PLATE 1 — CHEDDAR GORGE, LOOKING EAST-NORTH-EAST. GOUGH'S CAVE ENTRANCE BUILDINGS ARE AT THE EDGE OF THE SHADOW ON THE SHARP BEND IN THE FOREGROUND.

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CHEDDAR GORGE AND GOUGH'S CAVE

by

W. I. STANTON

Cheddar Gorge is the classic example of a waterless limestone gorge with a tributary system of waterless limestone valleys. It is also one of Britain's greatest natural scenic attractions. Opening into it are several caves at different levels, whose origins are linked to the development of the gorge. The largest known cave is Gough's Cave, visited by half a million tourists each year.

THE ORIGIN OF CHEDDAR GORGE

Early speculation on the origin of Cheddar Gorge ranged from earthquake rifting to marine erosion. These ideas were replaced in the later nineteenth century by the cavern collapse hypothesis (Winwood & Woodward, 1891) which held that the 'Cheddar Pass' had been created by roof collapse in a series of great caves. Balch (1947, pp. 65-7) summarized the arguments for collapse, citing the approach ravine to Wookey Hole Cave as an example of the process in action.

Present-day views on dry valley formation were heralded by Reynolds (1927) who argued that the smaller dry limestone gorge of Burrington Combe, 4 km north of Cheddar, was eroded by a surface stream. This was possible because the ground was permanently frozen in the colder phases of the Pleistocene. Water from rain or snowmelt could not infiltrate underground as it does now, but ran off the Mendip plateau via the existing valley system, eroding gorges where the flow was strong and the gradient steep.

Coleman & Balchin (1960) introduced a different concept, regarding 'Cheddar Gorge as a simple youthful valley which has recently performed the typically youthful action of abandoning its surface course for an underground one'.

Ford & Stanton (1969) combined earlier theories by arguing that the Mendip dry valleys and gorges were excavated in two main stages. First, when sea level was higher and the Mendips were hardly distinguishable as a range of hills, the high water table in the limestone allowed permanent surface drainage in the principal valleys, as happens today in the far east of Mendip in, for example, the Nunney Brook. Later, when sea level fell during the Early Pleistocene and the Mendips were rapidly exhumed from their enveloping soft post-Carboniferous strata, the water table dropped faster than the streams could wear down their beds. Swallets and caves formed, and the surface flow in the valleys became intermittent, finally ceasing except in great floods.

In periglacial phases of the Pleistocene the ground froze, the swallets and percolation channels were blocked with ice and frozen mud, and summer meltwater torrents reactivated the valley systems. The steepest gradients were at the valley mouths, which had been left 'hanging' by the exhumation process, and there the gorges developed. Cheddar Gorge, with its catchment area of 40 km^2 (most of the Mendip plateau), is by far the biggest. The smaller gorges, Ebbor and Burrington, have catchment areas of only about 3 km^2 each.

MORPHOLOGY OF CHEDDAR GORGE

The 3 km long Gorge is the deeply incised downstream end of a complex dry valley system that extends 13 km to its head at Pen Hill above Wells (Ford & Stanton, 1969, fig. 5). It is a narrow sinuous canyon with limestone cliffs up to 140 m high (PLATE 1). The Carboniferous Limestone strata dip to SSW at about 20°; thus the highest vertical cliffs are on the south side where down-dip slippage cannot occur. Some of the history of the Gorge can be deduced from the variable gradients of its floor, from the caves that open in its sides, and from the terrace remnants that are present here and there.

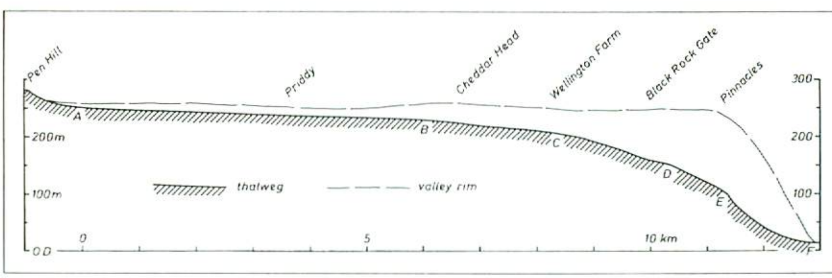

FIG. 1 — LONG PROFILE OF CHEDDAR GORGE AND ITS MAIN TRIBUTARY VALLEY
Based on O.S. maps (above Wellington Farm) and on levelling by the writer

The long profile of the Gorge and its principal tributary valley is divisible into five segments (FIG. 1). The highest segment, A-B, has a gradient of only 3.3 m per km and ends in an almost imperceptible knickpoint near Cheddar Head. This is the oldest stretch of the valley, incised before the water table had fallen below stream level. Projected beyond the knickpoint it leaves Mendip at c. 210 m O.D., but the contemporary sea level could have been higher than this because the valley floor, like all the limestone outcrop, has been lowered many tens of metres by dissolution since the first emergence of Mendip in the later Tertiary or Early Pleistocene. The sea level to which this oldest valley drained could well have been around 300 m O.D.

