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RESERVOIR HOLE: EXPLORATION AND SPELEOGENESIS

by

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Reservoir Hole, Cheddar, Somerset. NGR ST 4746 5447
Length: 2236 m Depth: 131 m

ABSTRACT

This paper presents an account of Reservoir Hole, including a description and survey of the cave and a history of exploration. The geomorphology of the cave is discussed : it demonstrates several phases of development, spanning multiple glacial-interglacial cycles. Initial cave development began when the water table was at, or above, 160 m OD. has fallen in stages to the current level of approx. 26 m OD. Uranium series and palaeomagnetic age data suggest that initial cave development began some time before 700 ka, and that dewatering of the higher parts of the cave took place prior to Marine Isotope Stage 11.

INTRODUCTION

Reservoir Hole is located on the south side of Cheddar Gorge, just above Horseshoe Bend at NGR ST 4746 5447 (Figure 1). The entrance comprises a small hole at 128 m OD. The cave has been almost entirely opened up by digging since it was first brought to the attention of cavers in the early 1950s. Recent discoveries include the remarkable 'Frozen Deep', the largest chamber yet discovered under Mendip and one of the largest in the country. Its position and vertical range imply that it was active as a conduit draining water from the Mendip plateau to the risings at Cheddar for a considerable period of time.

CAVE DESCRIPTION

Entrance Passages

From the gated entrance, crawling and stooping for 30 m leads gently downhill to a T-junction, where a dug passage on the left, South Passage, can be followed for 20 m as a muddy crawl to a 4 m high blasted aven. This passage is often partially flooded at the far end. To the right a rift passage leads quickly through Stanton's Drive into Moonmilk Chamber, about 5 m high and 3 m wide, developed along a fault. A path is followed to the right for about 20 m to the top of a 40 m vertical descent, excavated downwards between bedrock and boulders which have been stabilised in places with concrete, railway track and sleepers.

The climb down is broken into several shorter descents, the final climb being aided by a rope. Opposite the climb is a narrow eroded rift, which gets too tight after 10 m. The route on leads through boulders to a small, rift chamber with solutional holes in the roof. A short excavated crawl passage follows. Just before the short drop into Grand Gallery, a blind, low

bedding plane, Glühwein Passage, runs back parallel to the crawl. Continuing on, a scramble over stacked boulders emerges in Grand Gallery, a fine passage of rectangular cross-section, 6 m wide and 3 m high, descending at a shallow gradient for almost 60 m. Upstream, to the right, a route has been excavated through boulders for 20 m past two short climbs into a section of narrow, hands-and-knees excavated passage, Happy Snappers. This leads after 3 m to the Silo, a well-watered 10 m high aven. A small intermittent stream flows along the right-hand wall of Grand Gallery and a marked pathway on the left should be followed to avoid some interesting mud formations and moonmilk deposits.

At the lower end of Grand Gallery, a way ahead leads into Topless Aven, but the stream follows its course downslope to the right under the boulder floor of a low, wide and rather muddy passage. After an initial stoop the constantly dripping Pulsation Aven is entered where there are some attractive gour pools. Adjacent is the lofty Moonmilk Aven and a high-level connection exists between these two avens. A wriggle down a stal bank leads into a continuation where the main passage bifurcates at a prominent stalactite formation in Chain Chamber. At this junction the stream continues ahead down Jill's Slither and, after passing a wet weather showerbath on the right beside some black, manganese-stained stalactites, the Inkwells, the main passage continues on while the stream flows off down a descending bedding plane to the right. At the base, the trickle can be followed to the left along a low, gently descending passage with an arched roof. This terminates after about 8 m in a dig through mud banks. Continuing down the main route, the passage becomes increasingly muddy as it descends to a mud choke where a voice connection has been achieved with Potter's Heaven. Back in Chain Chamber, Potter's Heaven starts as a low muddy crawl to the left that develops into a roomy descending phreatic tube containing a number of large mud-covered speleothems. It ends in a small chamber, now mostly filled with digging spoil, where the voice connection was made back to Jill's Slither. Beyond, an excavated tube, The Hollow, leads along the strike for 15 m to a pool above which is a low bedding chamber. This area floods slowly in wet weather and is close to the level of the Cheddar Risings

Topless Aven and Golgotha Rift

Straight on from the end of Grand Gallery, the passage ascends to Topless Aven, about 20 m high with a prominent ledge, which was originally reached by maypoling, 12 m up on the left. This leads after 9 m to an 8 m climb and a further short passage and too-tight aven. Opposite the ledge is the 10 m long blind Edwards' Folly. The floor of Topless Aven is followed upslope and leads into a bouldery and well decorated grotto, where a handline has been installed to prevent muddying a tall stalagmite. At the back of Topless Aven, a 40 m climb up through boulders (dug open from below) is divided into three sections by two small, solid roofed chambers. In the second chamber a stoop under an unstable arch to the east enters the southerly continuation of Golgotha Rift, which ascends to a boulder choke. Concrete and stone walling has, again, been used to stabilise some of the route through boulders. The climb emerges from beneath large slabs into the awe-inspiring Golgotha Rift, a wide and lofty rift developed along a fault. It closes to the north in a near vertical choke of boulders that has been climbed to a short, decorated passage, Mrs Herbert's Grotto. To the south, the boulder floor ascends for 45 m, passing some stalagmite formations on the right wall that resemble skulls and evoke the name 'Golgotha'. Ahead, the boulder floor ascends and the rift increases to nearly 7 m in width. The climb steepens appreciably and a 12 m handline at the right wall assists an almost vertical stretch to a scramble up through boulders to a level area. This provides a good vantage point from which to appreciate the huge rift. Slickensides are visible on the left wall,

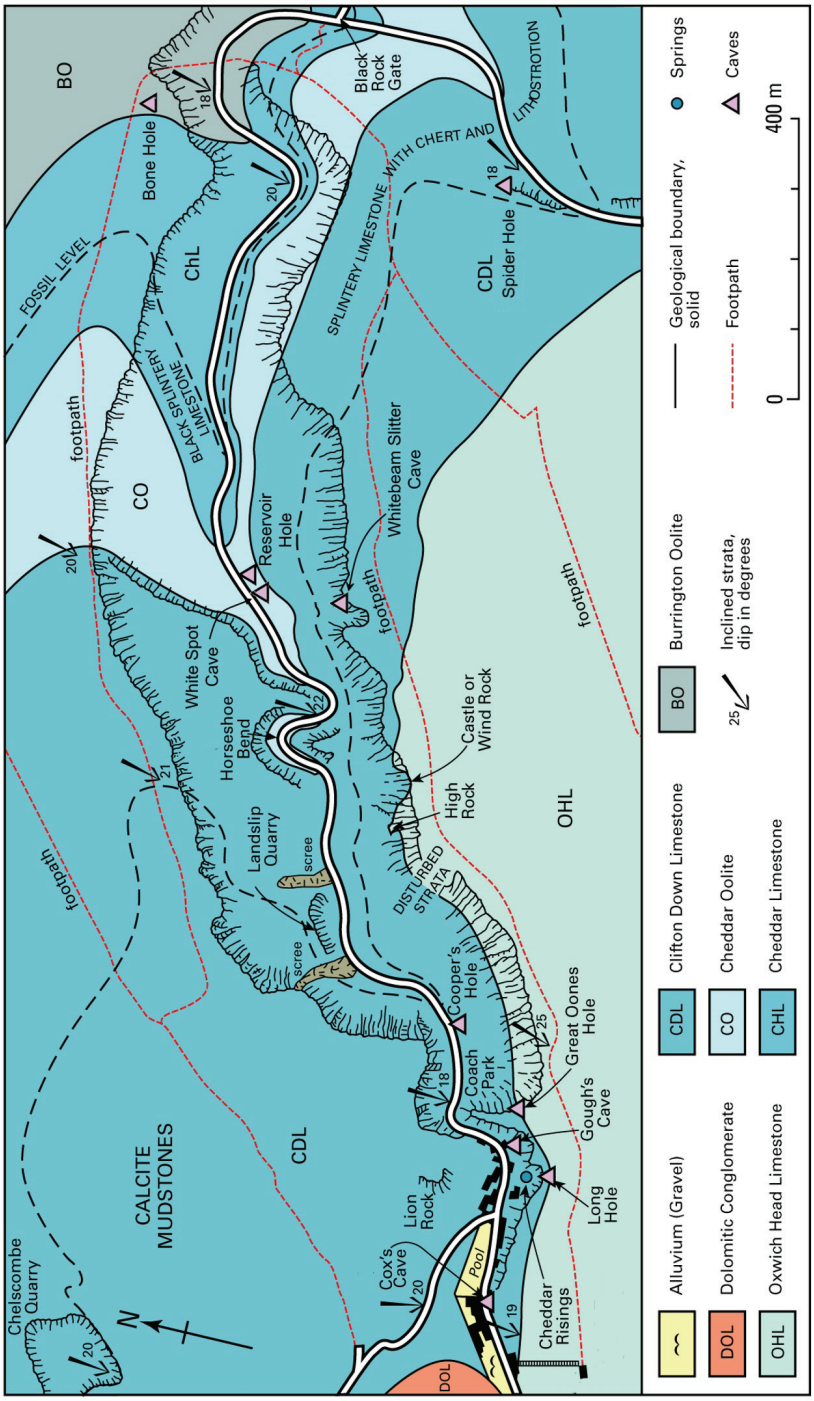

Figure 1. *Geology of Cheddar Gorge (from Farrant, 2008).*

across a void in the boulder floor. An 8 m fixed ladder continues up to a final 10 m of handline-assisted climbing to reach the boulder summit, with a large stalagmite boss, affectionately named Herbert Balch, immediately on the right.

