg (2003, fig. 1) published a photograph of a vertical section of the Creswellian Cave Earth. Microscopic examination showed the section in excavation I has particles of dominantly silt to fine sand size of angular quartz, with frequent bands of fine, medium and coarse quartz sand. They found very coarse sand dominant in some layers. Limestone, calcite and clay granules were also present. The stratification was horizontal. Both Collcutt and Macphail and Goldberg note the presence of Carboniferous Limestone fragments of local origin.

The summary above refers only to the clastic components of the Creswellian Cave Earth. Collcutt (1985) and Macphail and Goldberg (2003) describe extensive modification of the original fabric by pedogenic processes, and cementation by calcium carbonate.

Jacobi (2004, 8) has summarised earlier views on the origin of the Creswellian Cave Earth. It is here attributed primarily to periodic flooding. Parry (1929b) observed that the sand increased with depth, and upward decrease of sand would agree with progressive reduction of 'overflow' events as the channels below Gough's developed. However, the cause could alternatively have been climatic.

The Creswellian Cave Earth includes angular pieces of limestone, the proportion ranging from very small to an amount where the rock becomes a breccia, as seen in excavation B and C of the 1950s (Donovan, 1955). I noted then that small limestone fragments tended to fill the spaces between larger ones. There is now too little information on the distribution of the breccia phase to support any significant comment. Breccia died out rapidly eastwards between excavations C and D (Donovan, 1955 figs. 14 and 15), about 30 m from the present entrance.

Davies (1904) also noted "boulders of the [limestone], well-rounded at the edges, evidently transported by flood-waters" but I have not seen any such myself.

Large boulders of limestone are also found, and some of these rest on the Conglomerate and so are contemporary with (or predate?) the commencement of accumulation of cave earth. A few of these are indicated in Figure 3. The largest seen by the writer is the one at the western end of the entrance to Cheddar Man fissure. Davies (1904, fig. 4) in his section of the deposits in the fissure shows three boulders within the cave earth, each at least 60 cm in its greatest dimension.

Creswellian occupation

In the absence of proper records it is not possible to know the relationship of the Creswellian occupation to the stratification of the Cave Earth. Parry recorded flints from ten of his six-inch layers (leaving aside the smaller number recorded from the Conglomerate, discussed above). The distribution of the final count of artefacts is shown by Jacobi (2004, fig. 4). Jacobi (2004, 10) raised the possibility that there was in fact only a thin occupation layer 'whose small scale topographic irregularities has led to attribution of parts to different layers'. However, more than small topographic irregularities seem to be needed if this was the case. It is clear that the major stratigraphical units dip inwards from the entrance to the cave (Figure 4), but if stratification within the Cave Earth was more nearly horizontal, as was recorded for Area I (but over a very small area) then there would have been a discordance between it and the

layers by which the excavation was progressed, which were apparently parallel to the cave floor at the time.

Radiocarbon ages for human bones and humanly modified animal bones span about 1500 ^{14}C years (Jacobi, 2004, Table 29). This is not a precise figure due to the possible errors of age determinations, but a span of less than 1200 years is unlikely. The radiocarbon ages are evenly distributed throughout the time span. If the modal class (layer 13) in Jacobi's (2004, fig. 4) distribution of Creswellian artefacts by recorded layers has any significance, the peak of occurrence was a little below halfway up the section. Probably, the flints were collected over too wide an area for the distribution by layers to be significant.

There is one clue: Davies (1904, 229; figs. 1, 2) recorded a limestone block surrounded by a large number of flint flakes, with some also on its upper surface. It was said to rest on 'an old surface in the cave earth' about 1.07 m below the stalagmite. As noted above, Parry's (1929b) section does not tell us the exact thickness of the Creswellian Cave Earth, but it may have been about 1.3 m. Thus Davies' 'old surface' would have been near the bottom of the cave earth. His longitudinal section (Davies 1904, fig. 2) shows it a bit less than half way up. The block has long since disappeared. It was not mentioned by Parry. There is no independent evidence as to the dating of the Creswellian Cave Earth but it is likely to represent a much longer span than 1500 years. Davies' evidence suggests that the occupation took place during the earlier part of its accumulation.

