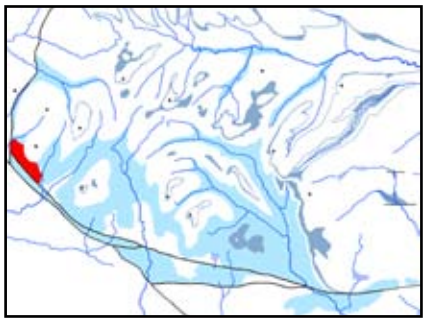
CHAPTER 20

Caves of Leck Fell and Ireby Fell

Tony Waltham and Tim Allen



Wrapped around the southwestern end of Gragareth, the belt of limestone outcrop between the cap of Yoredale rocks and the North Craven Fault overlies a host of interconnected caves that form the middle section of the Three Counties Cave System (Brook, 1968; Walsh, 2010). To the north they are linked by underwater passages to the Ease Gill Cave System (see Chapter 19). To the east, an old high-level trunk passage reaches close to Keld Head, but a link to the Kingsdale caves has not yet been discovered (see Chapter 21). More than 50 km of passages constitute this middle section of the Gragareth caves, including more than 3 km of underwater passages. The interconnected cave system is also the deepest in the Dales, with the entrance of Large Pot lying 253m above the lowest point reached in the upstream sump of Gavel Pot.

***Figure 20.1**. A flowstone cascade within the long stream passage that forms the Notts Pot Master Cave (photo: Paul Deakin).*

Caves of Leck Fell and Ireby Fell,
by Tony Waltham and Tim Allen,

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Most of the stream caves converge on either of two, long, low-level, main drains, one in Lost John's Cave and one in Notts Pot, which then join underwater to drain out to Leck Beck Head, along with the Ease Gill drainage. However, streams flowing through Marble Steps Pot, Rift Pot and Large Pot currently appear to join the Kingsdale waters to resurge at Keld Head. The area's drainage has not always been thus, and abandoned, high-level passages reveal evidence of a long and complex evolution of the cave systems.

Though nearly all the caves are interconnected, the passages fall into distinct groups. Beneath the heart of Leck Fell, Lost John's Cave has various tributaries descending to its main drain. Short Drop Cave and Gavel Pot lie directly above Lost John's, and there are related caves to the immediate north. At low level, the outlet to Leck Beck Head is largely underwater, but intersects dry passages in Witches Cave. Southwards and upstream, Notts Pot has a main drain with numerous tributary passages and also associated high-level passages. Even further upstream, Ireby Fell Cavern is notable for its old trunk passages, which are fortuitously intersected by a younger streamway. Beyond the Leck Beck Head catchment, Rift Pot and Large Pot breach a section of large old trunk passage, but have no apparent connection with the nearby Marble Steps Pot. Lying beneath the northern slopes of Leck Fell, the extensive series of passages in Pippikin Pot is essentially an extension of the Ease Gill Cave System, so is described in Chapter 19.

***Figure 20.2**. Dark Yoredale limestone overlying paler Great Scar Limestone, exposed in the short cascade midway down the main streamway of Short Drop Cave (photo: Paul Deakin).*

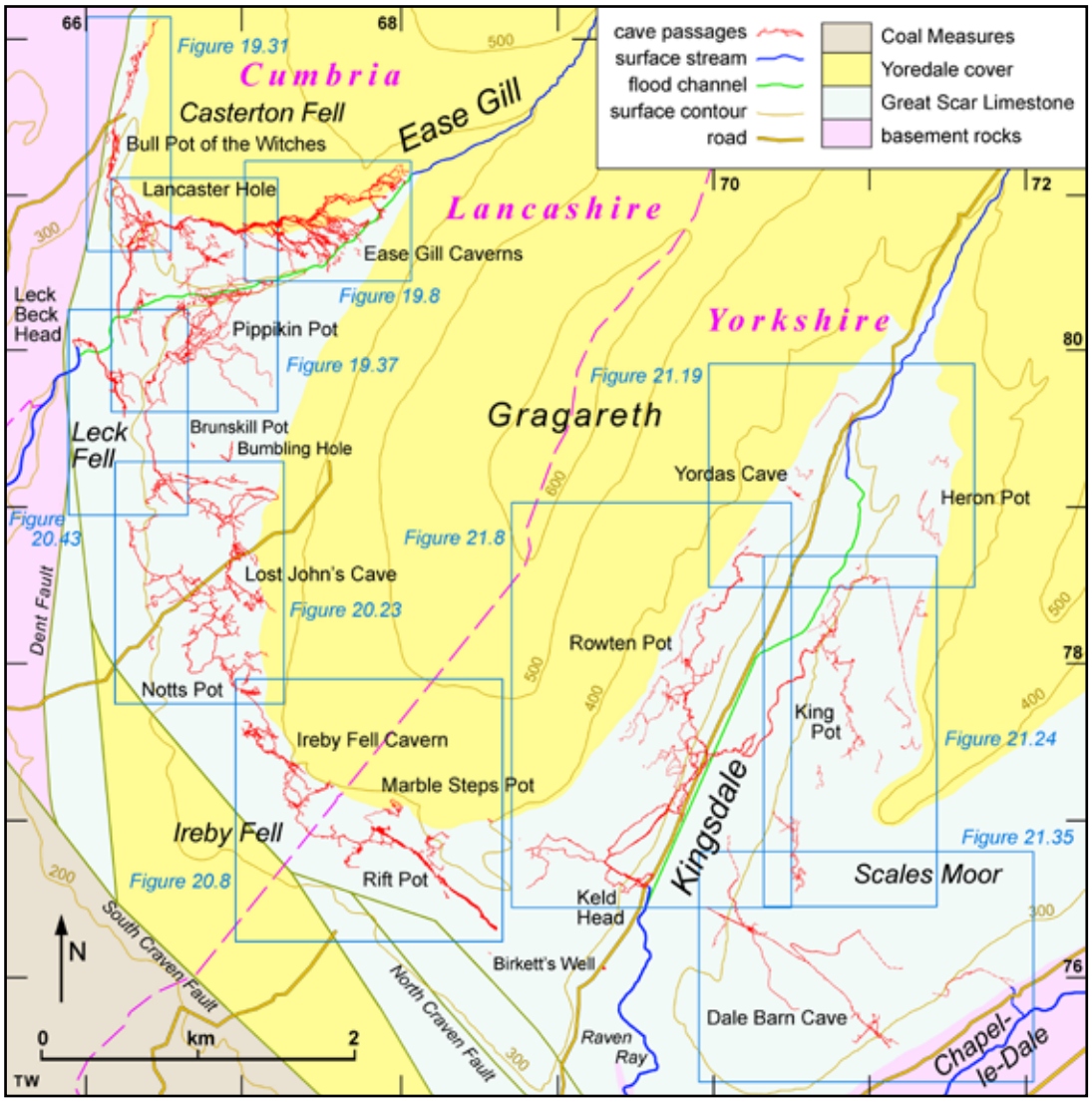


***Figure 20.3**. Caves that constitute the notional concept of the Three Counties Cave System. Passages explored all the way from Bull Pot of the Witches to Rift Pot pass beneath the two county boundaries and therefore have made the Three Counties Cave System a reality, but routes through to the caves of Kingsdale and Scales Moor have not yet been discovered. The Great Scar Limestone includes those Yoredale limestones that locally are contiguous with it to form a single cavernous unit. Further details of the Leck Fell and Ireby Fell caves are shown Figures 20.8, 20.23 and 20.43; the caves of Ease Gill and Kingsdale are described in chapters 19 and 21 respectively. The county boundary between Cumbria and Lancashire follows the Ease Gill streambed except where it diverges downstream of Leck Beck Head, and that between Lancashire and Yorkshire follows the topographical divide over Gragareth.*

The topography of the Leck and Ireby fells is singularly unexciting. Though over-run by Quaternary ice sheets, their position in the lee of Gragareth led to the ice having little erosive power and depositing large amounts of its sediment load. Nearly all the limestone is buried beneath glacial till that is up to 10m thick, and is consequently distinguished by numerous large and deep subsidence dolines. The caves are all within the Great Scar Limestone when regarded in its widest sense, with the Hawes and Gayle limestones locally contiguous with the underlying Gordale Limestone.

