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THE GOUGH'S CAVE SYSTEM: EXPLORATION SINCE 1985 AND A REAPPRAISAL OF THE GEOMORPHOLOGY

by

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NGR ST 46706391
Altitude 32 m AOD
Surveyed Length c. 2300 m

ABSTRACT

The recent explorations in Gough's Cave are described including the discovery of the main river passage, the alternative dry route into Lloyd Hall and the passages at the top of the Fonts. The cave is a complex resurgence system, developed on several levels along a minor drag fold, whose axial trend is 120°, parallel to the strike. Strong north/south jointing is well developed, and has a strong influence on cave development. A modified scheme of evolution is presented, which is contrasted with that of previous authors who suggest that there was only one input to the system via the Boulder Chamber. Recent digging in the cave and the exploration of the River Cave show that this is not the case and at least three other inlets existed including Damocles Rift, Makin' Progress and the River Cave. Four major still-stands of the water table deduced from passage morphology are proposed, the highest at or above 105 m AOD in Great Oones Hole/Long Hole, one at 70-75 m (Damocles Rift/Sand Chamber level), another one at c. 45 m (Boulder Chamber/Western Creep level) and the present water table at 23 m AOD in the River Cave. These are related to the evolution of the cave system. The modern active conduit exhibits strong structural control, forming a series of deep phreatic loops parallel to the dip and a horizontal water table passage along the strike.

EXPLORATION SINCE 1985

The most important of the recent discoveries is the River Cave (Figure 1). On the 11th November 1985, Andy Sparrow, then working for Cheddar Caves, persuaded cave diver Richard Stevenson to investigate a small sump pool at the bottom of a shaft in the oxbow just off Heartbreak Hill. This had previously been examined in May 1980 by Martyn Farr, who reached a depth of 12 m before abandoning the dive. On the first dive by Stevenson this depth was exceeded, and during a follow up dive on the 18th November, he passed a squeeze to enter a large chamber with crystal clear visibility, and a noticeable drop in water temperature. This was the River Cave, the main active conduit carrying the water to the resurgence. The entrance squeeze was christened 'Dire Straits' in view of its awkward nature. Further dives early in 1986 by Stevenson, Rob Harper and Rob Palmer with Mike Duck as dive controller penetrated upstream to discover an air surface in Lloyd Hall (named after Dr Oliver Lloyd) after c. 120 m. Sump One was eventually passed, on the 2nd March 1986 to surface into Bishop's Palace, the largest known chamber in the Cheddar complex (Figure 2).