Jacobi (2004, 73) has discussed the Gough's sequence in the light of the environmental record at Llanilid in South Wales (Walker *et al.* 2003). Walker *et al.* found a major warm episode (c. 20° maximum temperature) early in the Postglacial Interstadial. Difficulties arise in correlating with the Quaternary time scale because of uncertainty in calibrating the ^{14}C ages, i.e. converting them to actual, calendar dates. However ^{14}C ages near the base of the Llanilid section, when temperature was just rising to the maximum, are 13 200 ± 75 BP (at 5 cm above base of section) and 11 480 ± 100 BP (at 24 cm) near the end of the warm spell. Given the dependence of ^{14}C dating on the chance occurrence of material suitable for analysis, these ages agree remarkably well with the earliest and latest ages for the Creswellian occupation at Gough's, namely 12 940 ± 140 and 11 480 ± 90.

Ages for the warm episode at Llanilid are rather widely spaced so one must not make too much of this coincidence. As the Cave Earth at Gough's accumulated by repeated flooding the occupation cannot have been literally continuous. However, Jacobi (2004, 73, 74) also notes low atmospheric moisture, and possibly low rainfall, from the Llanilid evidence during the warm episode, in which case flooding at Gough's may have been rare, allowing nearly continuous occupation and resulting in a concentrated deposit.

Stalagmite (the upper stalagmite of Davies 1904)

This is now seen only as traces on the cave walls. Davies (1904 p. 338) described it as follows: "The deposit is chalky, soft, and laminated, the average thickness of the laminae being 0.08 inch, and that of the whole mass from 5 to 12 inches. There is a considerable mixture of fine sand with the calcareous matter, the residue, after treatment with strong acid, being nearly 40 per cent. of the weight tested." This description agrees well enough with the traces that can now be seen, the calcareous laminae remarked on by Davies being separated by layers of sediment which may be thicker than the laminae themselves. The late Victor Painter described it to me as alternating layers of thin stalagmite and pure clay. My notes repeatedly refer to papery laminae.

At the 1950s excavation F, about 50 m from the cave mouth, I noted that the stalagmite laminae were thicker and more crystalline at the east end, becoming thinner and more papery at the west end, over a distance of 4 or 5 m.

Davies' longitudinal section (1904 fig. 2) shows the stalagmite as continuous from about 10 m inside the cave mouth (the figure has no scale) to east of the Cheddar Man fissure. Victor Painter told me that it formerly extended as far as The Fonts, i.e. about another 27 m eastwards.

Davies also wrote "The upper stalagmite-bed covers the cave-earth as a continuous sheet." At both ends of its extent it is shown in Davies' section as meeting the cave roof, which is clearly wrong. Presumably Davies had to make what he could of the inadequate information at his disposal. The implication of his work is that the stalagmite had been completely removed from the area of the path that Gough had cut through the deposits, but remained in the banks of sediment that Gough left against the cave walls (see Figure 1a). However Parry, who removed and supposedly excavated these banks, makes no mention of stalagmite (Parry 1929, 1931). I cannot explain this.

The calcareous laminae are thin (< 1 mm) and often papery in texture. They are probably best described as crusts. Hill and Forti (1986, p. 29) write "Coatings and crusts are one and the same speleothem type, only coatings usually form on cave walls while crusts usually form on clastic floor sediment." They divide them into subaerial and subaqueous. One possibility is that a flood deposited the sediment, and after it had settled, the remaining water became super-saturated for CaCO₃ and the crust was precipitated.