***Figure 20.4**. Panorama of Leck Fell, seen from the fell road to Bullpot Farm. Ease Gill is lower left, with Gragareth forming the skyline beyond; just right of centre, the poorly defined flat in the skyline, above the expanse of purple heather, is the profile of the limestone bench on Ireby Fell (photo: Jane Allen).*

Most of the sub-horizontal entrance passages in the Leck Fell caves are developed within these dark, thinly-bedded, Yoredale limestones (Fig. 20.2), as are the entrance shafts of the potholes on Ireby Fell. The Craven faults lie hidden beneath the till blanket, with the North Craven Fault passing only about 300m south of the closest known cave passages, and basement rocks are not exposed between the Dent Fault in the west and the Kingsdale inlier to the east.

Though the southeastern ends of the Ireby Fell caves reach well into the Kingsdale basin, the older cave passages and most of the modern caves drain towards the north and out into the lower end of the Ease Gill valley. They are best reviewed in a sequence heading northwards and downstream, from the highest sinks to the active and abandoned resurgences at and near Leck Beck Head.

Rift Pot and Large Pot

The main element of the caves beneath the Kingsdale flank of Ireby Fell is the large, abandoned, phreatic tunnel that extends for more than a kilometre, aligned from southeast to northwest (Fig. 20.7). It varies little in altitude except where its roof profile has been modified by collapse. Most of this passage is 10–15m high and wide, except that much of it contains piles of breakdown and huge amounts of mainly fine-grained, clastic sediment that reduce parts of it to low slots over wide mud banks (Pacey, 2014; Swire, 2016). Some of the sections with less sediment along the Eastern Front contain an abundance of stalagmites and straw stalactites, whereas the Necropolis chamber and Coates Cavern are both larger sections with floors of boulders and sand (Fig. 20.9). The southeastern end of Eastern Front is at a massive boulder choke that lies 100m below ground level and nearly 500m away from the flank of Kingsdale. This abandoned, high-level tunnel passes about 320m from, and 50m above, the nearest point yet reached from Keld Head within the Kingsdale Cave System; however this is in the active, underwater Southern Passage, which is unrelated to Eastern Front and is likely to pass beneath it. Just beyond Coates Cavern, another equally large boulder choke marks the northwestern end of this ancient trunk passage, still about 500m short of any likely continuation in Ireby Fell Cavern.

***Figure 20.7**. Calcite floor in Crystal Inlet, in Rift Pot, a section of passage developed on the cave's conspicuous bedding level at an altitude of about 295m (photo: Paul Deakin).*

Two known potholes have smaller, youthful passages that provide routes from the fell down into the chambers along the old trunk route. Large Pot has the active, Red Herring, stream passage that descends in the direction of Keld Head, to which it is almost certain to drain (Edwards, 1982). Its twelve shafts are all short, and silt banks prevent further progress in a large sump passage at a depth of 122m, therefore perched about 10m above Keld Head. Some 35m below the entrance, and still within the dark Yoredale limestones, a series of small, sub-horizontal, bedding-guided passages and narrow rifts leads to the head of a shaft that drops 45m into the Necropolis chamber. The entrance to Rift Pot is in Great Scar Limestone exposed at the foot of a deep doline. A short series of excavated rifts and bedding-plane passages descends to the head of a 55m shaft that breaks through the roof of Coates Cavern. East of Large Pot, the Mohole has deep rifts descending almost vertically for 100m to an

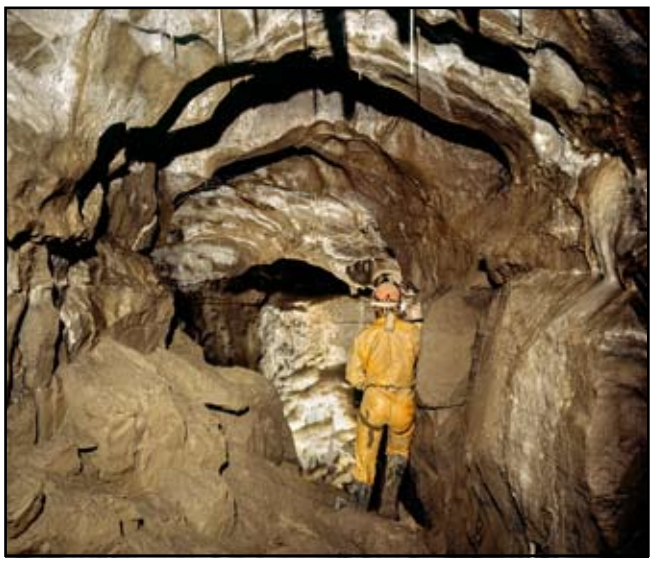


***Figure 20.5**. A domed phreatic roof on one of the smaller passages within Rift Pot (photo: Paul Deakin).*

***Figure 20.6**. The large trunk passage that is Eastern Front, with its height probably reduced by a considerable thickness of clastic sediments on its floor (photo: Jeff Wade).*