Sump Two was dived at the end of August 1986, to a tight slot (the Thynne

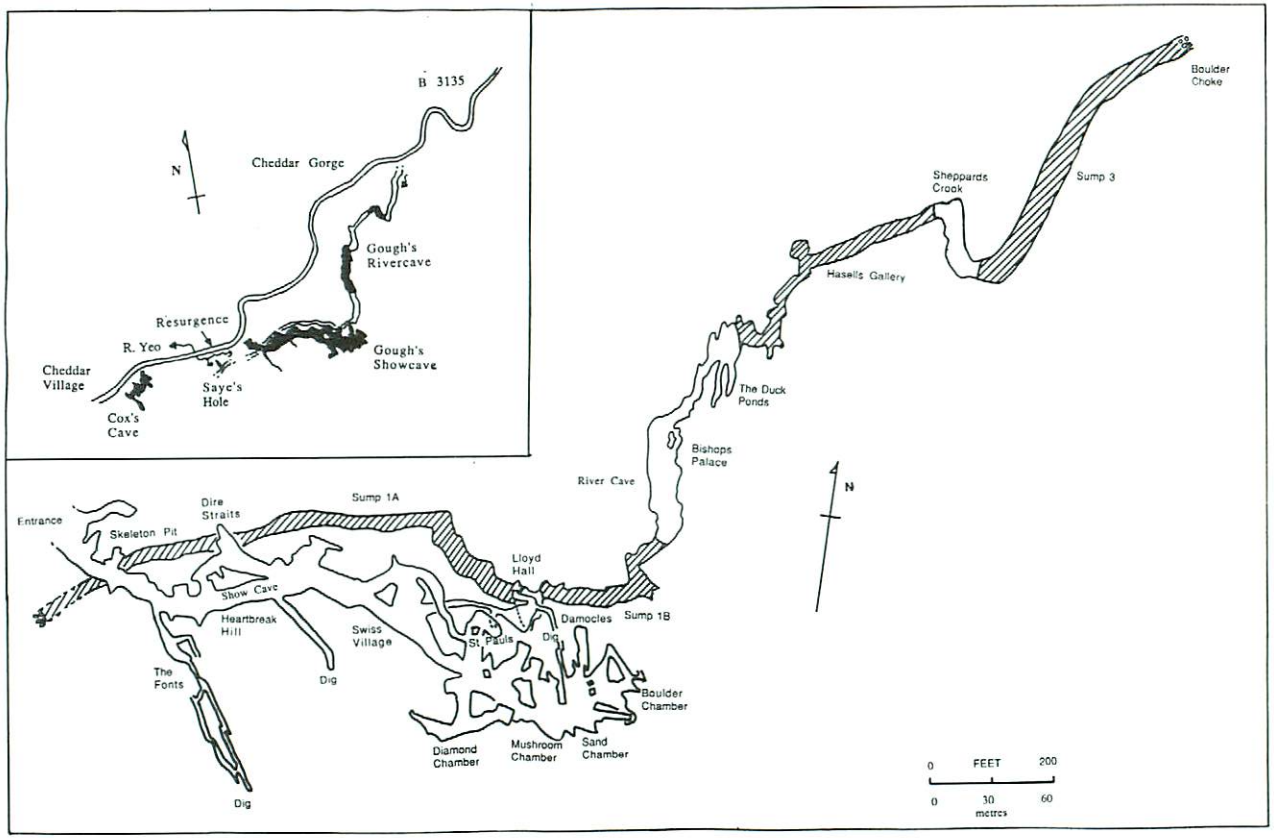

Figure 1. *Survey of Gough's Cave, including the River Cave and showing the position of the cave in relation to the gorge.*

Thynng) at a depth of 27 m, later passed by Palmer and Stevenson to surface in Sheppards Crook (Figure 3). This small chamber led almost immediately to Sump Three. After several initial dives, Palmer and Stevenson discovered a large passage at a depth of 58 m. A major push in June 1988, with a total of eight divers and over thirty support cavers, extended Sump Three by 100 m, to a point 26 m below water level. Another push in May 1990 extended the cave further to a point at −19 m, where a boulder choke appears to block the passage. In September 1990, Robin Brown followed the passage downstream from Dire Straits for 100 m, to a point 30 m below the Caveman Restaurant (just outside the entrance to Gough's Cave), where boulders halted progress.

In August 1986 during an attempt to radio-locate Lloyd Hall, a dry connection was discovered when Stevenson's voice was heard, albeit distantly, through a draughting boulder choke at the top of a bedding plane in the passages behind St. Paul's. This choke was later blasted, and a large chamber known as Makin' Progress discovered. A further short dig revealed a 25 m pitch into the lake in Lloyd Hall, since by-passed by a short traverse and a 12 m ladder climb.

Several minor discoveries have also been made. A low archway in the northwest corner of Sand Chamber was excavated and about 15 m of rift passage dug out by various diggers over a period of several years. In September 1989 a short section of open rift was discovered which connects to a dig at the south end of Makin' Progress (although impassable at the moment). Since 1985 Paul Hodgeson and Dave Evans of the Axbridge Caving Group have opened up about 70 m of passage at the top of the Fonts. Several other digs have taken place recently in Gough's, notably in Far Rift and on the right hand side of Heartbreak Hill, but both have been abandoned. The Heartbreak Hill dig may be a small oxbow passage. Irwin (1985) provides a well-documented account of the previous discovery of the Showcave.

DESCRIPTION OF THE DISCOVERIES

The caves and passages discovered prior to 1985 are documented in Irwin and Knibbs (1987) and Barrington and Stanton (1977). The River Cave is also described in the Cave Diving Group logs (Stevenson, 1985-1989).

The River Cave

The original entrance to the River Cave is reached by a 70 m stoop along the oxbow off Heartbreak Hill, followed by a climb down a narrow chimney to the water level. Underwater a tight constricted shaft (Dire Straits) descends for 12 m into larger passage (Sump 1a). The 6 m by 3 m passage continues downstream in a southwesterly direction to a depth of 30 m where it ends at a boulder choke a short way before the resurgence. Upstream a 5 m by 3 m passage trends east along the strike for about 150 m at a depth of between 7 and 12 m. At several places small airbells exist, and deep north/south cross rifts are present in the floor. The passage surfaces in Lloyd Hall, a large rift chamber 18 m long, 7 m wide

and up to 22 m high. Sump 1b continues east from Lloyd Hall for another 50 m, where it turns north up a scalloped bedding plane, becoming more complex with cross rifts and rock arches, before entering another bedding plane. This ascends up dip to break surface on a large slippery mudbank in a small chamber. A short scramble leads into Bishop's Palace, a chamber 100 m long, 15 m high and 25 m wide which runs due north over an enormous boulder pile. At the far end the chamber degenerates into a series of north/south rifts known as the Duck Ponds, which lead into Sump Two.