A muddy chamber, Herbert's Attic, is entered by a slope down to the left, and a 3 m climb up piled boulders leads onto a causeway of digging spoil. Following the causeway to the left passes below a 12 m high aven, and a muddy tunnel leads to a 5 m shaft excavated down through boulders. From the opposite end of the causeway, a promontory looks back out into the blackness of the rift beyond.

Great Expectations and the Frozen Deep

The other passage leading off from the Topless Aven grotto leads to the right down an obvious draughting crawl. This has been excavated for 33 m to a point where an upwards wriggle gives access into a void above the crawl. This higher level passage, aptly named Great Expectations, can be followed in either direction. To the north, it trends back towards Topless Aven for 20 m and ends in a decorated 8 m long, 4 m wide and up to 8 m high rift chamber. Turning down-cave, to the south, from the entry point a sometimes low and uncomfortable, decorated bedding crawl, Hard Times, leads to a stooping-height arch which opens dramatically into Resurrection, a 25 m high and 6 m wide rift chamber with a very steeply upward sloping boulder floor.

A careful 30 m ascent of this loose scree and boulder slope leads to a handline-assisted climb to a balcony in the right-hand wall, WIS(h) You Were Here, and a spectacular view into The Frozen Deep, which has the largest chamber floor plan in the United Kingdom. A 10 m pitch broken by a platform on a boulder ledge reaches an unstable boulder slope in a lofty rift up to 30 m high. From here a careful descent first on the right then the left walls, partially aided by a handline, enters the chamber proper. The western side is dominated by two pure white 4 m high stalagmite columns and a very large stalactite. To the south the rift ascends to a magnificent grotto dominated by white totem pole stalagmites.

By following a taped path, it is possible to pass behind the largest column and descend over slippery boulders via a short fixed ladder climb to an area of mud floor scattered with calcite drip pits. On the roof at the northern side of the chamber at this point are some prominent phreatic pendants. Beyond the fixed ladder the chamber stretches under an arched roof to an ascending fault wall 40 m away. Its width is 40 m and the floor consists of a large boulder pile sloping to the south. A taped path has been laid around the chamber to avoid damage to some of the delicate floor formations that include many botryoidal stalagmites.

Two passages lead off from the south-west corner: one from the boulder floor, Pickwick Passage, and the other, Skyfall, starting further up the boulder slope. Pickwick Passage is entered by wriggling down and then along between boulders against the southern wall of the chamber. This awkward manoeuvre is followed by a 4 m descent of a vertical smooth-sided rift. The base of the rift opens out into a bouldery void that extends upwards and is directly below Skyfall. Where the passage first enlarges, a vertical hole over to the left provides a tortuous descent between boulders, with a couple of awkward squeezes. A seasonal heavy drip, probably the water from Skyfall, enters part of the way down. The route drops into solid limestone and continues as a low muddy crawl that bends left to break out into a larger section of passage. From here an ascending passage to the left leads back to where a visual, but impassable, connection can be made with the boulder descent, near the drip. Turning right, a flat out crawl opens out into a 10 m long and 6m high decorated but muddy rift. A letterbox in the wall at chest level allows access to another muddy rift chamber from which a draughting

eyehole opens directly onto a further section of rift, Dingley Dell. Here a mud slope descends steeply to a static sump. The 10 m high aven above this point has been climbed to a too-tight tube.

The underwater passage starts as a steeply descending tube about 1.5 m wide and up to 0.9 m high with a soft glutinous mud floor. Initially, the sump is static but after 15 m a low arch at a depth of 10 m gives access to a 3 m high rift with some active water flow. This is up to 1.7 m wide near the floor, but narrows at higher level. A slump in the floor at the point of entry to the rift denotes the exit for the water on the right (west) side down a low mud-choked passage which has been followed for 4 m before it becomes too tight. Ahead, the rift continues for a further 5 m to where the walls of the rift close in at a distance of about 20 m from base. The water flow comes from an impenetrable gravel-filled slot under the left (east) wall. Water levels can vary by 2-3 m depending on weather conditions.

The taped path to Skyfall branches off across a bouldery terrace and the entrance is easily identified by a large tilted slab, held in place by a chockstone. The floor at the start of this draughty, scalloped rift passage has been raised by digging debris and a crawl now gives access to an excavated route up through a boulder-filled rift. The upper section, a 4 m high vertical wall of partly flowstone-cemented rocks, should be treated with particular respect. Above this point the rift opens out into a high aven, up to 1.5 m wide and aligned north to south. In wet weather a steady trickle of water enters from an inlet in the roof. The northern end heads back towards The Frozen Deep but soon chokes. A short 2 m fixed ladder climb ascends to a gate designed to catch boulders and then to another fixed 2 m ladder. From here, a higher level stance can be gained by stepping up and across into a small overhead hole with a sloping flowstone floor. A vertical upward squeeze then provides access to a window out into the aven where a platform of flowstone-cemented boulders forms a bridge across to a northern extension which chokes after about 4 m. The aven extends upwards for a further 10 m, with the inlet entering near the top from the west wall. From the top of the second fixed ladder ahead to the south is a steeply ascending excavated tube. This enters a short crawl and a squeeze up through the Trapdoor an excavated hole in the stalagmite roof. Trapdoor Chamber is a 10 m high colourfully decorated rift about 1 m wide and 6 m long which pinches out immediately to the south and has a roof of stalagmited boulders to the north.

Ascension and the High Country

At the north-west corner of The Frozen Deep is Ascension, an ascent of 25 m against the west wall, adjacent to a rift filled with boulders. It is broken into two sections, and a wooden platform has been constructed at the head of the 12 m bottom pitch to keep ropes and ladders away from the wall of unstable infill. A 12 m ladder needs to be hauled up to this platform using a 30 m pulley line, and a 30 m lifeline is required. Alternatively a 30 m SRT rope can be used on this pitch. Behind the platform a steep debris slope leads up to the base of the next pitch, which has a fixed ladder The second pitch, of 7 m, gains a wide, decorated and bouldery stance, Heaven's Landing, where there is a choice of passages which together comprise the High Country.

To the right, a continuation of Heaven's Landing leads through Splash Chamber and a stooping-height, highly scalloped tube before terminating in a cross-rift, which breaks out at high level into The Frozen Deep. The remnants of this earlier passage can be seen continuing across the roof of the chamber. From Splash Chamber, a highly scalloped sinuous rift, Vertigo, can be followed by traversing at mid-level to where it also debouches into the roof of The Frozen Deep. There is a light connection between this point and the slightly lower level cross-