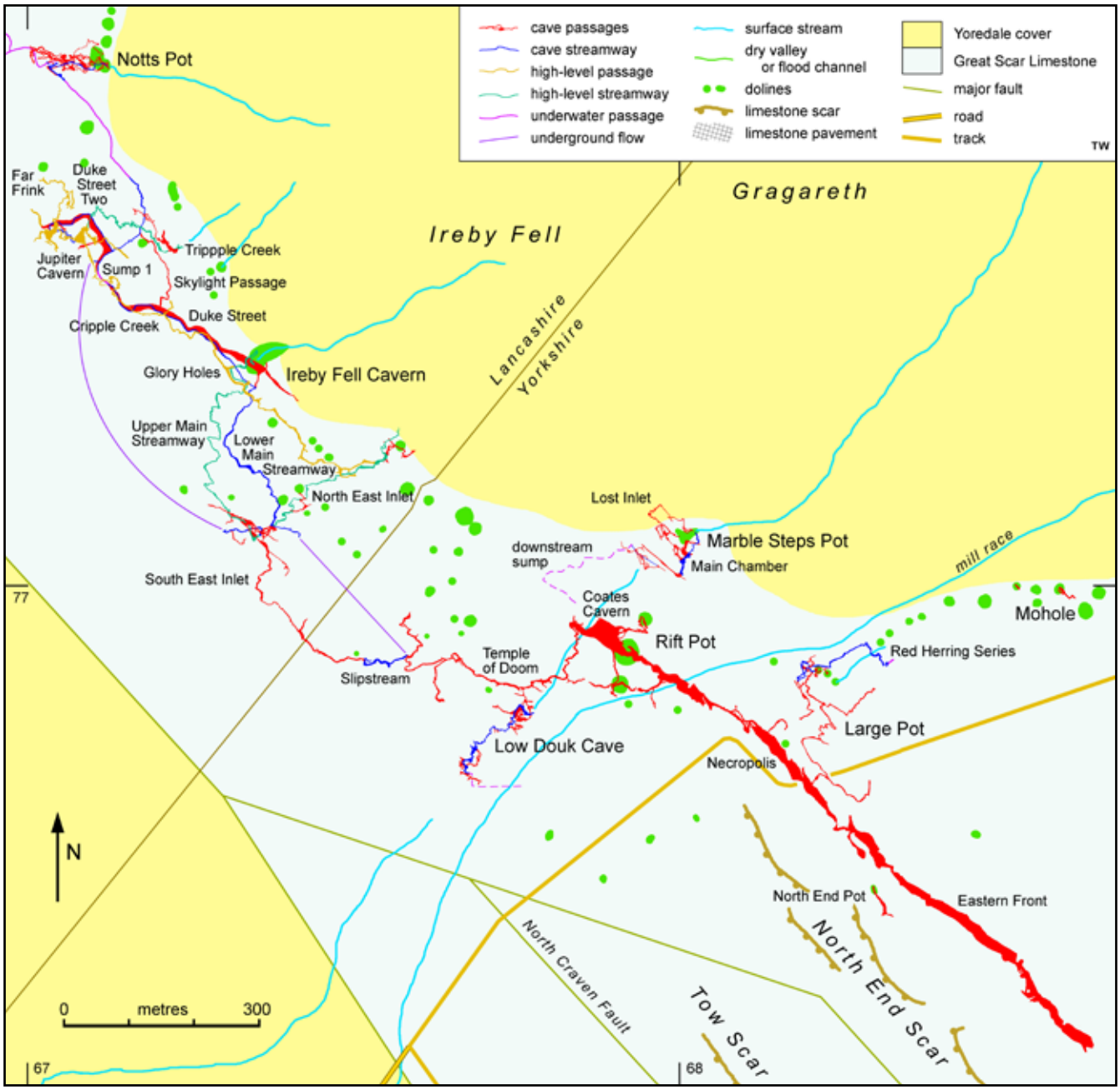
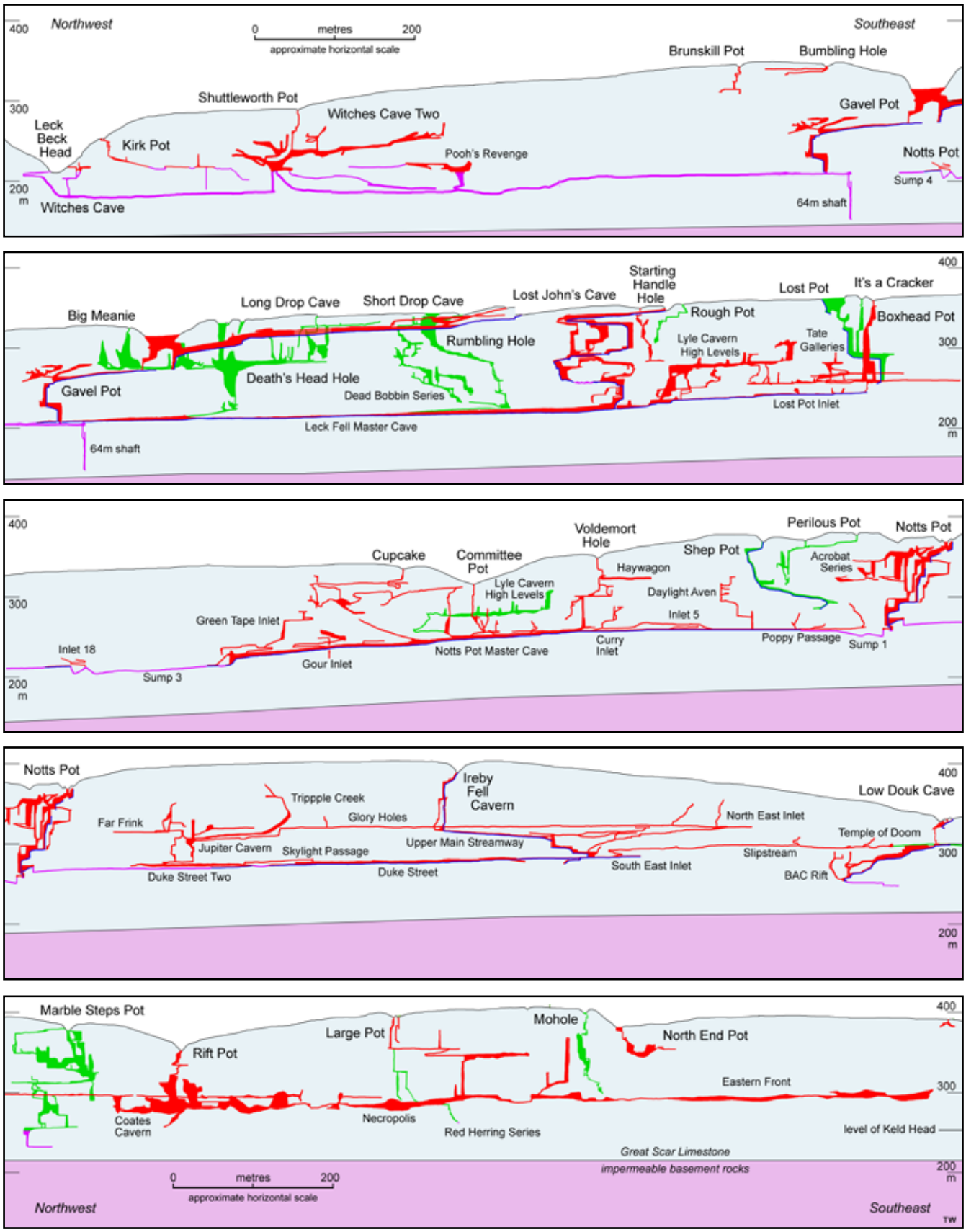


Figure 20.8. *The known cave passages beneath Ireby Fell and the area around Marble Steps Pot. The colour depicting high-level stream caves refers to no specific altitudes, but merely distinguishes cave streamways that lie at higher levels than others directly beneath. Minor streams and flood routes are not identified. Broken lines indicate approximate alignments of underwater passages not yet surveyed. Streams in Marble Steps Pot, Low Douk Cave and Large Pot all appear to drain eastwards to Keld Head. (After surveys by NCC, NPC, MMMMC, LUCC, HWCPC, SUSS and others.)*

unstable choke that is still 50m above water level (Allen, 2015). Well away from the shale margin, North End Pot is known only as far as a boulder-floored rift chamber; this is 50m above the Eastern Front trunk passage, though less than 100m from some tall avens.

With no passable connection into the adjacent cave systems, Marble Steps Pot remains something of an enigma. Its large, stepped, entrance shaft has been a major sink in the past (Fig. 20.11). However, the major passage descends steeply and is lost at a depth of only 90m where it is choked with boulders at the foot of a 25m shaft that can fill with



[opposite] ***Figure 20.9****. Coates Cavern, where the entrance passages of Rift Pot drop into an enlarged section of the old phreatic tunnel that extends into the Eastern Front (photo: Paul Deakin).*

Figure 20.10*. A sequence of profiles through the caves of Leck Fell and Ireby Fell. All profiles are projected onto alignments that are roughly northwest to southeast, and viewed towards the northeast. Some passages have been rotated slightly or displaced horizontally, and some side passages have been omitted (notably within the shaft complex of Notts Pot) to avoid overlap and improve clarity. Underwater passages are shown in purple, and the main cave streams are marked in blue. Cave passages shown in green lie behind those drawn red within these projected views. The basement rocks are not exposed west of Kingdale, so the base of the limestone as shown is approximate and diagrammatic.*

floodwater beneath the main chamber. There are four sinks feeding into the cave. Main Entrance (only active in flood), the wet route down Stream Inlet, and Lost Marbles Pot (into Lost Inlet) converge in Main Chamber. The permanent sink, further up the surface bed, probably also re-joins as a high-level inlet to Main Chamber. All the passages, both in the complex inlet series and in the twin downstream series, are influenced strongly by the multiple northwest–southeast joints (Waltham, 1968b). The two far passages converge on the lower streamway, where the flow is negligible except in flood. Downstream, an underwater passage that is largely a bedding-guided tube nearly 2m in diameter at around 20m depth, has been followed for 330m, initially towards the southwest but then turning towards Keld Head, to which it probably drains (Stanton, 2015). The southeastern end of the Lower Streamway (away from its sump) is a choked rift that issues the sound of falling water, which is probably the cave's main stream far below its normal sink in the Main Chamber, and is known to drain to Keld Head.