Sump Two enters a large north/south phreatic rift passage which quickly descends to a depth of 27 m, where it narrows to a gravelly slot, the 'Thynne Thynng'. The rift continues north to an underwater swirl chamber similar to Chamber Three in Wookey Hole, at a depth of 20 m. The main way upstream turns northeast and gently ascends up dip in a well scalloped elliptical tube, which breaks surface after 170 m at Sheppard's Crook. In this small chamber, the river cascades over a low waterfall, from the start of Sump Three. Sump Three begins as a 3 m by 3.5 m phreatic rift which descends vertically to a depth of 58 m, enlarging to much grander proportions. A passage over 7 m wide and 2 m high leads up the dip to the northeast for over 100 m, and is almost filled with thick laminated sediment in places. At this point the passage is developed in the lower part of the Clifton Down Limestone, with many chert nodules projecting from the roof, while the rest of the cave is developed in the higher purer part of the member. The present end (July 1991) is at a point 19 m below water level where the passage appears to terminate in a boulder choke, at the base of which appears to be a vertical shaft (Palmer pers. comm.). This point has been radio-located to a point in Cheddar Gorge a short way east of the car park just before Horseshoe Bend, and not far from the lower end of Reservoir Hole.

Dry Route to Lloyd Hall

From St. Paul's Chamber in the Showcave, a short climb over flowstone and through a gate leads into the annex behind St. Paul's. A squeeze down to the right through boulders leads into another small decorated chamber. In wet weather a small stream appears from under the right hand wall, presumably from St. Paul's. Another squeeze under a boulder in the floor of the chamber leads to a T-junction, turning left goes back to the Showcave near the Swiss Village, while turning right a phreatic tube leads to a choke from which water appears in wet weather. This is almost certainly the lower end of Western Creep, which leads off from the Boulder Chamber. Just before the choke a wide flat-out inclined bedding plane on the left continues for 23 m, through a crawl inboulders (the breakthrough point) and into Makin' Progress. Directly above the point of entry into the chamber is a round phreatic tube 1 m in diameter, which leads south, and connects with Sand Chamber. This passage heads along a rift developed in an inclined joint plane, and emerges under a low archway in the northeast corner of Sand Chamber. At the opposite end of Makin' Progress a choked passage heads off, and a 4 m deep rift leads to the top of the 23 m pitch into Lloyd Hall. Alternatively an exposed traverse 15 m above water level, followed by a 12 m fixed ladder leads to the diver's platform in Lloyd Hall.

Figure 2. *Bishop's Palace, the largest chamber in the Cheddar complex. The large amount of breakdown can be seen where joint segmented blocks have fallen from the roof.* Photograph Gavin Newman.