Downvalley from Cheddar Head the profile steepens progressively in four stages separated by increasingly well defined knickpoints. Each segment represents a downcutting phase adjusting to a lower base level. The segment B-C may have graded to an Early Pleistocene sea level of c. 180 m (Brown, 1960) which cut the Burrington Terrace (Barrington & Stanton, 1977, p. 217) and the Radstock Plateau (Wooldridge, 1961) on the north side of the Mendips.

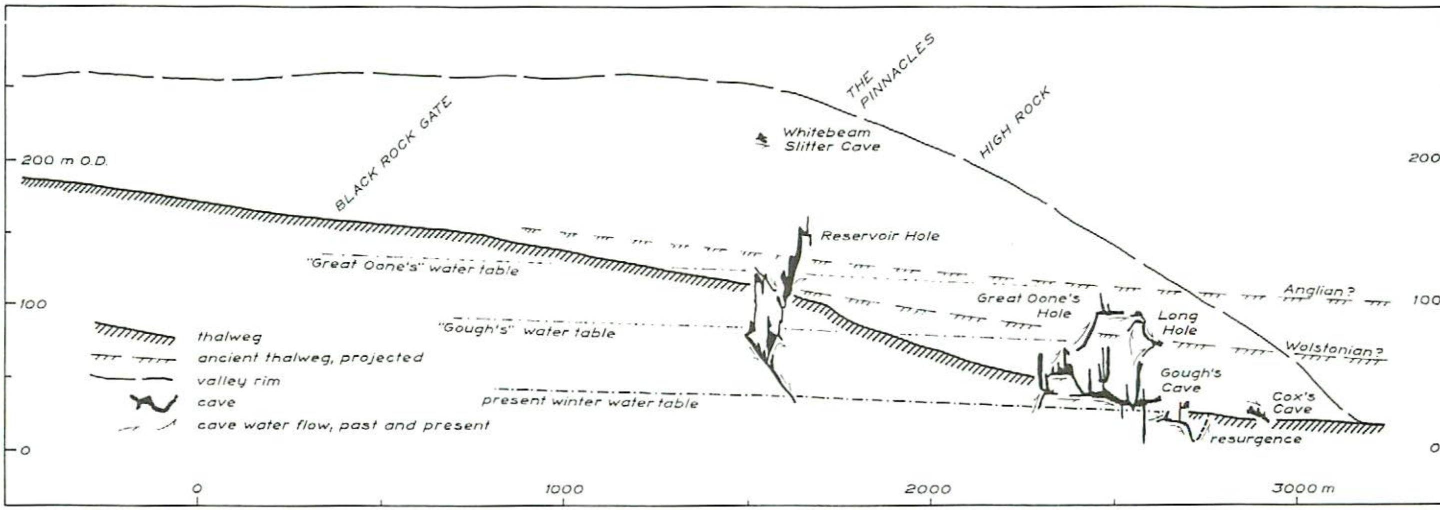

FIG. 2 — LONG PROFILE OF CHEDDAR GORGE, INCLUDING THE CHEDDAR CAVES
Based on levelling and cave surveys by the writer

The three lower segments are probably related to periglacial rejuvenations of stream flow as outlined above. The lowest, E-F, has the classic curved profile that has been cut away in the higher segments. It was definitely active in the Late Devensian, when the downcutting torrent breached the roof of Gough's Cave.

CAVE AND GORGE GENESIS RELATED

In FIG. 2 the original profiles of segments C-D and D-E are tentatively reconstructed (remnants of the lower one can still be seen at the Horseshoe Bends and the spur above Gough's Cave).

Ford & Stanton (1969) argued that Great Oone's Hole and Long Hole, which are upper levels of Gough's Cave, developed as feeder channels to springs rising in the floors of those early valleys, just as the present resurgences rise in the floor of the modern valley. Ford & Stanton, following Reynolds (1927) and Tratman (1963), assumed that infiltration and hence cave development was normally inhibited by permafrost during periglacial episodes (a concept that has been challenged by Atkinson, Smart & Andrews (1984)) and they believed that while valley deepening was a periglacial phenomenon, cave development at successively lower levels took place in successive warm phases. On this basis the present resurgence is in the floor of a valley dating from the Devensian cold stage; Gough's Cave may have formed in the Ipswichian, feeding an outlet in the floor of a Wolstonian valley; and the Long Hole/Great Oone's Hole system, of possible Hoxnian age, fed an outlet in the valley formed during a still earlier cold stage. Great Oone's Hole could belong to an earlier cycle still.