Precipitation seems likely to be at the water surface where CO₂ loss occurs. Holland *et al.* (1964, p. 56) described from a pool known as the Queen's Bath, Luray Caverns (Virginia, USA), a water surface deposit of CaCO₃, presumably supported by surface tension. Here and in other pools there were flakes on the bottom, presumably from a surface deposit that foundered when it got too heavy. These pools were fed by drip from stalactites so water circulation was presumably very slow. But the Gough's crusts are continuous, not broken into flakes, so that deposition may have been in fact at the water bottom. These floods must have remained for long enough for the carbonate crust to be precipitated. This necessitates that the water came from the cave system (as in the case of the other floods) in order for it to be saturated with carbonate. We have, perhaps, to think of seasonal flooding which remained for part of the year.

An alternative suggested by A R Farrant (*pers. comm.*) is that the heavy drip near the entrance may have deposited a thin layer of calcium carbonate across the width of the cave passage between flood episodes. The slope of the cave floor would cause the water from the drip to flow inwards. It seemed uncertain to me whether this source of water alone could have been sufficient to deposit carbonate over a distance of 50 m or so, but G.J. Mullan (*pers. comm.*) has described a similar situation in the cave of Lascaux, where a heavy drip close to the entrance has deposited a substantial layer of calcium carbonate over at least 40 m of the cave's floor.

According to Davies (1904, fig. 4) the stalagmite sealed the Cheddar Man burial, which means that deposition did not start until about 9000 ¹⁴C years BP or later.

Upper Cave Earth

Hardly anything can be said about this. So far as is known no Upper Cave Earth remains in place in the main cave. Davies (1904) regarded it as 'Recent superficial accumulation' above his upper stalagmite and did not describe it. It is shown in Davies' figure 2 but the vertical scale of the figure is not given. Thickness as shown was perhaps about 0.75 m. As

noted above, Parry's cave earth cannot be clearly divided because he did not record the stalagmite, but he seems to have regarded the deposits then remaining above path level (said to be 1.37 m) as post-palaeolithic. He recorded the top five layers (i.e. 0.75 m) as 'Reddish clayey cave earth with small angular limestones', and the part below this as similar, 'with sand'. The disappearance of sand in the top layers would be consistent with diminishing rate of the flow which led to the flooding.

Gray (1929, 1931) described the finds. They have not been restudied in recent years except for a review of Romano-British finds in Cheddar Gorge by Branigan and Dearne (1991). Gray recorded Early Iron Age pottery including Glastonbury ware as found in the Somerset lake villages, and Romano-British pottery. The material was sparse, never more than a few shards from a layer. The impression given by Parry's and Gray's accounts is that the Upper Cave Earth is of Early Iron Age and Romano-British date, but I believe that this is misleading. This is discussed further below.

The missing years

Not the least of the puzzles of Gough's Cave stratigraphy is the almost complete absence of artefacts, and presumably deposits, of the Mesolithic, Neolithic and Bronze Age cultures, which together spanned over 7000 years. In contrast the Creswellian occupation lasted perhaps 1500 years – deposition of the Creswellian Cave Earth somewhat longer – and the Early Iron Age and later deposits 2500 years at most (but see below). There are in fact five flint artefacts which Jacobi (2004, 13) identifies as Mesolithic microliths, 'all early forms', compared with 2202 Creswellian flint tools. The 'oldest' microlith was recorded from layer 14, one below the layer (13) with the most recorded flints, and the 'youngest' from layer 7 along with Romano-British pottery and 11 Creswellian artefacts. As with the Creswellian, failure of the excavators to keep their layers parallel to the stratification seems the likeliest explanation of this spread.

Davies (1904, 337) wrote that "From the talus at the base of the cliffs, which rose high enough almost to block the entrance to the cavern, a bronze celt of the plainest type and a looped lance-head of later date have been taken, which seems to indicate that the cavern had become choked before the Bronze Age." Cheddar Man is now regarded as a burial, so at the time of his interment, about 9000 ¹⁴C years BP (i.e. early Mesolithic), there must have been enough head room to allow access (Tratman, 1975).