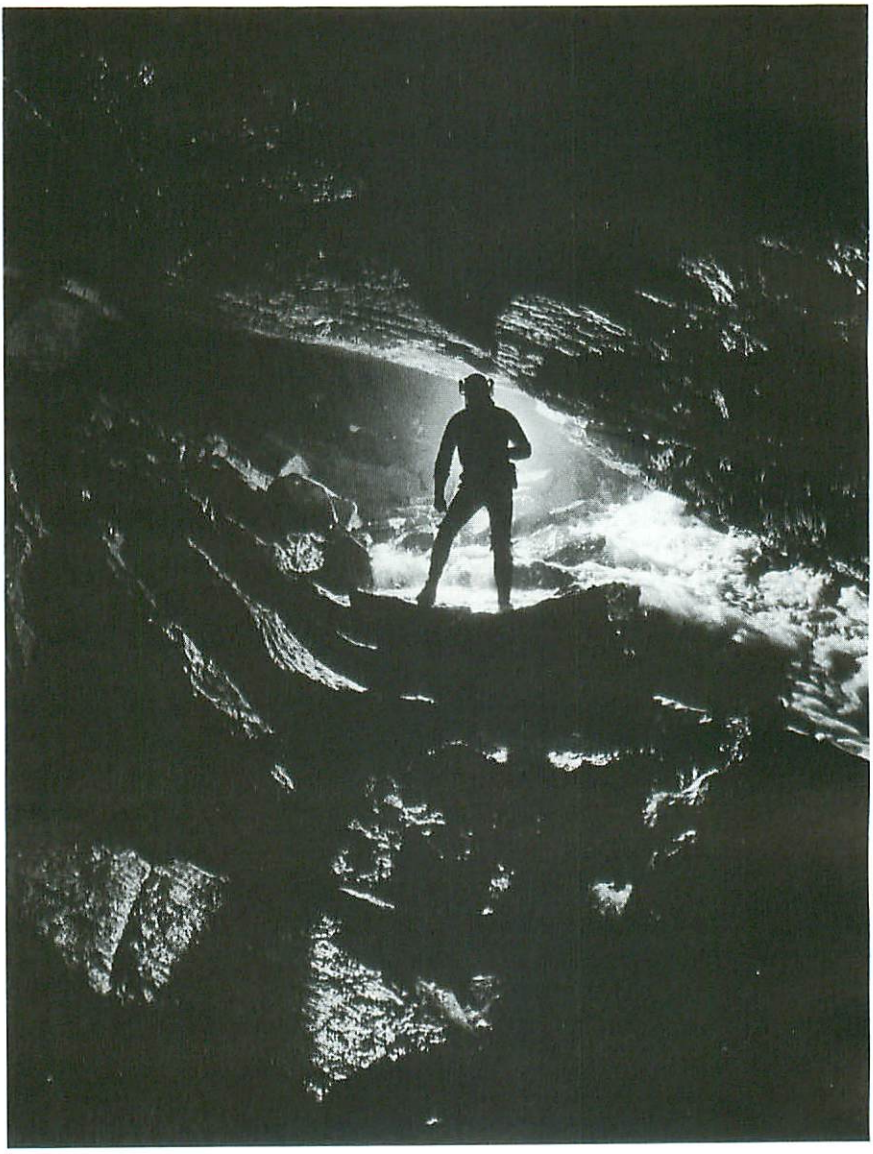

Figure 3. *Sheppard's Crook, a short stretch of strike aligned passage between Sump 2 and Sump 3. The passage shape indicates strong bedding plane control and vadose incision is beginning to occur at the crest of the phreatic loop.* Photograph Gavin Newman.

The Fonts

From the top of the Fonts a tight dug passage leads down into a small 'chamber' with a narrow rift in the floor. Carrying on over the rift another dug passage leads via a climb into a continuation of the rift which is choked after about 15 m. At the base of the climb, a short dug tunnel supported by concrete blocks drops down into larger passage at a junction. Turning left leads via a very tight rift back to the first 'chamber', while right leads down to a wet weather sump. Beyond the sump is a series of small rift chambers ending in a rift 2 m wide, 9 m high and 8 m long, with a flowstone blockage at the far end. One of the rifts has an aural connection with the higher level passage on the other side of the sump. The skeleton of a bat (as yet unidentified) was discovered here but left in place to preserve it. Its point of entry remains problematical. The total passage length is c. 60 m, heading southeast along a closely spaced set of joints. On the opposite side at the top of the Fonts, an exposed traverse leads into 20 m of narrow rift passage known as Duck's Delight which also heads southeast.

Damocles Rift

In the northwest corner of Sand Chamber, a short crawl enters a rift chamber with helictites. Stooping under the east wall leads into a similar chamber with remnants of a false floor on the walls. Damocles Rift itself is entered by passing a large boulder to enter a massive boulder choke. At this point the passage is up to 20 m high and 5 m wide and full of unstable boulders. A draught can sometimes be felt. The boulders are well scalloped, indicating that the collapse occurred before the passage was abandoned. Scalloping also indicates water flow to the south into Sand Chamber and the area at the top of Boulder Chamber. The collapse can be penetrated for about 8 m following either wall, until blocked by boulders, sand and clay. A climb up just before the collapse leads to a 'landing' where a route can be followed up for over 15 m through unstable boulders. In the dig following the left wall a large piece of bone, identified as part of a rib bone of a straight-tusked elephant, was discovered lying on the sediment. It appears to be well weathered, but does not seem sufficiently rounded to have come from the swallets several kilometres to the north. The collapse may thus extend to the surface, c. 80 m above, which may also explain the tufaceous flowstone found in the collapse.

GEOLOGICAL CONTROL ON CAVE DEVELOPMENT

The Gough's Cave complex is developed in the Clifton Down Limestone, a very fine grained dark grey micritic limestone with chert bands in the lower beds (Green and Welch, 1965). It is generally unfossiliferous, although bands of Composita and Productid brachiopods do occur. The rocks dip to the south/southwest at between 20° and 25° and strike at 095° to 115° east. However the dip is steeper along the southern limb of an anticlinal drag fold which runs

along the northern wall of the cave and can be well seen in the Showcave and in Makin' Progress (Figure 4). Another anticlinal drag fold can be seen in Boulder Chamber. Jointing is well developed throughout the cave trending between 315° and 350° north. Joint density is high and many joints are filled with vein calcite. There is very little faulting in the system, only two minor faults can be seen, one in Sand Chamber, associated with the drag fold and striking east/west with a dip of 45° north, and another just inside the Entrance, running across the passage next to Skeleton pit. In the blasted passage leading into St. Paul's Chamber a fissure in the limestone has been infilled with red marls and clay, probably of Triassic origin.