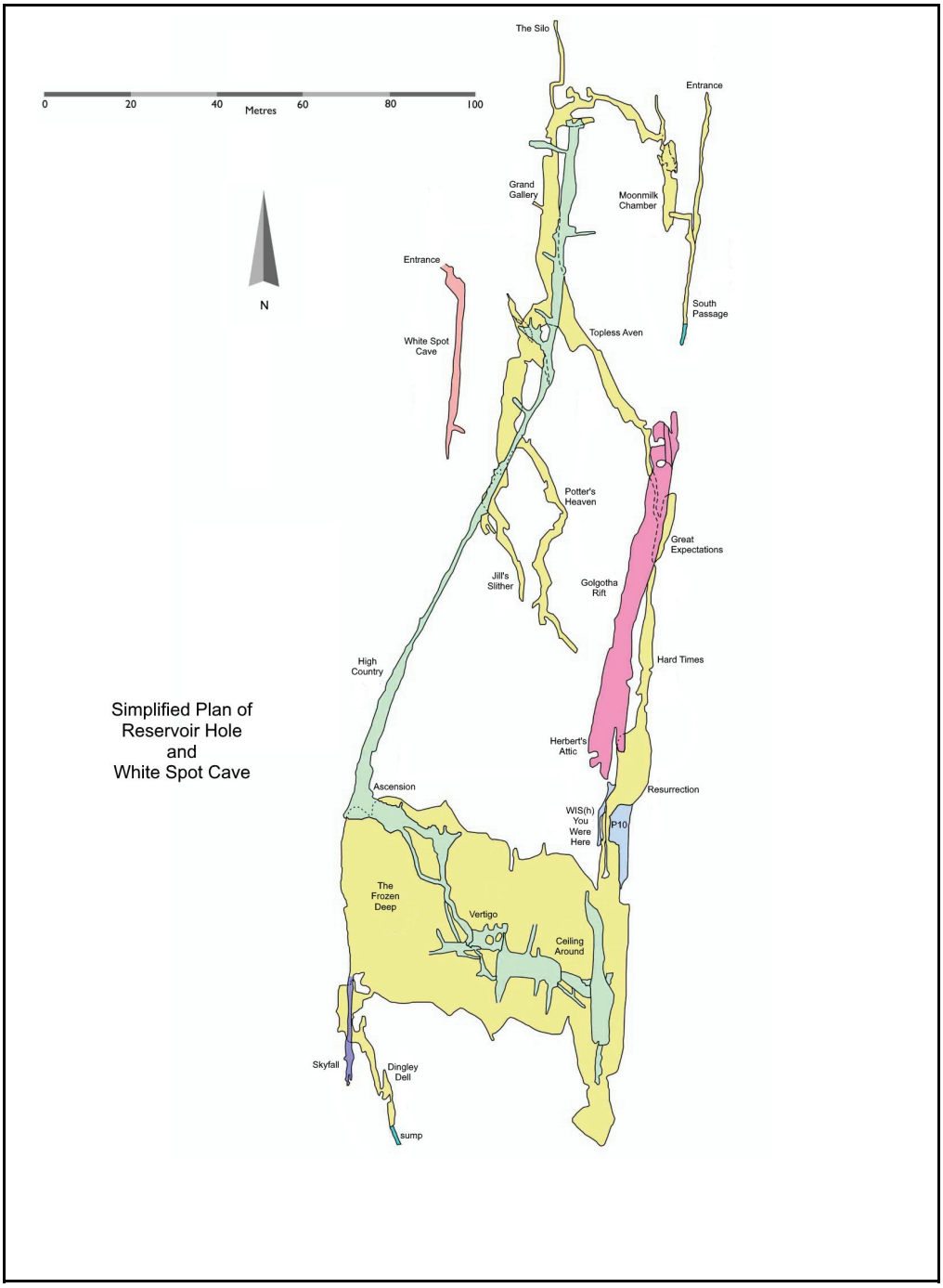

Figure 2. *Simplified plan of Reservoir Hole and White Spot Cave.*

rift mentioned earlier. By traversing out and up from the end of Vertigo, an extensive complex of well decorated interconnecting passages, Ceiling Around, has been explored, leading to the high rift of Ceiled Up. This rises up to a height of over 80 m above the floor of The Frozen Deep. Although most of these passages have floors, in places they have been intersected by the rifts that cut across the roof of the chamber giving rise to some very airy stances above drops of up to 35 m.

Returning to the top of Ascension, the main High Country passage is an impressive rift, up to 3 m wide and 14 m high, which heads NNE towards Grand Gallery. Much of the undulating floor of this passage comprises boulders and near the start an awkward 2 m ascent up a vertical wall of infill is made to gain the continuation of the passage. A taped path protects the fragile floor deposits of botryoidal stalagmite and care should be taken to avoid touching the moonmilk-covered walls. A large boulder tilted across the passage can be negotiated either by squeezing up from below or climbing over it using a pre-hung ladder. Of the few side passages in this linear rift, the first is found on the left, after about 100 m and immediately beyond a pair of fine goblet-shaped formations. Starting as a crawl above a narrow rift, progress is soon halted by a formation in the centre of the passage. An awkward excavated squeeze to the right gives access to a continuation, but after only 4 m the passage diminishes to a partly mud-choked rift which is impassable. The main route continues with an easy traverse over a blind descending rift in the floor, and some 20 m further the next side passage drops down steeply to the left. At the base of this slippery climb the passage enlarges and there are a few formations, but all options are choked or blind. A short drop by a large boulder should be descended on the left to preserve formations, and as the end of the High Country rift is approached the roof lowers before the passage rises to a junction. The branch to the left ends in a wet, muddy choke after a few metres, while ahead the main route is followed upslope to where it soon terminates in boulders and breakdown. This final point is only a few metres from the Gorge, and is located below the scree slope behind the reservoir.

HISTORY OF EXPLORATION

The exploration potential of what was originally just an insignificant hole on the south side of Cheddar Gorge was learnt when Luke Devenish met an old man in a Cheddar pub who had worked on the construction of the reservoir in Cheddar Gorge and had noticed a draughting hole in the cliff above. On April 22nd 1951, Devenish visited the cave with Willie Stanton and Stanton became the first person to enter the cave, getting as far as a moonmilk obstruction. A digging team, led by Devenish, subsequently blasted the entrance passage through four stalagmite obstructions to reach ‘the first chamber’. From there, a narrow passage continued south to end in a mud choke. Excavation there wasn’t considered practical, but a narrow rift that led back almost under the entrance passage entered a zone of three parallel descending rifts partially choked by boulders. The most westerly of these was dubbed Main Shaft and descended for 14 m until lack of stacking space and loose rock prevented any further progress. Holy Hole, the most easterly shaft, named for its pure white moonmilk walls, was also dug while attempts to dig upwards resulted in failure. Holy Hole was abandoned at a depth of 3 m when it pinched out. Stanton commented “this more or less, alas, puts paid to Reservoir Hole.” Digging did not restart until January 1965, 15 years later.

In 1965, the digging team decided to try blasting down Holy Hole. Meanwhile, Stanton was also working on a plan to drive a higher level tunnel into the proposed upward continuation of Main Shaft. The mined tunnel proceeded rapidly and after ten trips Stanton

entered to find a ‘gaping black rent’ opening to a rift chamber that extended northwards to a point only 5 m from the surface, with an abundance of snail shells suggesting an ancient entrance. A jumbled mass of boulders lay across the chamber and there was no indication of a solid floor anywhere. Smoke tests showed the draught percolated down through the boulders. Further work on the draught showed it to be influenced by air flow in the Gorge outside; a wind down the gorge caused an out draught and a wind up the gorge resulted in an in draught. By Good Friday and after 16 trips Holy Hole had been confirmed to enter the Middle Shaft and was basically a dead end.

After several trips digging in both Main Shaft and Middle Shaft, a probe in the floor of Moonmilk Chamber opened ‘a hole into blackness’. Middle Shaft was abandoned when it, too was found to re-enter the choked Main Shaft.

The digging technique used was to create a wideish shaft down the rift, although work had to be constantly done to keep the southern wall stable. This was achieved by positioning wide bridging boulders and the use of railway sleepers and welded track where no sleepers were available. Spoil was then stacked behind and above this and cement mix used to stabilize the completed structures. During this period the constricted entrance passage was also periodically enlarged. The solid walls of the rift proved to be none too solid in places and big flakes sometimes peeled away. Spoil not used for packing was neatly deposited across Moonmilk Chamber and a retaining wall was constructed around the Drive opening, allowing dumping behind it.

In February 1966, Stanton, on a solo trip, spotted a significant airspace at the base of Main Dig, although it took another 11 digging trips over the next three weeks before he could squeeze down into what was a small chamber created by massive jammed boulders in the rift. Work continued without him for a short while. He had suggested digging down against the west wall slightly to the south, but Will Edwards had started to burrow under the choke itself beyond the bridging boulders. This excavation can still be seen today

Work by Stanton restarted on his return from Portugal in February 1967, though Edwards had been working the dig during his absence. They were soon able to get into the next chamber down, where a small hole emitted a draught. They also started work on South Passage, work which was to continue intermittently for the next six years or so. Spoil from this work eventually completely hid the Holy Hole Middle and Main Shafts.

In October, Stanton turned the team’s attention to Main Dig and they had to face the problem of dropping through the draughting hole at the lowest point, surrounded as it was by unstable boulders. He measured the area around the hole and they came up with the idea of creating a short shaft of interlocked railway sleepers, chained together. This took a whole month’s work but the end result was a stable top to any hole they dug in the floor [and the ability to pack spoil around the sides of the sleepers as it was pulled up from below. Visitors to this location will see that it is by far the narrowest section of the Main Dig descent, but it must be noted that the floor level was originally at the base of the sleepers.

Stanton next returned in April 1968, he and Edwards carried in 80 lbs (36 kg) of sand and cement mix in tire inner tubes. Eventually, they enlarged the hole at the base of the sleeper shaft sufficiently for him to squeeze down into something new, a chamber mostly in solid rock with phreatic pockets in the roof. The slope in was very unstable so the diggers set about liberally cementing it. The next week, four anxious diggers watched Alan Trickey slide down even further into a lower space. After he emerged safely, digging down progressed. Stabilization was now wholly achieved by using copious quantities of premixed cement carried in inner tubes. Over the course of a year approximately 100 tubes of premix were taken into the cave.

After a three month hiatus whilst Stanton worked in Portugal, the cave began to yields its secrets rapidly. Within three days of his return, an entry had been forced into a northwards extension of the rift down a very steep and dangerous boulder slope. This area is unrecognizable today, the slope having been converted into a 3 m climb. Ten trips over the next month with numerous tubes of premix and a lot of walling enabled the team to peer into an inviting black space below and on 28 April 1969 George Brown slid into what is now known as Steps Chamber, a lofty phreatic rift with a short crawl off its base.

Figure 3. *Climbing up through a chimney constructed from boulders.*
Photo: A.P. Glanvill.