Ford & Stanton linked the earlier phases of downcutting and cave formation to base levels marked by erosional benches on Mendip's south flank, in particular the Wattles Hill Bench at 95-104 m O.D. and the Warrens Hill Bench at 70-80 m O.D. The present writer now believes that these 'benches' are random associations of flats, in many cases structural in origin. The relatively extensive flats of the type areas, Wattles Hill and Warrens Hill, are explained by the stripping of Lias clay and Triassic marl respectively off the underlying harder limestone strata. On this view, cave development levels depended on the levels of their respective spring outlets, which were situated close to the lowest outcrops of Carboniferous Limestone or Dolomitic Conglomerate exposed by periglacial valley downcutting. Around Mendip today, caves are developing at a wide range of altitudes controlled not by base level but by resurgence levels determined by local geology, varying from 10 m O.D. (Banwell Spring) to 148 m O.D. (St. Dunstan's Well).

THE GOUGH'S CAVE SYSTEM

Gough's Cave is the name given to the lower parts of a complex system of caves with a total passage length of 1600 m, ranging in altitude from 10 m O.D. to 105 m O.D. The other parts of the system are Great Oone's Hole, Long Hole, and Gough's Old Cave (FIG. 3). Passages exist linking

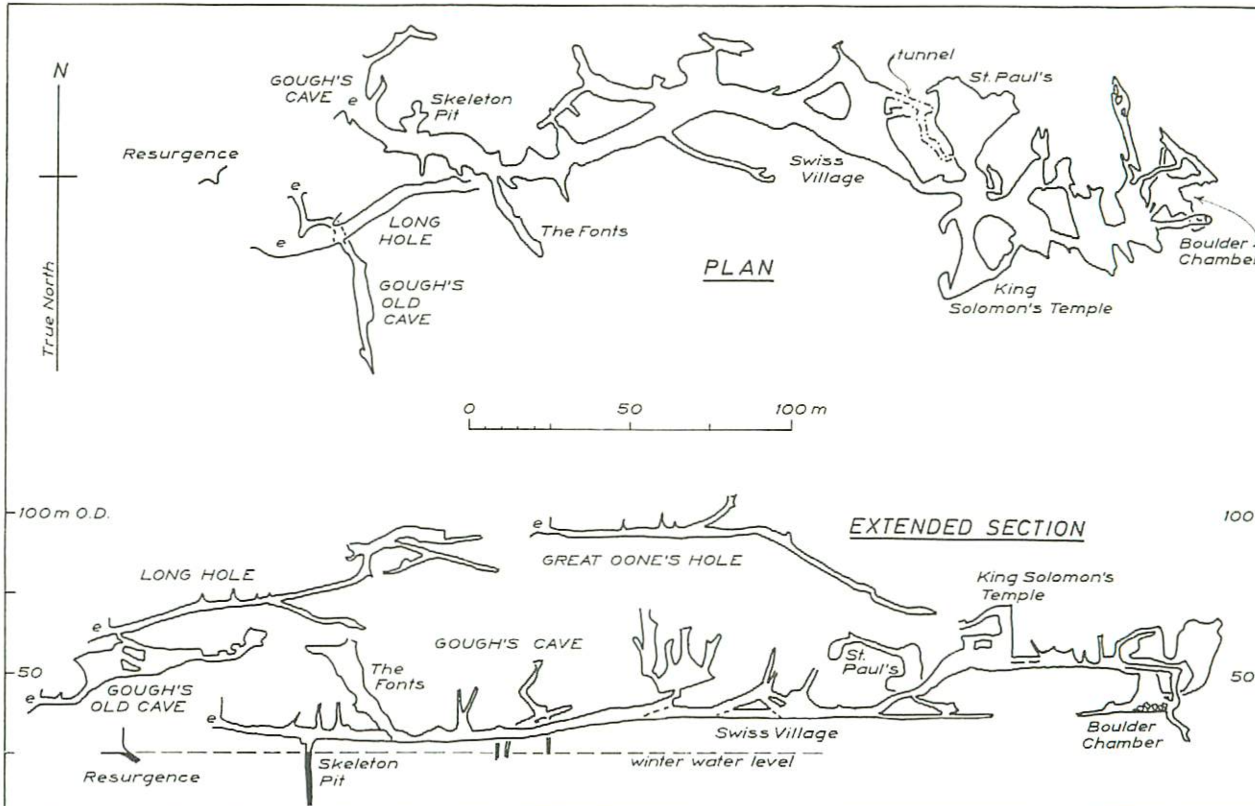

FIG. 3 — SIMPLIFIED PLAN AND SECTION OF THE CHEDDAR CAVES. GREAT OONE'S HOLE AND PART OF LONG HOLE ARE OMITTED FROM THE PLAN FOR CLARITY, AS THEY LIE VERTICALLY ABOVE GOUGH'S CAVE.

e: cave entrance

Based on surveys by the writer

each cave to one or more of the others, but all are blocked with debris or stalagmite except the Long Hole–Gough's Old Cave connection which is passable by cavers.