The Cheddar River Cave provides a classic example of a State 3 multiple loop phreatic cave (Ford 1977), the profile of which is to a large degree structurally controlled (Figure 5). In Sumps Two and Three the cave is aligned down-dip, with elliptical dip-tubes leading water down to the base of near-vertical joint-controlled rising segments such as that is Sump Two leading from a depth of 27 m to the Duck Ponds. The loop crest between Sumps Two and Three is breached by a short strike-orientated vadose segment in Sheppards Crook. At Bishops Palace this vadose action has resulted in extensive collapse of joint-bounded blocks, the river now either bypassing the chamber by another phreatic loop or flowing under the boulders. In contrast to this looping down-dip profile, where the flow is aligned along the strike downstream of Bishops Palace as far as Dire Straits, the passage is quasi-horizontal at a depth of less than 12 m. This passage may in fact have been a true water table cave of Ford and Ewers (1978), with a free air surface. However, the level of the resurgance has been raised by the accumulation of scree in the floor of the Gorge, and impoundment of the lake to drive a water mill. A similar strong structural control is found in the fossil cave passages with down-dip tubes and joint-controled risers (probably fed by dip tubes) feeding the known strike orientated passages, for instance in Great Oones Hole.

GEOMORPHOLOGY

Gough's Cave is part of a complex resurgence system over 2300 m long which includes Long Hole and Great Oones Hole and ranges in altitude from −28 m AOD (−58 m below local water surface) to 105 m AOD. At least four sequences of phreatic development can be recognised. The highest of these is the Great Oones/Long Hole system, formed when the water table was at or above 105-110 m AOD (Figure 6, stage 1). Great Oones Hole is a large tubular passage developed along the strike from a phreatic riser at the far end. It is similar in size to Long Hole, the upper end of which terminates in a boulder choke very close to the surface not far from Great Oones Hole. It is suggested that water originally flowed from Great Oones Hole downdip into Long Hole to discharge into the Gorge north of Lion Rock. The passage is much smaller than the present river passage, possibly due to a less protracted occupation by the river. Dating of stalagmite in Great Oones Hole by Electron Spin Resonance gives a date of 1060 ± 160 ka (Smart et al, 1988). Scalloping on the flowstone indicates the cave was reoccupied after