In October, the final two boulders in this dig were demolished and, after removal of more spoil, Alan Trickey squeezed through and enlarged the route for Stanton and Edwards. Stanton then took the lead and pushing some slabs aside he records that he was amazed to find himself "in a huge rock tunnel cross section c. 8' by 10' going down-dip away into the distance [Grand Gallery]. Alan and Will followed and Will led the way, very slowly to prolong the excitement, onward while we marvelled and exclaimed with fine abandon." The boulders were silt covered and the floor liberally covered in bat droppings both ancient and modern. Pulsation Aven was entered by Alan after 'a crescendo of agricultural noises'. They crossed the chamber and slid under the wall. Stanton's log states: 'We had been descending at a good angle all the way and we were beginning to listen for river noises' when they encountered the formations at what was latter called Chain Chamber after the chain Stanton installed on the wall to protect them. The passage then dwindled rapidly and they turned back shortly after encountering the manganese formations dubbed the Inkwells. With failing lights, they carefully retraced their steps. Stanton blew up the squeeze on the way out

and locked the cave when they left it 'without exaggerated hopes as to its permanence if word gets around'. The trip had lasted five hours.

The rest of October was busy with exploration and surveying. But activities paused again as Stanton had to return to Portugal and it wasn't until February 1970 that the team returned. Digging in the spring of 1970 was directed principally towards a promising looking choke at the bottom of Grand Gallery but side projects included Stanton's novel idea of clearing mud at the end of the cave, initially Jill's Slither, by focusing the power of the intermittent stream through a hose pipe and sprinkler which apparently started in quite promising fashion. There were also attempts to reach the stream heard in Chain Chamber. The promising dig proved to be exactly that and after only half a dozen trips Topless Aven was entered on 9 March 1970. There was a low passage going south and Stanton crawled down it for 30 feet (10 m) until it got too tight, although it gently draughted outwards.

At the end of October, a team arrived at end of Topless Aven to commence the assault on the ascending choke and after several trips Stanton began to envisage how progress could be made by constructing a sort of reverse well inside the choke using the one solid wall. This required careful selection of appropriately shaped boulders. After 16 trips and the help of 10 kg of explosives, they could see a space above them. The diggers worked their way up and in mid-March 1971, after 23 trips, a void, dubbed the Chamber of Horrors, was entered. Any hopes of a speedy breakthrough were dashed by the sight of the boulder choke extending ever upwards. The next three months proved to be one of the most dangerous phases in the exploration of Reservoir Hole and there were a number of narrow escapes. Eventually, on 1 July 1973, a large, unstable chamber was opened up and, Stanton states: 'giggling helplessly at the horridness of it all we crept stealthily about the chamber starting nervously at every noise.' To the north east was a narrow boulder choked rift thought to be a likely connection with South Passage. This was eventually abandoned as being just too dangerous to work on. More frantic boulder rolling and late nights ensued before Stanton was able to climb up an unstable slope into a massive ascending rift, but massive chockstones ahead prevented further progress until a process of walling was accomplished. At last they could move safely out and upwards. One digger was temporarily spooked by a skull on the wall that turned out to be a stalagmite, which led to the new find being named Golgotha.

There were numerous small mammal bones scattered about; fresh bat bones and those of mouse and field mouse were collected. As the team ascended, they started to realise just how big the rift was and combined tactics were required before, on 23 January 1974, they reached a chamber at the top dubbed Herbert's Attic. There was no pause in the digging effort and throughout the next 12 months there were over 40 working trips, concentrating on a dig at the end of Herbert's Attic (which turned downhill and became a shaft), stabilizing the climb up Golgotha with installation of fixed aids and attacking South Passage in the hope of a short cut to the end of the cave. Early in this phase, the north end of Golgotha was climbed to a short passage and pretty grotto named Mrs. Balch's Grotto.

South Passage was eventually abandoned after it became clear it wouldn't yield quickly and Herbert's Attic received the diggers' attention next. At the end of 1975, visits became more sporadic and after the shaft in Herbert's Attic had been found flooded on one occasion it was abandoned in January 1977 as 'mucky and unpromising'. Attention turned to the draughting crawl at the base of the climbs up to Golgotha. Right from the beginning, it was deemed to be a long job with spoil having to be chained out along the crawl, which was very much out of character for a dig by Stanton as virtually all other his other digs were in passage that could be enlarged to walking size. After the expenditure of a paltry 4 lbs. of explosive over 13 visits it was abandoned as 'hopeless'. It was to be left for another 31 years.

In 1985, Stanton developed an autoflush system in Pulsation Aven linked to a hosepipe in an effort to clean out Potter's Heaven. Edwards returned and the two of them started assaulting the choke at the head of Grand Gallery. Boulders were moved to create an antiblast wall protecting the rest of Grand Gallery, in the process covering the point of entry for the stream. Observation of the sediment showed that it was likely that material had been washed into the cave from the Gorge above. By now blasting techniques were much more efficient with explosive quantities greatly reduced through the drilling of shot holes. The last digging session by Stanton was on a trip with his son in law. He notes 'cementing next time, after some digging.' He never returned. His log book records about 10 more tourist trips, the last being in 1998 to inspect the gate. Will Edwards died in 1993 and Luke Devenish (who could be said to have started it all) passed away the following year.

For ten years, the cave remained the domain of bats and the occasional tourist. Willie relinquished the keys to a fellow caver and the leader system set up in 1970 was maintained. The cave would have slid into relative obscurity if it hadn't been for the discovery of the underground river in Gough's Cave. This changed things. Reservoir Hole was upstream of the end of Gough's Cave and there were roomy if choked fossil passages at its lowest point that flooded in wet weather suggesting a link with the underground river.

Digging restarted in December 2007 led by Peter Glanvill. The first forays were made in Potter's Heaven and Jill's Slither but a reinvestigation of the crawl above Topless Aven was deemed to be the best prospect and work was concentrated here for the next two years. Progress slowed after about 5 m and the dig at the upper end of Grand Gallery was also dug. The Topless Aven dig stalled when an almost permanent pool of water formed by the low digging face and most attention was given to the other, upper dig. Stanton's stooping sized passage was slowly moved forward along the solid left hand wall but cement and latterly some scaffolding were required to maintain a semblance of stability. This issue was brought sharply into focus as more boulders had to be brought down from the roof. A large gravity defying boulder, the Fridge, remained in the roof and after its eventual destruction dark space appeared near the wall. This needed enlarging before Nigel Cox, Peter Glanvill and Nick Chipchase passed through. They entered a narrow rift with a floor blocked by stalagmited boulders. The choke reared up behind whilst ahead the passage dwindled disappointingly to a stalagmited choke within 3 m.

However, the first discovery had been made in the cave since the 1970s and it seemed to have left the choke behind. Unfortunately, the removal of a few boulders revealed a low arch leading into a void that seemed to be walled and roofed by pebbles, the Silo. The only way to progress was to use a long bar to prod the roof and keep collapsing it. The large amounts of spoil and increasingly large boulders were kicked down the passage so that Stanton's stooping passage ended up being a crawl whilst back at the top of Grand Gallery the floor rose well over a metre and the walling became increasingly extensive.

As the Silo frequently required only two diggers, the surplus members decided to reopen a front in Potter's Heaven which had been abandoned for nearly two years. They were encouraged by the results of a probe with Nigel's homemade Cave Ferret – a video camera on a trolley pushed in on flexible drain rods. It seemed to show the passage enlarging about 3 m beyond a constriction. We made good progress and passed the constriction in 6 sessions. Conditions were unpleasant. The digger had to prise up slabs of mud then work them back to a drag tray behind them where they were hauled out on a lengthy rope. Potter's Heaven yielded some of its secrets in late September when John Williams managed to wriggle up into a chamber at the end of the tube. Below it lay a very constricted sump pool but the mud filled chamber was quite roomy with a rock pendant roof. There was little evidence of the draught

that had been encountered whilst digging. Digging at one end of the chamber commenced and on the second session the diggers found the sump was threatening to flood the entry tube so they slithered rapidly out and abandoned the dig again.

At about the same time the Silo gave up its secrets. Now cleared, it was revealed to be a well-watered fluted aven with 'hanging death' boulders in the roof. A survey revealed it to lie 20 m below road level so further progress upwards seemed inadvisable. It seems that the Gorge had bisected the system creating the debris for the diggers to work through. A different team took over work in the Silo in the winter of 2013 but after six months work they had dug down 3 m to find a solid floor and no apparent way on.

Figure 4. *Scalloped tube, Ascension*.
Photo: A.P. Glanvill

The diggers' options had dwindled to the Topless Aven dig. It was decided to remove the roof above the pool and the work went ahead on 3 January 2012. Forward progress was surprisingly rapid. Any sections of threatening roof were supported by pinned scaffold and cement applied to the loose left hand wall. For the next few months, steady progress was made and after 32 trips Cox and Chipchase could see into a void that did not seem to be just another gap in the boulders. Three more trips were required to stabilize a route up through them.