Figure 20.11. *Looking towards the north across the main entrance of Marble Steps Pot to where the person is standing close to the entrances to both the Stream Inlet and Lost Marbles Pot (TW).*

Figure 20.13. *The 30m shaft in the far series of Marble Steps Pot, a joint-guided shaft that is normally dry but is washed clean during major flood events (TW).*

West of Coates Cavern, the large phreatic tunnel is lost at a major boulder choke, some 600m southeast of its likely continuation as Duke Street in Ireby Fell Cavern. However, a route around this undiscovered link is formed by a kilometre of smaller passages that largely follow a bedding plane about 20m above the choke in Coates Cavern (Pacey, 2010). These are mainly phreatic tubes 1–2m in diameter. For much of their length, accessible passage is reduced in size by sediment, flowstone and breakdown, though some stretches are entrenched by small canyons where fill has been washed out by invading underfit streams. This chain of smaller passages departs at roof level from the main tunnel east of Coates Cavern; far to the west, after a long horizontal stretch, it descends gently as the South East Inlet into the stream passage of Ireby Fell Cavern. It thereby crosses the underground watershed between the catchments of Keld Head and Leck Beck Head.

Figure 20.12. *A dip in the corroded phreatic roof creates a very low and muddy section within the long, high-level passage that links Rift Pot to Ireby Fell Cavern (photo: Neil Pacey).*

Near the Rift Pot end of this trans-catchment passage, a small tunnel links to the upper galleries in Low Douk Cave and thereby provides another entrance to the cave system. Low Douk's main stream descends a meandering canyon draining from the base of a massive boulder choke that underlies a small complex of high-level chambers. The canyon ends at a sump in which a low passage along a bedding plane has been followed for 110m towards the east to a sediment obstruction; it drains to Keld Head. Above the Low Douk sump, the steeply inclined BAC Rift rises towards Straw Chamber.

Ireby Fell Cavern

Beneath a ruckle of boulders at the end of its conspicuous blind valley (Fig. 20.15), a sequence of short, clean-washed shafts forms the entrance series to Ireby Fell Cavern (Atkinson, 1949). At a depth of nearly 60m, a meandering canyon known as the Upper Main Streamway heads southwards for 400m, then drops down the Well and Rope shafts into a complex area of inlets. The canyon then heads back almost beneath itself as the Lower Main Streamway, with a trench in the floor of the older phreatic tube from Rift Pot (Fig. 20.14), which enters as the South East Inlet. This invaded passage eventually breaks out into the large tunnel of Duke Street directly beneath the entrance at a depth of 110m. Some 30m beyond the Rope waterfall, the stream escapes from the canyon into a bedding-guided passage under the left wall; it then descends a short streamway to a sump and is next seen emerging from flooded rifts to form a short inlet into Duke Street Two. The Lower Main Streamway only takes water from the inlets, along with overflow floodwater from the entrance stream.

***Figure 20.14**. The Lower Main Streamway in Ireby Fell Cavern, with its vadose trench cut beneath the phreatic tube that emerges from the Rift Pot linking passage (TW).*

***Figure 20.16**. A beautifully fluted wall on the Bell shaft in the entrance passages of Ireby Fell Cavern (photo: Mark Burkey).*

Duke Street is 300m of abandoned phreatic tunnel, most of which is 5–8m high and wide, with its underfit stream draining between banks of gravel and sand towards the northwest (Fig 20.17). Beyond the gentle down-loop that forms Sump 1, Duke Street Two is an even larger passage, notable for its exposed sections through thick sequences of clastic sediments (Fig. 20.19). The stream turns off into a small, gently descending canyon leading to a long canal and the sump through to Notts Pot. Skylight Passage links the Whirlpool roof dome in Duke Street with the streamway towards Notts Pot, providing a sump by-pass along a bedding plane passage just a few metres above the main old tunnel.

***Figure 20.15**. The blind valley cut into glacial till upstream of the stream sink entrance to Ireby Fell Cavern (TW).*

***Figure 20.17**. The underfit stream flowing through the old phreatic tunnel of Duke Street in the lower reaches of Ireby Fell Cavern (photo: Paul Deakin).*

Above the Rope waterfall in the streamway from the entrance, a complex of roof passages leads into the North East Inlet, with its canyons and high-levels that end in chokes and avens still 40m beneath the fell surface. Roof passages in the lower part of the entrance series lead into the long, abandoned Glory Holes passage, which extends towards the southeast into the high-levels of North East Inlet. Downstream towards the northwest, this long, small, sub-horizontal passage continues as Cripple Creek and remains 50m above Duke Street until it steps down a few beds before breaking out into Jupiter Cavern (North, 2009). This is 30m long and lies at the junction of several passages midway down a major inlet series (Wood, 1969).

Upstream and towards the east, the fine canyon of Blissful Creek ends at Trippple Chamber where inaccessibly small inlets converge only about 20m beneath a number of choked dolines. Jupiter Cavern is a major vertical feature, with an aven rising 40m into its roof and a floor of breakdown blocks that is collapsing into the Escalator Rift beneath. The adjacent Frink Chamber also has a floor of breakdown and a high aven in its roof, and lies at another convergence of multiple high-level passages. Beyond it, the Far Frink passage extends northwards to a calcite-cemented choke. Beneath both chambers younger stream routes descend into Duke Street Two close to the sediment choke at its northern limit of current exploration.

***Figure 20.18**. Whirlpool Chamber in the Duke Street tunnel in Ireby Fell Cavern, with its high-level tube (in deep shadow) linking through to Duke Street Two (photo: Paul Deakin).*

***Figure 20.19**. The large phreatic tunnel of Duke Street Two, with its extensive banks of stratified clastic sediments, in Ireby Fell Cavern (photo: Mark Burkey).*