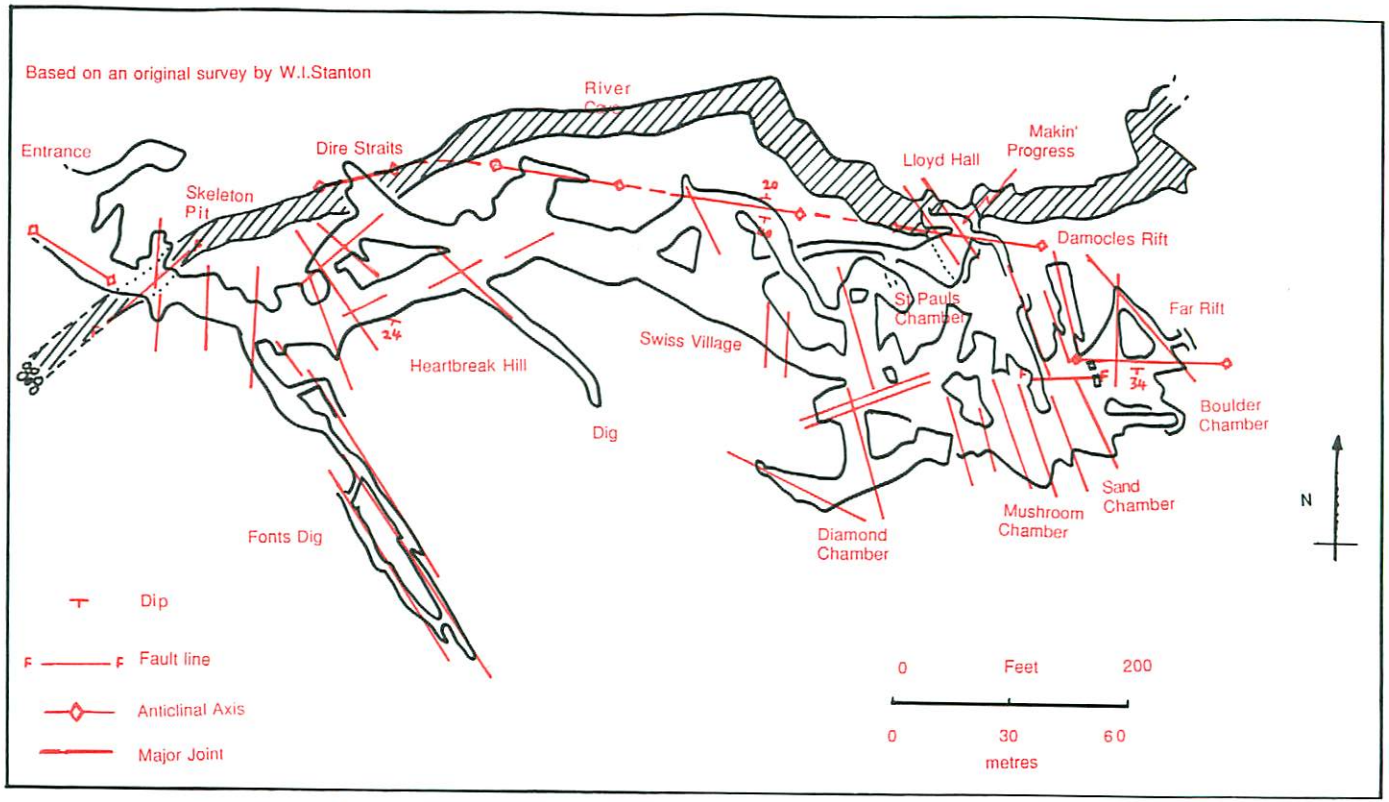

Figure 4. *The Structural Geology of Gough's Cave (excluding the River Cave).*

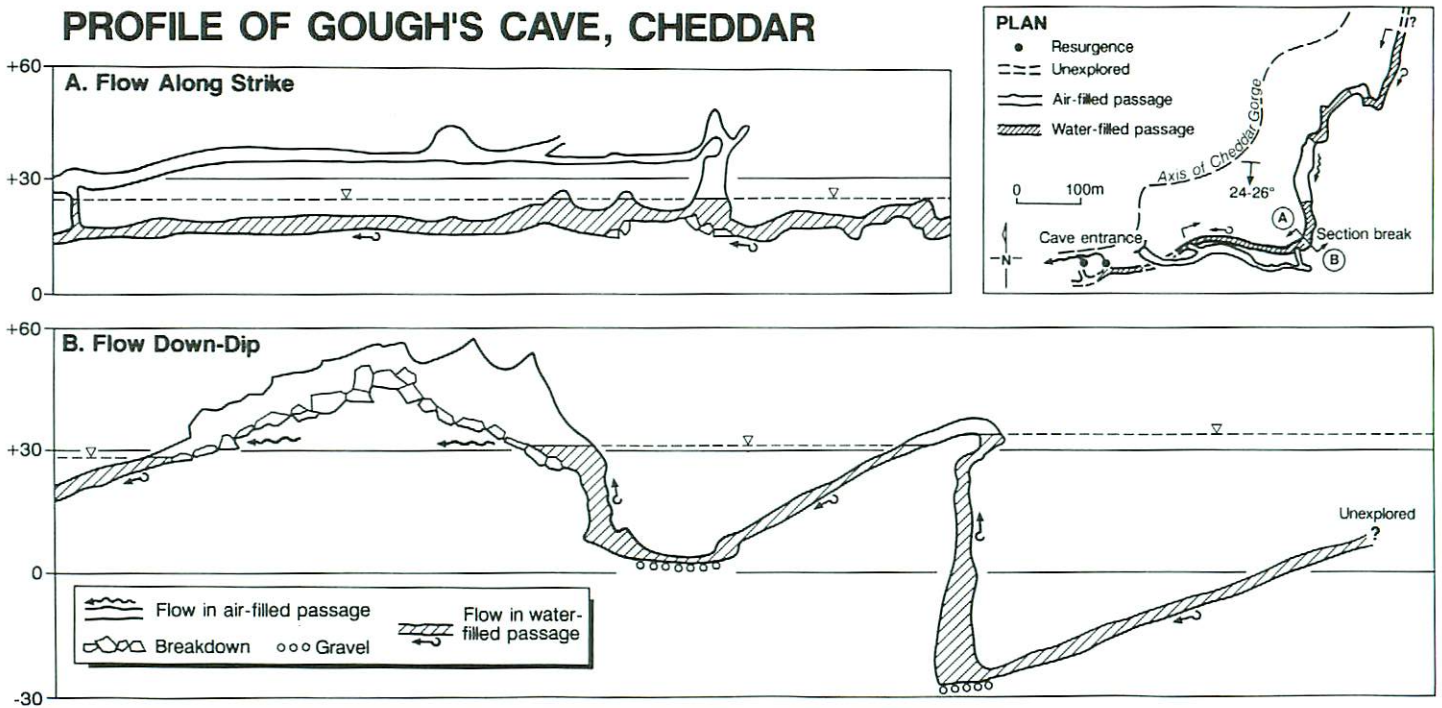

Figure 5. *Profile along the River Cave, showing the cave morphology perpendicular to and along the strike.*

initial phreatic diversion, and then drained to permit speleothem deposition (a sequence which can also be seen in the Showcave). Uranium series dating of speleothems suggests that the Great Oones / Long Hole conduit had been abandoned before 350 ka B.P. (Atkinson et al., 1977).