On 14 August 2012 a new chamber was entered. It ran back over all the passage that had been so assiduously dug for the last few years. The roof was extremely unstable. The likely way on from which the draught issued was a descending bedding heavily choked by large slabs. The chamber was named Great Expectations as it was Dickens' bicentenary

Tony Boycott and Peter Glanvill departed for a fortnight in Iceland but Cox and Chipchase returned the following week with Rob Harper who seemed to have a scent for success! Over the course of a six hour trip they broke and levered slabs aside sufficiently for Cox to wriggle forward and see the passage continuing. A larger team augmented by Alison Moody and Martin Grass returned a week later.

More excavation followed and at last a hole large enough for everybody to negotiate was engineered. And the party wriggled off down a knobbly bedding plane passage, fending off a run-in from the left hand wall. Confronted by a boulder breakdown Cox 'manfully' crowbarred it aside crawled through and entered the base of a very large breakdown rift chamber. Tony Boycott later suggested the name of Resurrection to continue the religious theme of the upper passages, and the unpleasant crawl was dubbed Hard Times. From the base, a loose scree slope seemed to ascend to a solid wall but it was found on closer inspection that the rift continued in one corner to the head of a deep pitch. They could peer into almost impenetrable darkness although some white stalagmite deposits glimmered far below. There was some discussion about leaving the cave and getting ladders from a car and one member felt he could free climb the pitch but in the end it was felt fairest to the remaining members of the digging team in Iceland to come back the following week suitably prepared for the descent. They were surprised to receive a text about the breakthrough while in Iceland and at first were somewhat sceptical until a phone call confirmed this was not a hoax.

A team returned the following Tuesday, September 4th 2012. Before Resurrection could be entered Cox climbed to the top to dislodge a massive unstable slab right on the proposed trade route. This done, they all climbed to the top and bolting commenced. Glanvill was given the privilege of the first descent into what Chipchase had decided would be called the Frozen Deep. The pitch head area had to have a name and after some thought WIS(h) You Were Here was decided on, a piece of word play containing Willie Stanton's initials, sadness that he wasn't there for this discovery, a reference to common sentiments expressed on a holiday postcard and the title of a Pink Floyd song which Glanvill liked.

Glanvill was pursued down the ladder by the odd stone; he had to kick off some massive slabs en route to the bottom and, after everybody had hurriedly descended the team set off to explore, marvelling at the now iconic trio of stalactite formations in the first part of what they soon realized was an extremely large chamber. Bat bones and guano were everywhere in evidence particularly in the south western corner of the chamber. Conservation was an early priority and it did not take long to establish a route around the chamber particularly as they had come armed with marker tape. Photographs were taken and mindful of the time they slowly made our way out somewhat overwhelmed by it all. The ensuing weeks were taken up by stabilization, path laying, filming for the BBC and a 3D LIDAR survey of the chamber by Kevin Dixon and Andrew Atkinson during which time a passage down through loose boulders in the south west corner of the cave was found and named Pickwick Passage to continue the Dickensian theme. It ended in a muddy chamber with a static sump – Dingley Dell. A probable passage high up on the north western wall could also be seen but after an abortive initial attempt to bolt up into it was foiled by rotten rock, Andrew Atkinson managed to enter it on 23 October. Dubbed Ascension, the climb led into a high rift The High Country that ended eventually only metres from the Gorge below a scree slope above the reservoir. Other passages suggested potential high level routes across The Frozen Deep but it was not until May 2013 that Clive Owen and Andrew Atkinson climbed into the roof from Ascension and explored Ceiling Around (a bad pun on the Frozen Deep). This proved to be a network of ancient rift passages intersected by cross rifts dropping into the chamber 35 m below.

The sump in Dingley Dell was initially dived by Glanvill on 16 October 2012 but only for a distance of 10 m. The following week, whilst High Country was being explored by others, Rob Harper explored it for another 10 m into a rift where there seemed to be water flow. In early May 2013, Duncan Price dived it again. The sump closed down although at the base a significant amount of water could be felt flowing across the passage.

The final phase of exploration was the establishment of a dig in the middle of the south wall of the chamber that was called Magic Smoke Dig after the disco smoke used to trace the draught. This was taken to a depth of 9 m before being mothballed in mid-2015. In the middle of 2013 a descending draughting tunnel was opened up off Jill's Slither and this was dug inconclusively over the course of half a dozen or so trips. Over a two year period ending in March 2015, an ascending choke in the south west corner of Frozen Deep was dislodged leading to a high rift (Skyfall) and the choke near the top excavated. On the 3 March 2015 a decorated rift (Trapdoor Chamber) was entered.

Currently the cave still offers opportunities for digging. The draughts in Frozen Deep are a puzzle and the draughts in Jill's Slither and Potter's Heaven also suggest potential for further exploration but any further extensions will be hard won. The underground river remains as elusive as it did 65 years ago.

SURVEY

The cave was surveyed between 2010 and 2015 using the now standard paperless method of data collection employing a DistoX modified laser instrument and PDA. Details of the methodology can be found in Mullan and Atkinson, 2013. A survey grade of UISv1 6-4 BEF is claimed. The raw data can be found at http://cave-registry.org.uk/ and a large scale drawing, somewhat more detailed than the simplified versions found in this paper can be found at http://www.ubss.org.uk/resources/surveys/survex/Reservoir-WhiteSpot.pdf

In addition, the Frozen Deep has been scanned using a Leica 3D laser scanner, kindly loaned by Leica Geosystems AG for the occasion. The resultant 'flythrough' video of the chamber can be seen or downloaded from http://cave-registry.org.uk/cheddarcatchment . Copies of the triangular mesh data are available on the same page.

GEOLOGY

Reservoir Hole is formed within the Clifton Down Limestone Formation, part of the Lower Carboniferous Pembroke Limestone Group (Waters *et al*., 2009). In the Cheddar area, the Clifton Down Limestone Formation is approximately 220 m thick and dips at c. 20-22° to the southwest (Fig. 1). In western Mendip, three distinct lithofacies can be recognised in the Formation (Green and Welch, 1965). The lower part of the formation comprises alternations of calcareous mudstone, white oolitic limestone and dark splintery limestones with scattered *Lithostrotion* corals up to 30-36 m thick. This passes up into grey to black rather fine-grained, locally stromatolitic limestones with sheets and masses of *Lithostrotion,* around 50 to 60 m thick. The upper part of the formation comprises dark grey to black calcite-mudstones — known colloquially as 'chinastone' — about 50-75 m thick. Stromatolites and algal limestones are locally common. In the Cheddar area, the lower part of the Clifton Down Limestone Formation is exceptionally thick, and the basal oolites and splintery limestones can be separated into two distinct divisions; the Cheddar Limestone Member, a basal dark limestone division

30-36 m thick, and the Cheddar Oolite Member, a white oolitic limestone c. 58 m thick (Green 1953, p. 20).

In Cheddar Gorge, the lower half of the Cheddar Limestone consists of dark grey granular limestone with a restricted fauna. Both in the gorge and farther west, the base of the Cheddar Limestone is poorly defined, the granular limestones merging into the top of the underlying Burrington Oolite. It is well exposed in the Gorge up-valley from Reservoir Hole where it consists of black, fine-grained, well-bedded, splintery limestone and mudstone passing down into dark grey and grey, current-bedded, fine-grained, detrital limestone with numerous *Composita* and *Productid* brachiopods at the base. The basal 15 m or so consists of grey, granular, crinoidal, rather fine-grained limestone with some oolite beds.

The overlying Cheddar Oolite Member consists of light grey to dark grey coarse oolitic limestones, typically cross-bedded and commonly porcellanous in texture, interbedded with a 2 m bed of grey and black calcite-mudstone and splintery limestone. Fossils are locally common including abundant *Composita*, *Lithostrotion aranea* (McCoy), *Chonetes* (Megachonetes) aff. papilionaceus, and *Productid* brachiopods. It is exposed in the Gorge between Reservoir Hole and Horseshoe Bend. The floor of White Spot Cave [ST 4742 5446] consists of limestone 20 m below the top of the Cheddar Oolite. The upper part of the Clifton Down Limestone crops out in the Gorge below the Horseshoe Bend. The Formation is marked by a locally abundant, but low diversity fauna including *Lithostrotion martini* (particularly in the lower and middle divisions), *Composities ficoidea*, *Davidsonina carbonaria* (confined to the lower division) and *Productus*.

Within the cave, Reservoir Hole spans over 130 m of elevation. The lowest part of the stratigraphy yet reached in the cave is the bedding plane on which the Grand Gallery-Jill's Slither conduit is developed. This prominent bedding plane is close to the base of the Cheddar Limestone Member, some 85 m below the top of the Cheddar Oolite.