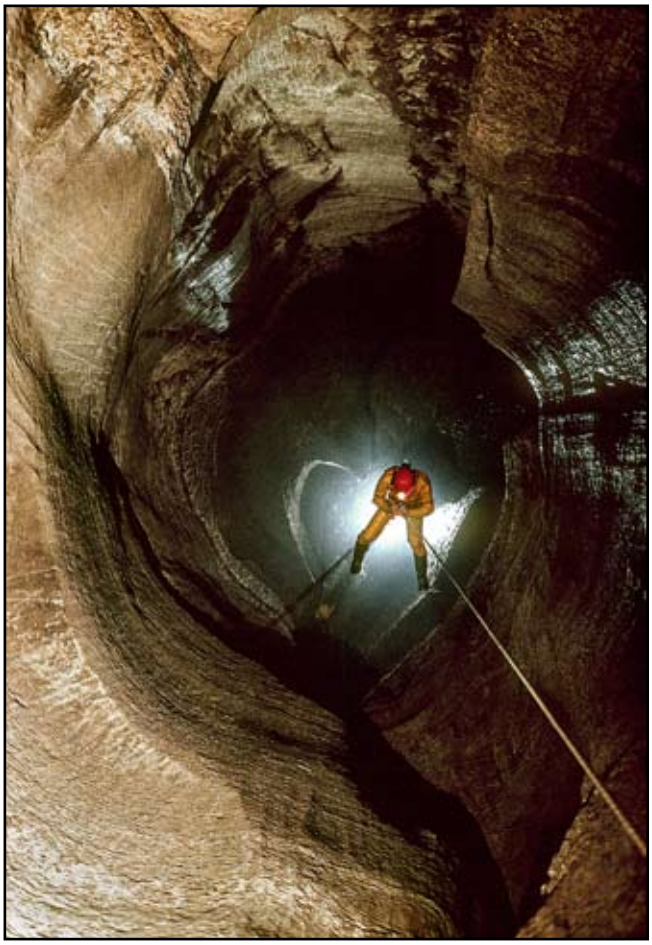


***Figure 20.20**. The vadose shaft with the Double Bucket descent in the Left Hand Route down Notts Pot (photo: John Forder).*

Notts Pot and its inlets

From the floor of a multiple and partially collapsed doline within the thick glacial till, a descending canyon in Notts Pot provides one of a number of routes down to Three Ways Chamber (Gemmel and Myers, 1952). Beneath this lies the most complex cluster of shafts yet found in a British cave. Formed in a zone of intersecting vertical fractures, five shaft systems with numerous interconnections ultimately converge on an outlet streamway 60m below the chamber. Abandoned high-level passages in the Acrobat Series head westwards (Brook and Crabtree, 1969), but all can be followed only as far as major chokes of clastic sediment and breakdown. Below the convergence of the main routes, the short, lower stream passage descends two more shafts, into the roof of the streamway from Ireby Fell Cavern. Less than 30m upstream, a deep pool is the top of an underwater pot where the flow rises 10m at the end of an active, phreatic loop 220m long. Downstream and below another short cascade, the combined waters enter a sump 210m long through to the head of the main streamway in Notts Two.

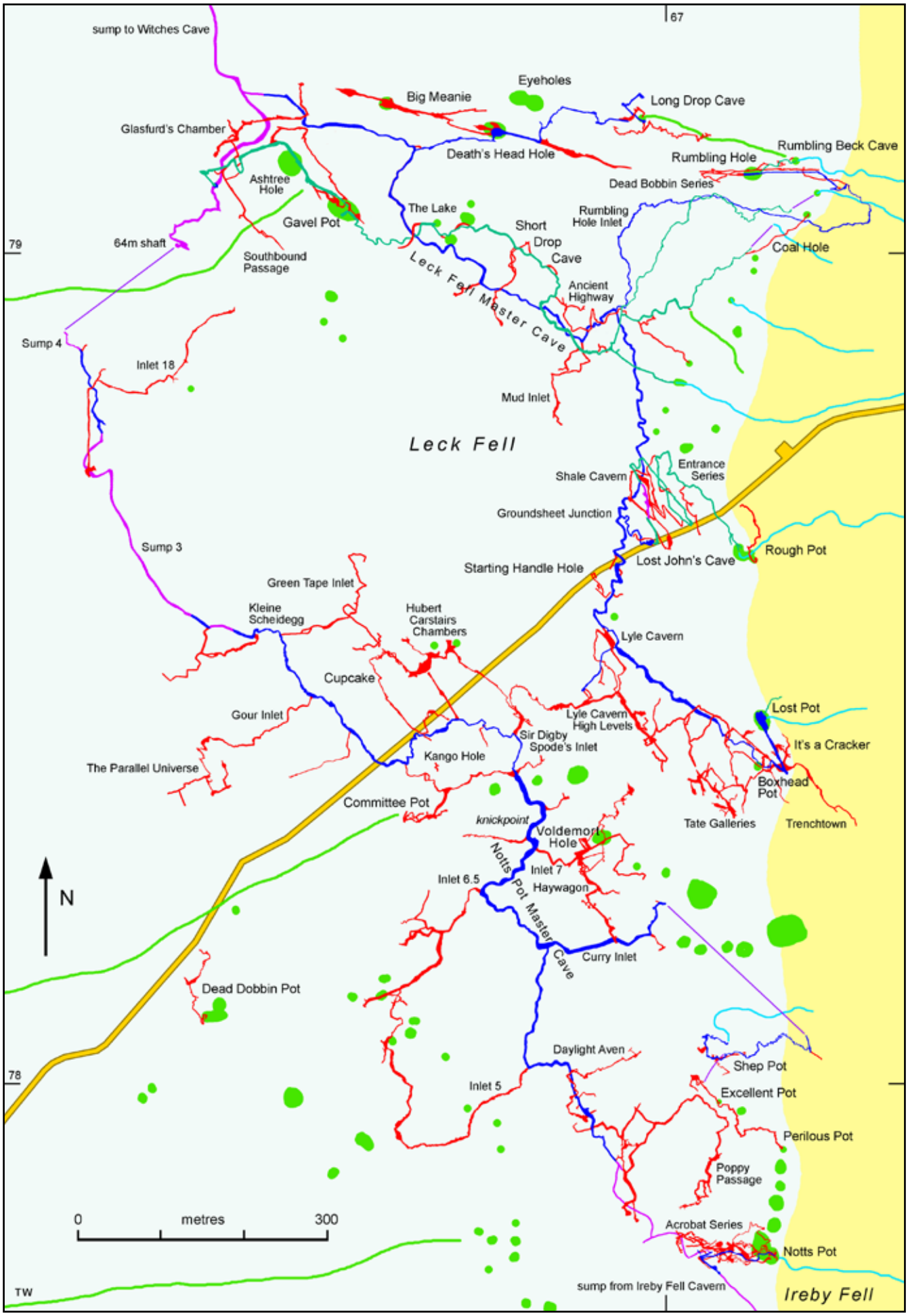
Within Notts Two (commonly written as Notts II), the 1300m-long streamway that lies between Sumps 1 and 2 (Stanton, 1987) is widely known as the Notts Pot Master Cave (Fig. 20.23). It is a classic main drain with numerous inlets, but it descends about 30m, with no significant waterfalls, and so barely fits the bygone concept of a base-level master cave. From the Sump 1 exit some 400m of slow-flowing canals lie within an almost horizontal, partially drained, phreatic tube

***Figure 20.21**. The doline complex where a debris floor collapsed early in 1946 to reveal the entrance to Notts Pot (TW).*

2–3m in diameter. The following 250m of passage descends very gently with the water starting to cut into the floor of the old tube (Fig. 20.22), and much of this part of the streamway is more than 5m high and wide. A metre-high cascade marks the knickpoint at the head of a narrow, meandering canyon. The tube continues above the canyon until it turns to the west to form the dry passage through to Inlet 13 where it is lost in the boulder choke below Mincemeat Aven. A branch of the tube continues north over the streamway, until it rises gently up Sir Digby Spode's Inlet and is lost in the choke within the faulted ground between Notts Pot and Lost John's Cave.

More than 500m downstream from the knickpoint, the canyon is around 12m deep, and a series of small cascades culminates in a 2m drop into the Kleine Sheidegg chamber. The stream then flows through another 500m of sumps, by-passes and gently descending streamway, until it cannot be followed past gravel banks 30m into Sump 4 (Skorupka, 1995).