The next major phreatic level is at 70-75 m AOD, forming the Gough's conduit. This is mainly a strike orientated passage, formed initially where the water could penetrate most easily along the axis of the anticline. Water probably entered the system through a network of north/south rift passages in the Boulder/Sand Chamber area (Figure 6, stage 2). The main inlet for the water was probably Damocles Rift with water then flowing into the top of Boulder Chamber, into Sand Chamber, and then into the Showcave via Diamond Chamber. Water possibly also flowed in from the Makin' Progress area via the connection into Sand Chamber, where scalloping indicates a southerly flow. Other inlets may exist in the Far Rift area, but have yet to be found. Gough's Old Cave may also have been formed at this time by water entering from the south to join the main conduit. Similar southerly derived flows were probably responsible for the passage at the top of the Fonts in Gough's Cave, and Duck's Delight and Reynold's Passage in Long Hole. As with Long Hole, the distal parts of Gough's cave have been truncated by subsequent erosion of the gorge. The show cave may have connected with Cox's Cave, a single truncated passage heading down dip which is blocked at its lowest point. This passage also has many northwest/southeast trending rifts aligned along joints.

As the water table continued to fall, phreatic captures took place and the strike passages migrated slightly down dip to the south. Water found a lower route into Boulder Chamber, probably from inlets to the north below the chamber floor, and then flowed up into Sand Chamber, as indicated by scalloping on the walls of the passages to rejoin the original conduit (Figure 6, stage 3). Another capture took place between the Boulder Chamber and the Swiss Village forming Western Creep and the passage entering the Showcave at the Swiss village, by-passing Sand, Mushroom and Diamond Chambers and lowering the water table to c. 45 m AOD (Figure 6, stage 4).

The last phase took place when the water table fell to its present level at c. 23 m AOD forming the River Cave (Figure 6, stage 5). The water level fluctuates by about 3 m under normal conditions, but can rise up to 6 m above normal after exceptionally heavy rain. Water rises up Skeleton Pit and through the floor at the lowest point in the Showcave and floods the lower part of the cave flowing out through the turnstiles (Hanwell and Newson, 1970).

DISCUSSION

In earlier papers Drew (1975), Stanton (1965, 1985) and Ford and Stanton (1969) argued that the sole inlet to the Cheddar resurgance complex was the floor of the Boulder Chamber. This single inlet initially fed the resurgence at Great Oones Hole, then at the level of Long Hole, and finally the Gough's Showcave. This view can no longer be accepted. It is apparent from recent explorations that