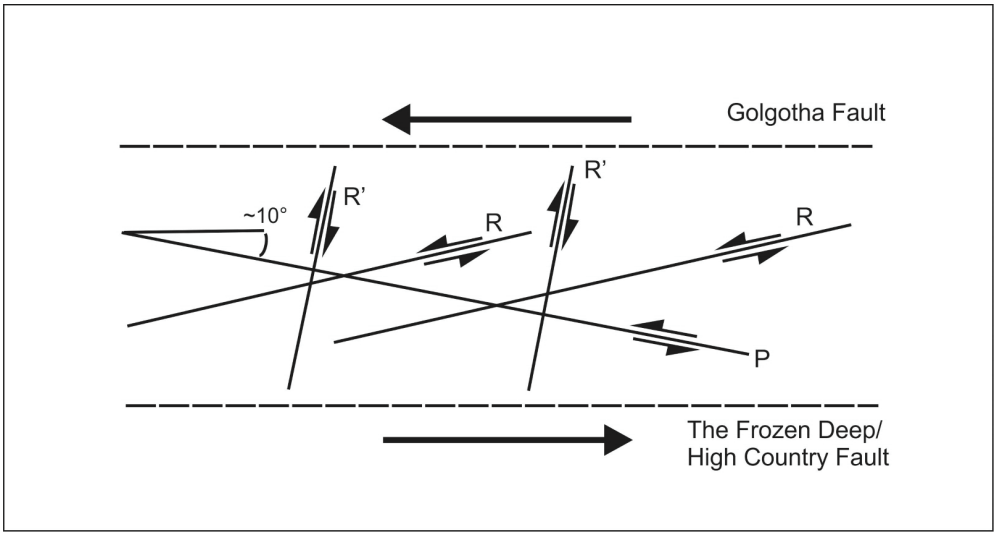

Figure 5. *The relationship between strike slip faulting and Riedel shears in the context of Reservoir Hole.*

Faulting.

A conspicuous feature of Reservoir Hole is a suite of vertically extensive rift passages. Many of these are associated with strike-slip faults. Slickensides are clearly visible in many parts of the cave. In particular, Golgotha, Resurrection, the eastern side of The Frozen Deep, and Ceiled Up are developed on a closely spaced network of parallel strike-slip faults 4-5 m apart. Another significant fault marks the western edge of The Frozen Deep and Skyfall. Many of the N-S orientated rifts in the roof of The Frozen Deep are also probably related to minor faults or major joints running parallel to the main fault.

Many of the other passages in the cave are oriented on fractures associated with the faulting (Figure 5). The passages orientated at c. 30-40° to the main fault guided rifts including Topless Aven, Potter's Heaven and Jill's Slither are formed along synthetic Riedel (R) shears, whilst High Country is formed along a P-shear fracture The east-west trending passage in Ceiling Around may in part follow R'-shears.

GEOMORPHOLOGY

Reservoir Hole is located part way between the classic swallet caves along the south side of Blackdown such as GB and Charterhouse Cave, and the resurgence caves at Cheddar, including Gough's Cave and the Great Oones-Long Hole system. It comprises a series of inter-linked, stacked relict cave passage segments, each representing an abandoned segment of Cheddar catchment conduit system. The higher level passages are now truncated by subsequent incision of the Gorge.

The location of Reservoir Hole is influenced by the presence of N-S orientated strike-slip faults, major joints and related fractures. These acted as favourable loci for initial conduit inception. The numerous fractures have allowed several parallel alternative flow routes to develop, rather than a single conduit. These fractures have also influenced the development of adjacent caves including White Spot Cave, Whitebeam Slitter Cave, Bone Hole and Spider Hole, all of which are characterised by N-S orientated phreatic rift passages.

Scalloping within Reservoir Hole clearly indicates flow from the north to the south. The large vertical range of the cave, over 130 m, suggests it developed over a protracted period of time, the cave being utilised as a major conduit over several glacial-interglacial cycles as resurgence base-levels fell. It is clear that the cave developed in stages, each stage partially utilising conduits formed during previous phases of development.

The initial phase of development was almost certainly along the major fault zone from the entrance area (South Passage), via Golgotha, Herbert's Attic and into Ceiled Up. This is likely to have been under deep phreatic conditions, probably when the water-table was >160 m OD. Water initially fed down dip along South Passage and the adjacent parallel passage before rising back up along the fault into Golgotha. The vertical and lateral extent of the fault zones allowed water to rise stratigraphically up through the limestone sequence, essentially acting as the rising limb of a phreatic loop. Much of this conduit is now blocked by collapse, partly due to the shattered nature of the fault zone.

Following base-level fall, a second conduit, High Country, developed 40-60 m to the south of Golgotha, when the water-table was at around 120-125 m OD. This lofty N-S orientated rift passage is developed along a minor strike-slip fault and in part on prominent bedding planes. It eventually links back into the Golgotha fault zone above The Frozen Deep via Ceiling Around. It does this by flowing east through strike-aligned phreatic tubes, intersecting several

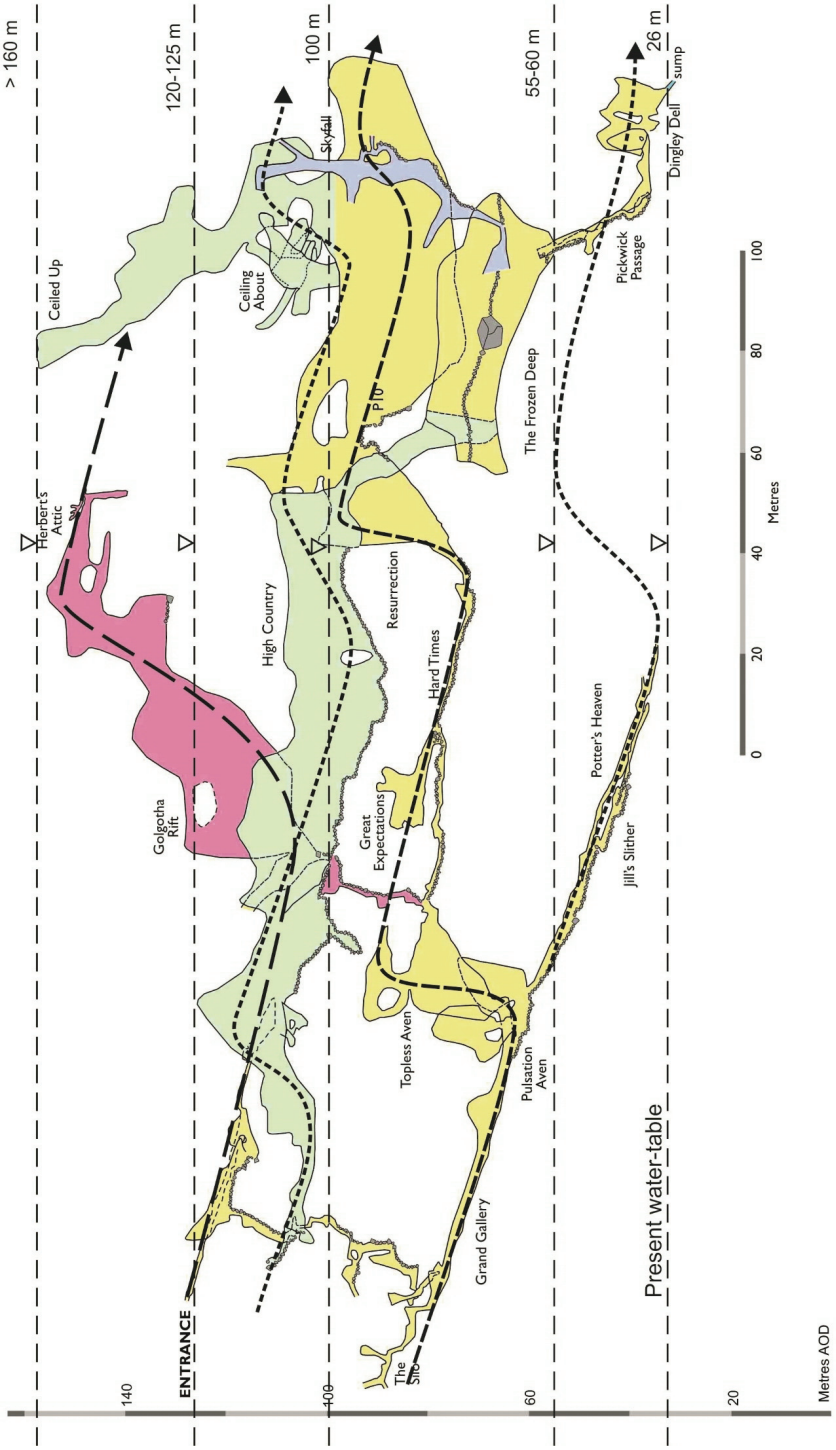

Figure 6. *Elevation of Reservoir Hole, showing elevation of the four main developmental phases, corresponding to water-tables at c. 160 m, 120-125 m, 100 m and 55-60 m OD. The present water-level is at c. 26 m.*

parallel N-S rifts above The Frozen Deep. It is likely that the South Passage-Golgotha-Ceiled Up conduit was still active as a flood overflow when the High Country conduit formed. Similarly, White Spot Cave is another parallel phreatic rift passage developed probably at the same time, but, as yet, not connected with Reservoir Hole. The size of the passages suggests that the Golgotha & High Country conduits were active over several glacial-interglacial cycles. Scalloping in the elliptical tube at the south end of High Country indicates a discharge approximately equivalent to that of the modern Cheddar Risings (Figure 1). This suggests that High Country was once at least part of the main drain for the Cheddar catchment rather than an inlet. The elevation suggests it was once part of the GB Ladder Dig (138 m) – Great Oones Hole (105 m) conduit.