***Figure 20.22**. The upstream part of the Notts Pot Master Cave with a phreatic half-tube forming its roof profile (photo: Brendan Marris).*


sump to Witches Cave
67
Eyeholes
Big Meanie
Long Drop Cave
Glasfurd's Chamber
Death's Head Hole
Rumbling Beck Cave
Rumbling Hole
Ashtree Hole
Dead Bobbin Series
Gavel Pot
The Lake
Rumbling Hole Inlet
79
64m shaft
Short Drop Cave
Coal Hole
Southbound Passage
Leck Fell Master Cave
Ancient Highway
Sump 4
Inlet 18
Mud Inlet
Leck Fell
Entrance Series
Shale Cavern
Groundsheet Junction
Sump 3
Rough Pot
Starting Handle Hole
Lost John's Cave
Green Tape Inlet
Kleine Scheidegg
Hubert Carstairs Chambers
Lyle Cavern
Cupcake
Lost Pot
Gour Inlet
Lyle Cavern High Levels
Sir Digby Spode's Inlet
It's a Cracker
Kango Hole
The Parallel Universe
Boxhead Pot
Committee Pot
knickpoint
Tate Galleries
Trenchtown
Voldemort Hole
N
Inlet 7
Inlet 6.5
Haywagon
Notts Pot Master Cave
Curry Inlet
Dead Dobbin Pot
Daylight Aven
Shep Pot
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Excellent Pot
Perilous Pot
Poppy Passage
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metres
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sump from Ireby Fell Cavern
Ireby Fell

***Figure 20.24**. Notts Pot Master Cave, at its confluence with Inlet 6.5 (photo: Chris Howes).*

***Figure 20.25**. The phreatic passage above the vadose canyon in Shep Pot (photo: Mark Richardson).*

The numerous inlets into Notts Two intersect or occupy various old high-level passages and also include routes that can be followed from subsidiary entrances on the fell. A passage above the upstream sumps leads to the choked Moribund Inlet with a draught that may indicate a link to the high-level Acrobat Series in Notts Pot. Low and muddy passages east of the sump extend through Passchendaele to Poppy Passage (Fig. 20.26), which continues in similar style as far as rising rifts and boulder piles that are also close to the Acrobat Series (Ramsey, 2009a). Its small stream flows northwards into a sumped outlet and is next seen in Curry Inlet. Daylight Aven is 30m tall to a small high-level inlet passage that descends a succession of four shafts below rift passages that become too narrow to follow.

***Figure 20.26**. An excess of water in the small tube that is typical of the lower part of Poppy Passage in Notts Two (photo: Neil Pacey).*

[opposite] ***Figure 20.23**. The main cave passages beneath central Leck Fell and Ireby Fell. A few side passages have been omitted to improve clarity, and some short sections of passage have been slightly warped or truncated where confusion can be caused by their vertical superimposition. Key as in Figure 20.8. (After surveys by MMMMC, LUCC, HWCPC, BUSS, CDG, ULSA, NCC, BPC, GC, MUSS and others.)*

Almost directly above Poppy Passage, the small streamway in Perilous Pot follows bedding planes less than 20m beneath moor level, with a second entrance through Excellent Pot. After 150m at high level, its small stream descends shafts to a sump 60m below the entrance, and drains into the lower streamway in Shep Pot. Adjacent to the active shafts, Constellation Hall is a larger, old shaft that rises to a roof of calcited debris less than 10m below ground level, and this is joined at floor level by a tall and narrow draughting inlet from the south.

Next towards the north, Shep Pot has 500m of passage descending 84m from a small stream sink on the shale boundary (Allen and Pearson, 2013). Its small streamway descends though old chambers that lie beneath a choked sink and are notable for their long calcite straws. However, below these, the tall and narrow downstream canyon drains towards the east, as far as a choked chamber on a north–south fault, from where its water is known to flow to the upstream sump in Curry Inlet (Peachey and Koziol, 2015).

Looping to the west of the streamway, an abandoned phreatic passage appears to have been a braid beside the old trunk route. The original Inlet 5 loops away to the west of the main streamway, and then connects to another phreatic tube; this is typically 3m high and wide and converges on the main streamway from the southwest at roof level, where it was initially named as Inlet 6.5 (Fig. 20.24). Underfit streams now occupy parts of the loop, and floodwaters have deposited banks of sand and mud that choked some sections prior to accessible routes being excavated through them; some branches are notable for their glutinous mud fill (Bendall, 2012).

Some 150m to the west and lower down the fell, Dead Dobbin Pot extends for 120m towards the north; it can only be followed as far as a low passage that is choked with gravel at a depth of 56m, but this is at the level of the Notts Two inlets.

Exploration history

The cave passages that are now linked into one grand system were largely explored piecemeal as individual potholes. Members of many clubs were involved. Starting in 1896, the Yorkshire Ramblers' Club had the pick of open entrances into the caves and potholes of Marble Steps, Short Drop, Death's Head, Lost John's and Rumbling Hole, and they discovered the Leck Fell Master Cave in 1928. Explorations by the British Speleological Association of the more obvious open passages in Notts Pot and Ireby Fell Cavern followed during the 1940s.

Between 1963 and 1985 the Northern Pennine Club explored Low Douk Cave, the main part of Gavel Pot, Large Pot and then the key trunk route of the Notts Pot Master Cave. Within the same period the Northern Cave Club made major extensions in Ireby Fell Cavern and also explored Rift Pot. The Cave Diving Group had its share of important discoveries, notably with the underwater links from Gavel Pot to Pippikin Hole in 1989 and to Witches Cave in 1997. Above water level, a key discovery was that of the Lyle Cavern High Level Series in 1969 by a small team from the Happy Wanderers Cave and Pothole Club, London University Caving Clubs and Bradford Pothole Club. Other clubs that were involved in a host of smaller discoveries and significant extensions include the Gritstone Club, the Craven Pothole Club, the Kendal Caving Club, Manchester University Speleological Society and the University of Leeds Speleological Association.

Largely active since about 2004, the Misty Mountain Mud Mining Corporation is a flexible group of caving friends with a core from the Red Rose Cave and Pothole Club and the Northern Cave Club. They have made nearly all the recent discoveries and connections beneath these fells, including the link between Notts Pot and Lost John's Cave, which made the Three Counties Cave System a reality in 2011 (as Lost John's Cave was already connected through the sumps to the caves of Ease Gill). The Eastern Front was their latest major breakthrough, but an accessible link to the Kingsdale caves still awaits discovery.

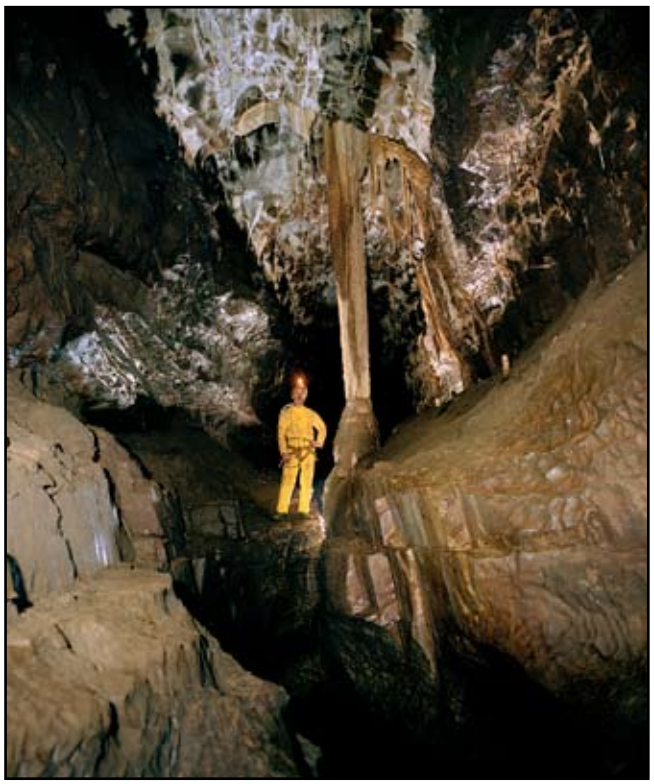


***Figure 20.27**. The large calcite column that is a landmark in the Notts Pot Master Cave, where an old phreatic tube survives above a vadose canyon down from its knickpoint (photo: Paul Deakin).*