The cave system originally extended into space now occupied by the Gorge. Thousands of metres of passage must have been eroded by valley downcutting and cliff retreat. Great Oone's Hole probably continued beyond its present entrance to join with the inner passages of Long Hole, which itself runs out into thin air at a level well below its resurgence. Gough's Cave probably continued along the line of the road down the Gorge until it turned south and became Cox's Cave and Fantasy Grotto (originally Pavey's Cave).

All the caves were formed below the water table by the underground river as it followed tortuous routes leading to an early resurgence at c.105 m O.D., then to a resurgence at c.60 m O.D. and finally to the present resurgence at c.23 m O.D. Nowhere in the system are there signs of prolonged vadose river erosion, but there was temporary reoccupation by the river of abandoned passages in parts of Gough's Cave. In the Boulder Chamber the river burst up through a massive deposit of laminated mud, forming a wide vertical 'pipe' filled with sand and pebbles (Stanton, 1965). Near King Solomon's Temple there were steep rills formed by trickling water in a sloping rock face that have been converted into tall asymmetric scallops by the river during a brief reoccupation of the passage.

The present-day underground river does not flow through any part of the known caves. Probably it follows a submerged course roughly parallel to, but south of, the main passage of Gough's Cave.

Passages in the cave system are mainly developed along bedding planes. Most follow the strike; thus, as dip in the caves is around 20° to the SSW, horizontal tunnels usually trend ESE. The main passage in Gough's Cave near the Swiss Village runs along the axis of a large drag fold parallel to the strike. Vertical north-south joints are strongly developed throughout Cheddar Gorge, giving rise to high, narrow rifts or avens often crossing the main cave passages. Some minor passages may have followed neptunian dykes, an example of which, containing red Triassic marl, can be seen in the artificial tunnel leading to St. Paul's.

All the caves at present known, with the possible exception of Gough's Old Cave, were formed by water that rose in the floor of the Boulder Chamber in Gough's Cave. The first cave climbed from the Boulder Chamber via King Solomon's Temple to Great Oone's Hole, then continued through Long Hole to the c.105 m O.D. resurgence in the floor of the ancient Gorge, long eroded away. Another route at a slightly lower level, along Gough's Cave and up the Fonts to Long Hole, may have been contemporary or somewhat later. These routes were abandoned when the present main passage developed along the length of Gough's Cave at a low level, continuing to Cox's Cave. The present resurgences of the cave that is now developing have yet to be explored.

THE BREACHING OF GOUGH'S CAVE

Fairly late in the Devensian the downcutting action of summer torrents that rushed down Cheddar Gorge broke into Gough's Cave 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. The cave stream, according to conventional theory, was not active at this time, and the deposit was not reworked. Continued downcutting and cliff retreat eventually destroyed all the passage between Gough's and Cox's caves, leaving the Gough's entrance in its present position. Pinching out into the cave, resting on the older well-sorted sands left by the underground river, and perhaps, because of the downward slope, extending further into the cave than might have been expected, was the unsorted pebbly and cobbly deposit of limestone and sandstone origin dumped into the cave by the surface torrents. This was the 'Conglomerate' described by Donovan (1955).

The cave passage sloped down from the entrance to a low point just beyond the Fonts, then rose again to the Swiss Village. At the low point (dug under and then blasted away by Richard Gough about 1893) the passage must have been choked at a very early date, at or even before the entry of the Conglomerate. From the low point to the entrance there is much tufaceous stalagmite, indicating that external air was freely circulating, but beyond the low point the stalagmite is all crystalline material of the kind that only forms in a closed cave environment. Throughout the Holocene, at times when the cave entrance was not blocked by scree, sediment and organic debris could work their way down the entrance passage towards the low point.

Currently, after exceptionally heavy rain, Gough's Cave becomes a resurgence. Water rises in the Skeleton Pit (Cheddar Man) Fissure and from other flooded shafts beyond the low point and pours out of the cave entrance. If, as is normally the case in high flood, the water is muddy, repeated such floodings will leave a laminated mud deposit, but no such deposit was recorded in the entrance passage (Donovan, 1955). 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.

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