If the cave was reserved as a Mesolithic burial site that would explain the rarity of artefacts of this date. It may be that the burial was intentionally in a location difficult of access, nevertheless minimum headroom of about one metre seems likely. Before the Goughs began clearance the cave entrance was 0.6 m high (Davies, 1904, 337), and there was 'a low creep' leading inside (Balch 1935, 39). The obvious conclusion is that deposition by flooding continued, perhaps more slowly as fewer and fewer floods reached the surface level of the deposits, and that during Neolithic and Bronze Age times, if not already in the Mesolithic, the cave was too low to invite occupation.

This interpretation is at odds with the Early Iron Age and Romano-British occupations apparently recorded by Parry. As noted above, the Early Iron Age and Romano-British finds were few. It is possible that any occupation of these dates was at the cave mouth only, and that a few objects rolled down, were thrown or otherwise found themselves in the interior which was already (as Davies thought) too low to be entered. Distribution of EIA and RB material down to layer 9 would seem to be against this hypothesis, but given the evident inconsistencies

of the recording could be due to incompetence. Burrowing animals, especially badgers, are a further possibility.¹

Recession of the cave mouth

The section seen in 1957 showed Creswellian Cave Earth to extend at least 3.5 m west of the present cave entrance, to a thickness of at least 1.5 m, while 2.5 m of undivided cave earth were recorded by Tratman (1972, fig. 15) just outside the cave mouth. If the cave earths were flood deposits they must have accumulated inside the cave. During Creswellian times the entrance was, therefore, at least a few metres west of its present site. There is no way of estimating the original extent of the cave.

CHRONOLOGY

The Main Sands: it is tempting to attribute the coarse sand to the Last Interglacial when underground drainage was fully functional. It has been suggested above that the change to laminated sand occurred when the present, lower resurgence came into operation. The interception of this phreatic channel by erosion of the thalweg could have been a matter of chance unconnected with any climatic episode, although it is also possible that it took place during a period of enhanced downcutting such as might have occurred during a cold phase.

If the Conglomerate was deposited when the underground drainage was not in operation, this was presumably during the last glaciation. There is no clue as to the length of time represented by the Conglomerate. Could it have been deposited in one catastrophic episode? Probably not. If the Main Sands belong to the Last Interglacial (see below), the Conglomerate, with a maximum thickness of not much more than a metre, seems a poor representation of the Devensian glaciation. But if the Gorge thalweg already lay below the mouth of the cave, so that most of the debris carried down went on to form the Cheddar alluvial fan (Clayden and Findlay 1960), this dating might be possible.

The Creswellian Cave Earth began to accumulate at or before about 13 000 ¹⁴C years BP, according to the earliest ages for the Creswellian occupation. This can be equated with the beginning of the Windermere Interstadial, or the Bølling, at about 13 000 ¹⁴C years BP.

The Creswellian occupation ended with a spell of deteriorating temperature as the Younger Dryas approached. The deposition of the stalagmite began not earlier than about 9000 ¹⁴C years BP, the approximate age of the Cheddar Man burial.

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¹ No Bronze Age pottery has been recognised in Gough's Cave. However Late Bronze Age pottery, with locally characteristic calcite temper, was present in the Second Hearth in Gough's Old Cave, some 60 m to the south (Tratman, 1960, p.19, fig. 4, 1-6), though then misidentified as Iron Age by ApSimon. It is perhaps possible that the three 'coarse, gritty' Iron Age sherds from Parry's *Layer 9* (Gray, 1931, p. 57) may also really be Late Bronze Age (A.M. ApSimon, *pers. comm.*).

information. Finally, I wish to remember two people who helped me many years ago: Kenneth Oakley who asked me to study the stratigraphy and was encouraging throughout; and Gerald Robertson, manager of the caves until his tragic death in an air crash in the 1960s.