East of the streamway Curry Inlet is a walking-size tributary passage with an abundance of stalactites and calcite curtains, but its main continuation is choked except for smaller passages that lead to the active sump. Inlet 7 is another low passage to the east, which passes beneath Oliver Lloyd Aven. More than 30m up the shaft, small passages loop around by following shale beds, and Pleasures of the Palm heads towards the northeast to a choke in faulted ground 60m short of the Lyle Cavern passages in Lost John's Cave (Ramsay, 2005) . South of the aven, The Incredibles is a tall rift chamber amid extensive breakdown that reaches to higher levels (Ramsay, 2009b), and Voldemort Hole provides an alternative entrance to the caves from the floor of a small shakehole. Some 30m below moor-level and 70m above the Master Cave, the Haywagon is a fragment of abandoned phreatic tunnel, named after its profusion of straws (Fig. 7.1) above stalagmites and some multi-coloured flowstone.

Sir Digby Spode's Inlet has 40m of large, muddy passage. Its continuation, largely filled with mud and containing a now-drained sump reaches into unstable and broken rock on a fault zone, where blocks of grit suggest that a choke extends up to the floor of one or more large dolines. A route excavated for 140m through massive breakdown in faulted ground rises nearly 30m to enter the Lyle Cavern High Levels in Lost John's Cave (Allen, 2012a). Close to the Notts Two streamway, Count Lazlo Stroganoff's Aven rises 50m into 800m of high-level passages, mostly following bedding/joint intersections (Ramsay, 2011). Midway along, the Hubert Carstairs Chambers are old, phreatic remnants more than 10m high and wide. Less than 20m beneath, a cobble choke marks the top end of Showerbath Inlet, which originated as a phreatic tube draining up-slope towards the northwest.

***Figure 20.28**. Part of Curry Inlet, one of the larger tributary passages to the Notts Pot Master Cave (photo: Jeff Cowling).*

***Figure 20.29**. The large, old, high-level gallery known as the Haywagon, between Voldemort Hole and Oliver Lloyd Aven above Inlet 7 into the Notts Pot Master Cave (photo: Rob Eavis).*

The smaller high-level rifts finally lead to The Cupcake entrance where a 15m shaft is floored with sediments that have yielded many animal bones from when it was an efficient pitfall trap during the early Holocene (Lord *et al*., 2016).

Further downstream, the canyon passage of Inlet 13 enters from the boulder-choked shafts that were cleared to create the entrance through Committee Pot, and Inlet 14 has just 100m of small, mud-choked passage. Gour Inlet has 200m of gently rising, old, phreatic tube containing a staircase of gour pools, to a crest from where it descends through a now-drained sump to a series of rifts known as The Parallel Universe (Parker and Speight, 2008). Some of these descend to sumps in narrow rifts that appear to drain towards the north. Also west of the streamway, Inlet 17 is a series of low bedding-plane passages. On the eastern side of the Master Cave, Green Tape Inlet (Inlet 16) has more than 300m of muddy passages; most head northwards, but a branch has a 20m shaft rising into high-level galleries that choke before reaching the nearby Cupcake passages. Joining the Master Cave at an air-bell in Sump 3, Inlet 18 has a small streamway draining from the east; most of its water enters from a cobble-choked bedding passage, and a longer tributary cannot be followed beyond a small sump.

***Figure 20.30**. The terraced stalagmite known as The Cupcake, just below the eponymous entrance at the head of a long inlet to the Notts Pot Master Cave (photo: Pete Monk).*

***Figure 20.31**. The Leck Fell Master Cave between Lyle Cavern and Groundsheet Junction (photo: Paul Deakin).*

Lost John's Cave and its inlets

North of Notts Pot, the low-level trunk drainage route is provided by the Leck Fell Master Cave (Fig. 20.23), the long underground walk that was first reached through its inlet passages of Lost John's Cave (Foley, 1930; Waltham and Hatherley, 1983). For a distance of more than 2000m, this cave passage is developed along a single, very thin, shale bed. Upstream, it descends a bed midway along the Lost Pot Inlet, and downstream it makes a steep underwater descent within the sump some 100m short of the Pippikin inlet. The upstream half of the Master Cave is a vadose canyon with an almost flat roof draining northwards into the trough of a gentle syncline. About 100m downstream of Mud Inlet, the start of a half-tube in the roof marks the change to early phreatic development (Fig. 20.59). Beyond this, the passage crosses the synclinal axis, rises slightly and then turns to continue roughly parallel to the plunge of the syncline. Subsequently, the water level within this passage fell by 7m, and a vadose canyon has been cut in the floor of the tube from the downstream sump back up to the lower end of The Lake, which remains ponded in the synclinal trough upstream of the new knickpoint. On the western side of the Master Cave, Mud Inlet has 150m of large passage beyond its initial, very low section.

***Figure 20.32**. Part of Lost Pot Inlet, the low-level passage upstream of Lyle Cavern in Lost John's Cave (photo: Mark Burkey).*

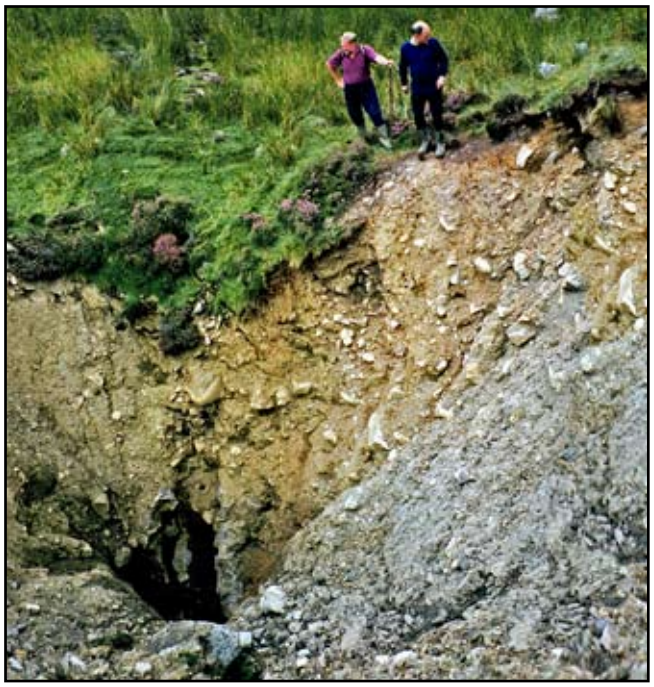


***Figure 20.33**. The entrance to Boxhead Pot shortly after collapse of the glacial till into the underlying shaft (photo: Wendy Thorp).*

The upstream inlets to the Master Cave are the shafts of Lost Pot (now blocked by collapse of its boulder fill), It's a Cracker and Boxhead Pot, which lie close to each other and all descend more than 100m to shafts at the head of the Lost Pot Inlet (Shaw, 1982; Allen, 2012b). The shafts lie on intersecting vertical fractures, and passages leave them on three shale beds, each 12m apart. The lowest is the stream outlet, and the other two lead into the abandoned, stalactite-rich Tate Galleries (Yeadon, 1985), and the muddy Trenchtown inlet. Some 40m above the streamway, the Lyle Cavern High Levels have 200m of old phreatic tunnel (Bowser, 1969). This originally drained from the high avens at its southeastern end, and probably then westwards into the massive choke that is now penetrated by the link to Notts Two. A vadose canyon drains from its midway bend to the roof of Lyle Cavern (Fig. 20.35), and may have been a later development. Two small streamways also drain from the High Levels down to the Master Cave.