A new lower level conduit, represented by the Grand Gallery, developed as a consequence of continued valley incision and base-level lowering at the resurgence. During this time, the High County & Golgotha conduits were finally abandoned. Unlike previous fault guided development, this new phase was focussed along a bedding plane close to the base of the Cheddar Limestone. The upstream end of the conduit ends in a boulder choke a few metres beneath the road in the Gorge. An aven here (The Silo) is probably a more recent development formed by invasive percolation water. Sandstone cobbles within the choke suggest that flood water flowing down the Gorge may have sunk here. Similar sandstone cobbles are absent in the lower reaches of Charterhouse Cave, so they seems unlikely they have travelled underground from the swallet caves. From the lower end of the Grand Gallery, water initially rose up into Topless Aven to feed back into the Golgotha fault zone at a lower level via Hard Times and Resurrection and on into a large phreatic rift which now forms the eastern side of The Frozen Deep. Flow was initially slow and phreatic as evidenced by large deep phreatic scallops above the pitch head at WIS(h) You Were Here. The water-table at this stage was probably at around 100 m OD. This correlates with the 120 m water-table level seen in Longwood Swallet, Manor Farm Swallet and GB Cave. The outlet of this conduit is not known, but was probably at c. 85 m OD, ie above the level of Gough's Cave. It is possible that the lower part of Long Hole or Gough's Old Cave represents fragments of this system, or possibly Sun Hole on the north side of the Gorge. It suggests there may be another as yet undiscovered upper level to Gough's Cave.

At some later stage, a much faster flow regime was instigated, as evidenced by much smaller scallops superimposed over the previous large phreatic forms (Figure 7). Similar well developed small-scale scalloping is also observed on the walls of the excavated passage between Topless Aven and Great Expectations, and also up into the base of Golgotha, up to an elevation of 100 m OD, indicating rapid flow (c. 1 ms^{-1}) to the south. This scalloping is also evident on many boulders in the boulder choke, indicating that collapse had occurred prior to conduit abandonment. This suggests the passage was reactivated, possibly during the development of the Longwood/Manor Farm (93 m) – Gough's Diamond Chamber (70-75 m) conduit.

As base-levels continued to fall, this conduit got progressively captured into first Potter's Heaven and then Jill's Slither when the water-table fell to c. 50-60 m OD. This correlates with the lowest of the former resurgence levels at Gough's Cave, at 45 m OD (the Boulder Chamber-Western Creep conduit; Farrant, 1991) and the 75-76 m level seen in Rhino Rift and Charterhouse Cave. Both Potter's Heaven and Jill's Slither are good examples of a descending limb of a phreatic loop developed down a bedding plane where it is intersected by a Riedel shear fracture. Both passages probably fed into rifts crossing what is now The Frozen Deep, possibly entering along its northern side where there is evidence of phreatic scalloping and roof pendants, but as the water table lowered, this route was probably abandoned in favour of lower routes now obscured by massive collapse. It seems most likely that the water drained south,

Figure 7. *Dual phase phreatic scallops at the top of the pitch down into the Frozen Deep (WISh You Were Here).*
Photo. A.R. Farrant.

down-dip along some of the joints and faults along the southern edge of the chamber. The phreatic rifts in Dingley Dell may date from this phase.

The modern active conduit does not follow the existing cave, but has developed an independent route. It probably drains south along the Golgotha fault zone before trending west along strike to meet the upstream end of the river in Gough's Cave. The discovery of a sump with flowing water in Dingley Dell suggests the active conduit flows beneath The Frozen Deep. The collapse of this conduit where it is crossed by a number of faults probably explains the origin of The Frozen Deep. The collapse of the chamber has probably caused the active river conduit to become at least partially blocked, forcing water to seek alternative 'by-pass' routes around the choke. The small, partially gravel choked conduit intersected at the base of the cave in Dingley Dell is probably one such bypass.

THE AGE OF THE CAVE

Relatively little work has been undertaken to resolve the timing of speleogenesis. Several speleothem samples were collected in 1993 for U-series dating (Farrant, 1995). Two samples were obtained from a stalagmite flowstone on both sides of a dug trench at the top of Herbert's Attic, just before the drop to the final dig face (RH-01-93; east side, RH-02-93, west side). The stalagmite layer, up to 10 cm thick is sandwiched by poorly sorted angular limestone gravels, silts and clay. Two more samples (RH-03-93 and RH-04-94) were collected from loose blocks at the base of and just below Golgotha Rift. Both these samples were not *in situ* and were derived from higher up the passage, where thin stalagmite wall coatings denote where former false floors occurred. In Moonmilk Chamber, a large stalagmite boss was retrieved from a drystone wall at the top of the climb down to Grand Gallery. The boss was not in situ, but almost certainly was derived from Moonmilk Chamber. From these samples, the basal portion

was dated using alpha-spectrometric techniques at the University of Bristol (Farrant, 1995). The results are shown in Table 1. As the samples were dated using alpha-spectrometric methods, they should be treated with caution as the large sample size and low precision of the dates means a precise age for the initiation of speleothem growth is not possible. However, they still can give a guide to the minimum age of cave abandonment. The dates suggest that much of the cave above c. 100 m OD had been drained prior to 300 ka.

Sample Location	Sample Number	Elevation (m OD)	Lab Number	U conc (ppm)	234U / 238U	230Th / 234U	230 Th / 232Th	Age (ka) with min and max ages	Comments
Herberts Attic (west side)	RH-02-93	150	6912	0.1838 (0.003)	1.1756 (0.013)	0.6691 (0.0180)	144.3936 (27.57)	115.4 (109.0 - 122.2)	
Gologotha Rift (loose block)	RH-03-93	110	6920	0.1346 (0.002)	1.0868 (0.008)	0.8467 (0.0168)	147.98 (20.79)	158.2 (150.5 - 166.5)	
Gologotha Rift (bottom date)	RH-03-93 B	98	6913	0.1944 (0.004)	1.0873 (0.016)	0.966 (0.0246)	104.678 (8.39)	309.3 (266.7 - 382.0)	
Below Gologotha (loose block)	RH-04-93	116	6914	0.1966 (0.002)	1.0692 (0.007)	1.023 (0.0289)	186.195 (77.96)	>350 (374.0 - infin)	Low Th yield
Moonmilk Chamber (stal boss)	RH-05-93	114	6915	0.1131 (0.002)	1.1533 (0.012)	0.9657 (0.0314)	190.16 (73.77)	286.6 (244.6 - infin.)	

Table 1. *U-series dates for speleothem samples dated in 1993 (from Farrant, 1995).*

More recently, additional speleothem samples were collected from The Frozen Deep, Ceiling Around and Skyfall (RH-1, RH-2, RH-3 and SKY) by Don McFarlane, Joyce Lundberg, Martin Grass and Nick Chipchase. RH-1 is taken from the top of the boulder pile of the Frozen Deep. It is about 3 cm thick flowstone with a modern coating, very dirty, opaque brown with a few paler lenses, the lowermost of which was drilled out for dating (RH1-B). Sample RH-2, also fallen from the ceiling, was taken from further down same the boulder pile. It is about 12 cm thick, flowstone complete with some of the rock on which it had grown, made of several layers with splayed growth form. It has a basal dirty layer, grading up to a cleaner palisade. A slice 12-14 mm above the base was taken for dating (RH2-B). RH-3 is a large broken flowstone curtain, which had also fallen from the roof, recovered from Ceiling Around. SKY is a piece of clean flowstone, about 15 cm thick, in growth position directly on top of a muddy sediment infill in a narrow rift of Skyfall. All these samples are from c. 100 m OD. U-Th disequilibrium dating was done by thermal ionization mass spectrometry (TIMS) at Ottawa-Carleton Geoscience Centre, Canada (Figure 9).

The oldest date, from the base of sample RH-1, is 370 ±13 ka (adjusted for detrital contamination to 368 ±16 ka). This indicates speleothem growth at the end of Marine Isotope

Stage (MIS) 11. The sample of flowstone is only 2 cm thick and full of detrital partings and hiatuses; thus, the date is not as reliable as the other two, cleaner, samples. Samples RH-2, a 12-cm-thick clean flowstone (with a basal date of 328 ±8 ka), and RH-3, a 3-cm-thick fragment of drapery that fell from the roof (with a basal date of 344 ±5 ka) began to grow at the start of MIS 9 interglacial period. These dates confirm the earlier alpha-spectrometric dates that indicate that de-watering of the cave had occurred during, or before, MIS 11. The sample SKY, although collected in order to add data on the most likely timing of upper level passage de-watering, yielded a date of only 10 ka, indicating resumption of calcite deposition in the post-glacial period after a period of sediment deposition, presumed to represent peri-glacial conditions above the cave during MIS 2. Thus this layer of sediment is not equivalent to the sediments collected by Farrant for paleomagmetic analysis (see below).