REFERENCES

- ATKINSON, T.C. 1967. The geomorphology of Longwood Swallet, Charterhouse-on-Mendip. *Proceedings of the University of Bristol Speleological Society*. **11**. 2. 161-185.
- BALCH, H.E. 1935. *Mendip-Cheddar, its gorge and caves*. Wells, Clare, Son & Co. 177 p.
- BOSCH, R.F. and WHITE, W.B. 2004. Lithofacies and transport of clastic sediments in karstic aquifers. Pp. 1-22 in Sasowsky, I D. and Mylroie, J. *Studies of cave sediments. Physical and chemical records of paleoclimate*. New York, Kluwer Academic/Plenum Publishers.
- BRANIGAN, K. and DEARNE, M.J. 1991. Romano-British usage of the caves of Cheddar Gorge. *Proceedings of the University of Bristol Speleological Society*. **19**.1. 19-31.
- CLAYDEN, B. and FINDLAY, D.C. 1960. Mendip derived gravels and their relationship to combes. *Abstracts of Proceedings of the 3rd conference of geologists and geomorphologists working in south-west England* (ed. J. Robson and S. Simpson), pp. 24, 25. Penzance, Royal Geological Society of Cornwall.
- COLLCUTT, S.N. 1985. Analysis of sediments in Gough's Cave, Cheddar, Somerset, and their bearing on the palaeolithic archaeology. *Proceedings of the University of Bristol Speleological Society*. **17**. 2. 129-140.
- CURRENT, A.P., JACOBI R.M. and STRINGER, C.B. 1989. Excavations at Gough's Cave, Somerset, 1986-7. *Antiquity* **63**. 131-136.
- DAVIES, H.N. 1904. The discovery of human remains under the stalagmite-floor of Gough's Cavern, Cheddar. *Quarterly Journal of the Geological Society of London*. **60**. 335-348.
- DONOVAN, D.T. 1955. The Pleistocene deposits at Gough's Cave, Cheddar, including an account of recent excavations. *Proceedings of the University of Bristol Speleological Society*. **7**. 76-104.
- DONOVAN D.T. 1972. Sections exposed in 1957. In Tratman, E.K., D.T. Donovan and J.H. Musgrave, Gough's Cave, Cheddar, Somerset. *Proceedings of the University of Bristol Speleological Society*. **13**.1. 54-56.
- DONOVAN, D.T. 2005. Aveline's Hole, Burrington Combe, North Somerset: stratigraphy and problems. *Proceedings of the University of Bristol Speleological Society* **23**.3. 159-170,
- FARRANT, A.R. 1991. The Gough's Cave system: exploration since 1985 and a reappraisal of the geomorphology. *Proceedings of the University of Bristol Speleological Society*. **19**.1 3-17.
- FINDLAY, D.C. 1965. *The soils of the Mendip district of Somerset*. Harpenden. Memoirs of the Soil Survey of Great Britain: England and Wales. [8] + 204 p.
- FINDLAY, D.C. 1977. Bourne (Avon): a temporary section in gravelly head. Pp. 21-25 in: *Quaternary Research Association. Field Handbook Easter Meeting 1977* Bristol.