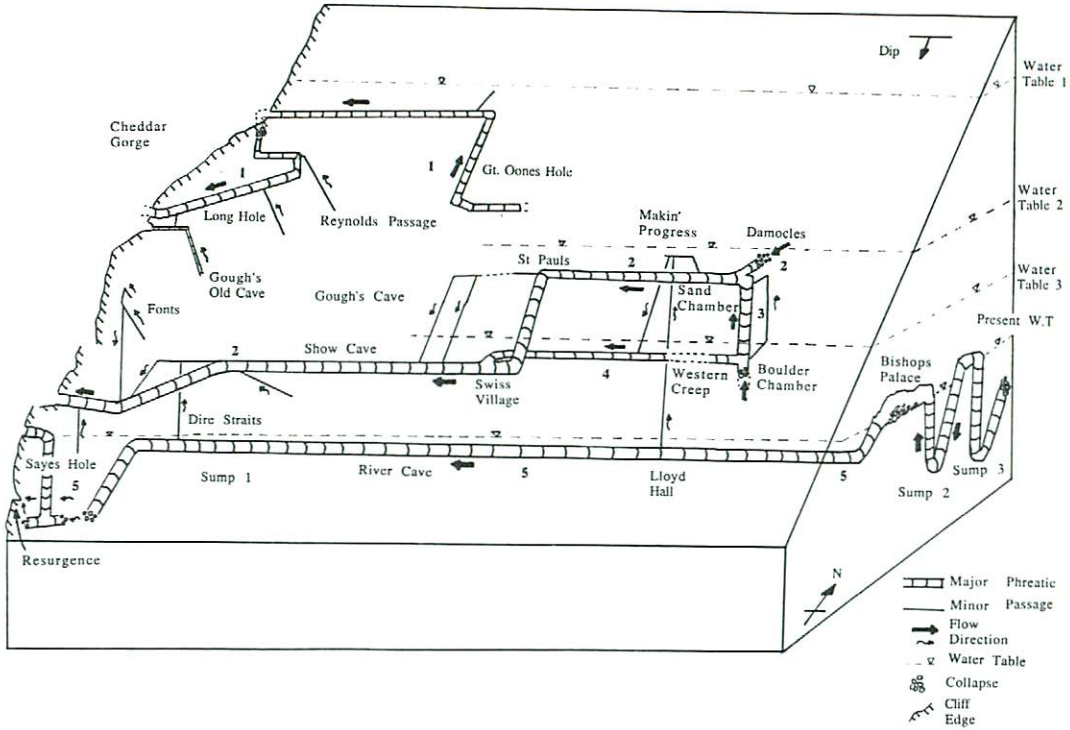

Figure 6. *Diagramatic representation of the evolution of the Cheddar Caves. Numbers relate to phases discussed in the text: (1) Great Oones/Long Hole Passage, (2) fall in water table to form Gough's Caves via Damocles Rift, (3) phreatic capture, formation of inlets in the Boulder Chamber floor, (4) phreatic capture, formation of the Western Creep/Swiss Village link, abandonment of Sand, Mushroom and Diamond Chambers except in flood, (5) phreatic capture, formation of modern active conduit (the River Cave).*

there have been at least two different inlets to Goughs Cave; Damocles Rift (via Sand Chamber and St Pauls) and Boulder Chamber (there is also a third possible inlet, currently sediment choked, leading off from Makin' Progress). Furthermore, careful inspection of the River Cave shows no evidence of an abandoned distributary feeding these high inlets (Palmer pers. comm.). No evidence of any link between Great Oones Hole and the known Gough's Cave system has been found. Radiolocation suggests that the end of Great Oones Hole is over 20 m from Diamond Chamber in Gough's Cave. It is also noteable that rather than acting as a feeder to Long Hole from Gough's Cave, the Fonts appear to have acted as a minor inlet to Gough's Cave from the south. Thus, as shown in Figure 6, at least four seperate inputs appear to have functioned during the development of the system.

At Cheddar over the long term (>1 Ma), the cave system thus appears to have responded to lowering of the external base-level by the development of a minimum of three independent feeder conduits leading back to the swallets. In some cases internal modification of these by phreatic capture occurred, for instance the Boulder Chamber/Western Creep/Swiss Village link, and abandonment of the Sayes Hole resurgence for the present Lake risings. However, there is little evidence for extensive vadose modification of the system, even thought the higher abandoned passages are interconnected to the active lower levels via tubes, such as Dire Straits which links the present River Passage with the abandoned Showcave conduit. This suggests that the lower passages were relatively mature before the resurgence level fell below the upper (later abandoned) passages, and that backflooding under vadose conditions was rare and geomorphologically ineffective; a suggestion supported by the infrequent flooding and lack of modification of the Showcave fossil conduit from Skeleton Pit (although sedimentation does occur).

This essentially Vauclusian development contrasts markedly with vadose dominated system response reported for Ogof Ffynnon Ddu by Smart and Christopher (1989), and is related to the structural disposition of the two systems. In Gough's Cave there is a predominantly down-dip deep supply of water to the resurgence, in contrast to the shallow dip and predominantly strike-orientated Ogof Ffynnon Ddu system. This permits development of cut-off links in response to head differences generated between proto-conduits within a deep phreatic zone at Gough's Cave, such that low level hydraulically efficient conduits develop prior to abandonment of the upper levels via base-level lowering. The water table levels recognised in the Gough's Cave complex may therefore represent not true water table conditions (as appear to occur in the present River Cave), but simply geometrically fixed points in a continuum of base-level lowering induced cave passage evolution.

Recent exploration, especially by divers has thus provided new insights into the development of the Gough's Cave complex. Additional work, especially at key sites such as Damocles Rift will be important in resolving some of the ideas discussed above, but application of radiometric dating techniques such as Electron Spin Resonance will be necessary before the evolutionary sequence can be placed in a firm chronological framework.

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ACCESS

Access to Gough's Cave, Long Hole, Great Oones and Gough's Old Cave is controlled by the Manager, Cheddar Showcaves, Cheddar, Somerset, and written approval should be obtained in advance. Access to these sites may be restricted during the winter to protect hibernating bats. Divers must be fully qualified members of the Cave Diving Group.

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