Sample	Age (ka)	+/-2σ	ppm U	^{230}Th / ^{234}U ±2σ	^{234}U / ^{238}U ±2σ	^{230} Th / ^{232}Th ±2σ	^{234}U / ^{238}U initial ±2σ
RH-1B	370 (368)	16/14	0.19	1.016 (0.005)	1.172(0.004)	33(1)	1.490(0.005)
RH-2B	329 (328)	8/8	0.17	1.008(0.004)	1.223 (0.001)	194(1)	1.563(0.002)
RH-3B	344 (344)	5/5	0.34	0.999(0.002)	1.147(0.001)	968(2)	1.390(0.002)
SKY	10.2 (10.0)	0.1/0.1	0.28	0.898(0.0004)	1.586(0.005)	51(1)	1.603(0.005)

Table 2. *Data from TIMS U-Th analysis. The value in parentheses beside the age is the calculated age if detrital contamination is assumed to have had an initial ^{230}Th/^{232}Th activity ratio equivalent to the crustal average (after Cruz* et al.*, 2005). Ratios are shown as activity ratios with 2σ error in parentheses. Dated using decay constants for ^{230}Th and ^{234}U from Cheng* et al.*, 2013. Isotope ratios measured on Triton TIMS, IGGRC, Ottawa-Carleton Geoscience Centre, Carleton University, Ottawa, Ontario.*

In addition to the U-series dating, a sample (RH-01) was collected from sediments at the base of the climb near the upper end of Grand Gallery for palaeomagnetic analysis (Farrant, 1995). The sample was collected from undisturbed clays and subjected to alternating field demagnetisation techniques in incremental steps up to 95 mT at the University of Plymouth Palaeomagnetic laboratory. The natural remnant detrital magnetisation had a declination of 348.3°, inclination of 15.6° and an a95 value of 62.1°. These values indicate that polarity of the sample was Normal, and thus mostly likely post-dated the Brunhes-Matuyama magnetic polarity reversal approximately 781,000 years ago.

These dates, coupled with other dated speleothem samples from elsewhere in the Cheddar catchment (Farrant, 1995), suggest, assuming a constant rate of incision, a maximum rate of valley incision rate of 0.20 mka^{-1} (± 0.01 mka^{-1}). As the incision of the Gorge fixes the level of the resurgence and is controlled by erosion to the south, this rate is equivalent to both the local and the regional base-level lowering rate. This incision rate suggests that the main Gough's show-cave conduit was abandoned by 110 ka, while the higher phreatic levels in Gough's Cave (Farrant, 1991) were abandoned by 250 ka, and the Great Oones Hole-Long

Figure 8. *Calcite specimens dated by Lundberg, indicating sampling sites.*

Hole conduit by c. 400 ka respectively. If this rate is extrapolated to the caves higher in the Gorge, including Reservoir Hole, it would suggest that that the Grand Gallery conduit was active at c. 275 ka while the higher level passages (Golgotha Rift-Ceiled Up conduit) was abandoned c. 700 ka and Whitebeam Slitter over 900 ka ago (Farrant, 1995).[1]

CONCLUSIONS

Digging in Reservoir Hole has enabled the discovery of an exceptional cave system with an unusual vertical range and one remarkably large chamber. Work continues in the further reaches and it is hoped that not quite so many years will pass before the next finds are made. At its most southerly point, exploration has reached active water flow a few above the level of the main river in Gough's Cave, the upstream limit of which is less than 120 m away.

A study of the cave geomorphology indicates that the cave represents an intermediate link between the resurgence caves at the bottom of the Gorge and the swallet caves along the south side of Black Down. It developed in at least four successive stages, each representing a fall in base level at the resurgence. The cave thus demonstrates that multiple independent relict

[1] Editor's Note. In March 2016, examples of cryogenic cave calcites were found in The Frozen Deep (M. Luetscher and G. E. Moseley *pers com*). The geomorphic implications of this discovery have yet to be fully worked out, but it demonstrates that at some point in the past, the permafrost layer extended at least as far as this chamber. This would mean that there was no water flow anywhere within the known cave. This discovery is perhaps unsurprising given the possibility of an open entrance in High Country and a strong inward draught into the cave during cold periods such as the Late Glacial Maximum.

conduits exist between the sinks and the resurgence. Dating evidence suggests that cave development began around 700,000 years ago.

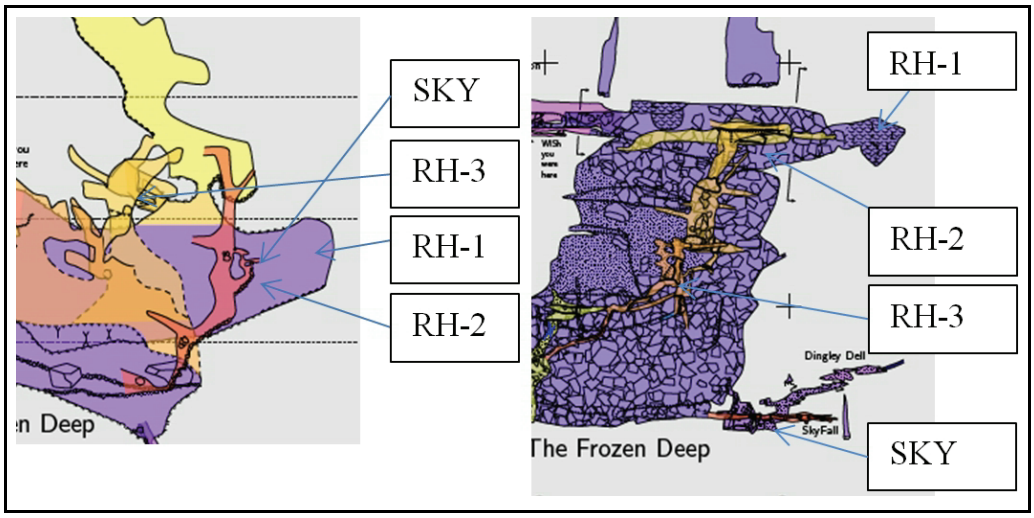

Figure 9. *Collection locations of specimens dated by Lundberg indicated on extracts of the elevation (left and plan (right) of the ful cave survey.*
After http://www.ubss.org.uk/resources/surveys/survex/Reservoir-WhiteSpot.pdf

ACKNOWLEDGEMENTS

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REFERENCES

CHENG, H., EDWARDS, R.L., SHEN, C.-C., POLYAK, V.J., ASMEROM, Y., WOODHEAD, J., HELLSTROM, J., WANG, Y., KONG, X., SPÖTL, C., WANG, X. and CALVIN ALEXANDER Jr, E., 2013. Improvements in ^{230}Th dating, ^{230}Th and ^{234}U half-life values, and U–Th isotopic measurements by multi-collector inductively coupled plasma mass spectrometry. *Earth Planet. Sci. Lett.* **371–372**. 82-91.

CRUZ, F.W., Jr., BURNS, S.J., KARMANN, I., SHARP, W.D., VULLE, M., CARDASO, A.O., FERRARI, J.A., DIAS, P.L.S., and VLANA, O., Jr., 2005. Insolation-driven changes in atmospheric circulation over the past 116,000 years in subtropical Brazil. *Nature*. **434.** 63–65.

FARRANT, A.R., 1991. The Gough's Cave System: Exploration since 1985 and a reappraisal of the geomorphology. *Proceedings of the University of Bristol Spelaeological Society.* **19.** 1. 3-17.

FARRANT, A.R., 1995. *Long-term Quaternary chronologies from cave deposits*. Unpublished PhD Thesis, University of Bristol.

FARRANT, A.R., 2008. *A walkers' guide to the geology and landscape of western Mendip*. British Geological Survey. Keyworth. Nottingham.

GREEN, G.W. and WELCH, F.B.A 1965. *Geology of the Country around Wells and Cheddar. (explanation of One-inch Geological Sheet 280, New Series).* British Geological Survey. HMSO.

MULLAN, G.J. and ATKINSON, A. 2013. A new survey of Gough's Cave, Cheddar Gorge, Somerset. *Proceedings of the University of Bristol Spelaeological Society.* **26.** 1. 27-36.

WATERS, C.N., WATERS, R.A., BARCLAY, W.J., and DAVIES, J.R. 2009. *A lithostratigraphical framework for the Carboniferous successions of southern Great Britain (Onshore).* British Geological Survey. Keyworth. Nottingham

APPENDIX

Caves in Cheddar Gorge longer than 50 m. All are on the south side of the Gorge except Canyon Cave and Bone Hole.

Name	NGR	Length (m)	Depth (m)	Altitude (m AOD)
Bone Hole	ST 4805 5472	320	42	185
Canyon Cave	ST 4698 5430	88	17	108
Cooper's Hole	ST 4682 5402	74	25	42
Cox's Cave	ST 4646 5390	99	10	23
Gough's Old Cave	ST 4668 5388	154	27	40
Gough's Cave	ST 4670 5391	3291	115	31
Great Oone's Hole	ST 4681 5393	261	37	94
Long Hole	ST 4668 5387	315	31	63
Reservoir Hole	ST 4746 5447	2196	131	185
Spider Hole	ST 4806 5424	136	86	184
Saye's Hole	ST 4663 5389	92	25	28
Whitebeam Slitter Cave	ST 4742 5433	75	9	214
White Spot Cave	ST 4740 5443	60	33	123

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