- FORD, D.C. 1964. On the geomorphic history of G.B. Cave, Charterhouse-on-Mendip, Somerset. *Proceedings of the University of Bristol Spelaeological Society*. **10**. 2, 149-188.
- GRAY, H. St.G. 1929. Antiquities other than those of flint found in Gough's Cave, 1927-28. *Proceedings of the Somersetshire Archaeological and Natural History Society*. **74**. 111-118.
- GRAY, H. St.G. 1931. Antiquities other than those of flint found in Gough's Cave, 1929-30. *Proceedings of the Somersetshire Archaeological and Natural History Society*. **76**. 53-57.
- HANWELL, J.D. and NEWSON, M.D. 1970. The great storms and floods of July 1968 on Mendip. *Occasional publications of the Wessex Cave Club*. ser. 1, no. 2.
- HEPWORTH, J.V. and STRIDE, A.H. 1950. A sequence from the Old Red Sandstone to Lower Carboniferous, near Burrington, Somerset. *Proceedings of the Bristol Naturalists' Society* **28**. 1. 135-138.
- HILL, C.A. and FORTI, P. 1986. *Cave minerals of the world*. Huntsville, Alabama, National Speleological Society x + 238 p.
- HOLLAND, H.D., KIRSIPU, T.V., HUEBNER, J.S. and OXBURGH, U.M. 1964. On some aspects of the chemical evolution of cave waters. *Journal of Geology*. **72**. 36-67.
- IRWIN, D.J. 1985. The exploration of Gough's Cave and its development as a show cave. *Proceedings of the University of Bristol Spelaeological Society*. **17** 2, 95-101.
- JACOBI, R.M. 1985. The history and literature of Pleistocene discoveries at Gough's Cave, Cheddar, Somerset. *Proceedings of the University of Bristol Spelaeological Society*. **17**. 2. 102-115.
- JACOBI, R.M. 2004. The Late Upper Palaeolithic lithic collection from Gough's Cave, Cheddar, Somerset and human use of the cave. *Proceedings of the Prehistoric Society*. **70**. 1-92.
- MACPHAIL, R.L. and GOLDBERG, P. 1985. Gough's Cave, Cheddar, Somerset: microstratigraphy of the Late Pleistocene/earliest Holocene sediments. *Bulletin of the Natural History Museum, London*. **58**. (supp). 51-58.
- PARRY, R.F. 1929a. Recent excavations at the Cheddar caves. *Annual Report of the Wells Natural History and Archaeological Society* for 1928. 32-36.
- PARRY, R.F. 1929b. Excavations at The Caves, Cheddar. *Proceedings of the Somersetshire Archaeological and Natural History Society*. **74**. 102-106.
- PARRY, R.F. 1930. The Great Cave, Cheddar (cited by H E Balch). *Annual Report of the Wells Natural History and Archaeological Society* for 1929. **26**. 27.
- PARRY, R.F. 1931. Excavations at Cheddar. *Proceedings of the Somersetshire Archaeological and Natural History Society*. **76**, 46-53.
- RAHTZ, P. and WATTS, L. 2003. *Glastonbury myth and archaeology*. 2nd ed. Tempus Publishing. Stroud (Glos.). 191 p.
- STANTON, W.I. 1965. The digging at the end of Gough's Cave, and its bearing on the chances at Cheddar. *Wessex Cave Club Journal* **8**. 102. 277-283.

- STANTON, W.I. 1977. Mendip water in Barrington, N. and Stanton, W. 1977. *Mendip the complete caves and a view of the hills*. Cheddar. Cheddar Valley Press & Barton Productions. 202-213.
- STANTON, W.I. 1986. Cheddar Gorge and Gough's Cave. *Proceedings of the University of Bristol Speleological Society*. **17**. 2. 121-128.
- STRINGER, C. 2000. The Gough's Cave human fossils: an introduction. *Bulletin of the Natural History Museum, London*. **56**. 135-139.
- TRATMAN, E.K. 1960. Gough's Old Cave, Cheddar, Somerset. *Proceedings of the University of Bristol Speleological Society*. **9**. 1. 7-21.
- TRATMAN, E.K. 1972. Gough's Cave, Cheddar, Somerset. Rescue dig, November 1968. *Proceedings of the University of Bristol Speleological Society*. **13**.1 49-54.
- TRATMAN, E.K. 1975. Problems of "The Cheddar Man", Gough's Cave, Somerset. *Proceedings of the University of Bristol Speleological Society*. **14**. 1. 7-23.
- WALKER, M.J.C., COOPE, G.R., SHELDRIK, C., TURNEY, C.S.M., LOWE, J.J., BLOCKLEY, S.P.E., and HARKNESS, D.D., 2003. Devensian Lateglacial environmental changes in Britain: a multi-proxy environmental record from Llanilid, South Wales, UK. *Quaternary Science Reviews*. **22**. 475-520.

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