The name of Lost John's Cave

There is much confusion over the correct name of the cave variously recorded as Lost John's, Lost Johns' or Lost Johns. The cave was discovered in 1837 by Mr J Mellray, who was the gardener at Leck Fell House, and whose name may or may not have been John. It is possible that he later lost the cave entrance, or was lost on the fell when he stumbled across it. Early books by R and M Balderston (1888) and H Speight (1892) recounted folklore referring to two Johns who became lost in the cave, but this was only hearsay. It is difficult to get lost in the single stream passage, though the story was that their candles were extinguished and their matches were dropped in water. Innes Foley reported on his explorations in Lost John's Cave, but his words in the Journal of the Yorkshire Ramblers' Club (1930) were edited (by E E Roberts) to Lost Johns' on the basis of the folklore. All versions of the name appear in the modern literature, but none can claim to be definitive. This chapter uses Lost John's, if only to be consistent with usage in Volume 1.

***Figure 20.34**. The main shaft in Boxhead Pot (photo: Mark Burkey).*

***Figure 20.35**. Lyle Cavern in Lost John's Cave, looking up the tall, fault-guided, rift chamber from the approach out of the top end of the Leck Fell Master Cave (photo: Jeff Wade).*

***Figure 20.36**. The Wet Pitch shaft where the main routes down Lost John's Cave converge on the active stream passage (TW).*

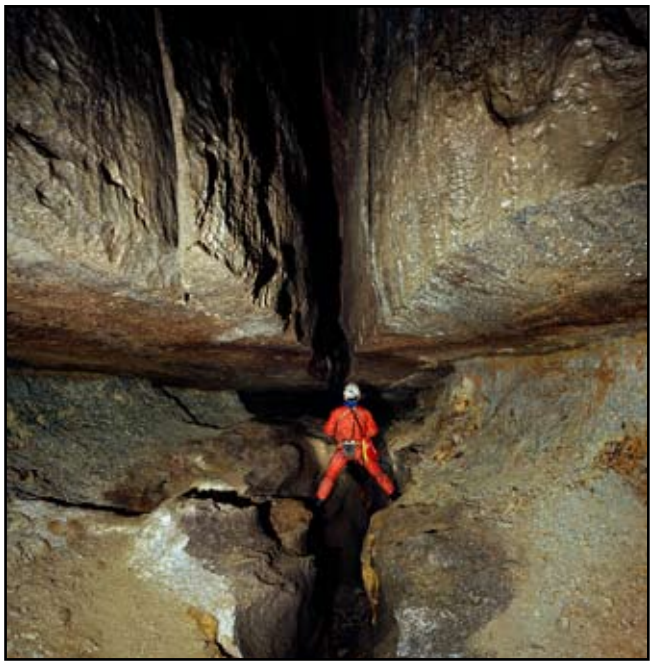


***Figure 20.37**. The thick shale bed that gives its name to Shale Cavern in the Lost John's entrance series (photo: Paul Deakin).*

***Figure 20.38**. The lower part of the fault-guided entrance shaft of Rumbling Hole (photo: John Forder).*

The entrance series of Lost John's Cave has more than a kilometre of tall, meandering canyons, towering rift chambers and fine waterfall shafts; these descend 130m from the shale-margin sink to the entry into the Master Cave at Groundsheet Junction (Foley, 1930; Simpson, 1950). The passages were guided largely by a dozen shale beds and an equal number of joints aligned northwest–southeast. They were developed by a single vadose stream that found a succession of zig-zag routes down through the limestone, invading along its way various, open, joint-guided rifts that could be regarded as features of early underflow. Adjacent to the Lost John's entrance, Rough Pot has 100m of small passages descending 50m to narrow rifts; it appears to provide an alternative route for water to reach an inlet in the Wet Pitch chamber, 100m down in the Lost John's entrance series. Almost directly above the Master Cave, Starting Handle Hole descends steeply for 65m to a streamway too small for further progress (Cartledge, 1998).

Rumbling Hole is a large, daylight shaft, 40m deep and formed on a fault (Roberts, 1934; Waltham, 1968a). Its stream enters though a short high-level inlet, and leaves towards the south down a steeply descending fissure streamway to a series of waterfall shafts. Below the shafts, a very narrow outlet normally contains a sump, but it continues beyond as a long, meandering canyon into the Leck Fell Master Cave. At the northern end of the entrance shaft, a high-level fissure opens into the Dead Bobbin Series (Ramsay, 2009c). This has abandoned shafts and narrow rifts, all formed along the same fault, that double back beneath the daylight shaft. Lower down, it picks up an underfit stream that flows into a sump very close to the head of the inlet below the shafts in the main stream cave.

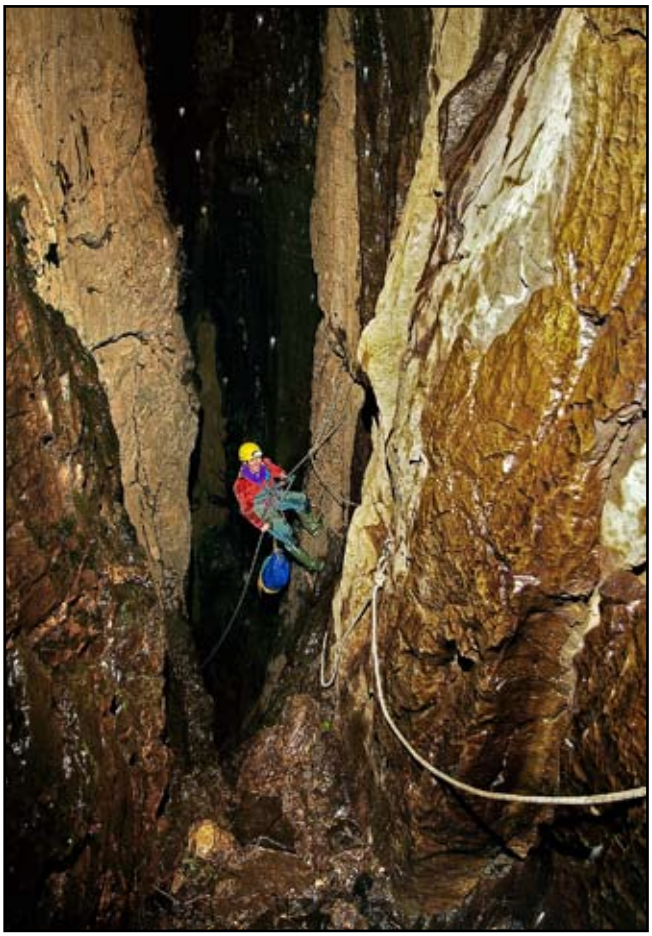


***Figure 20.39**. The 65m-deep entrance shaft of Death's Head Hole with its guiding vertical fault in the far wall (photo: Jeff Wade).*

Farther west on the Rumbling Hole fault, Death's Head Hole is an elliptical shaft more than 5m across that descends 65m from a doline floor and breaks through the roof of a chamber 15m wide. This is midway along an abandoned, horizontal, phreatic tunnel, mostly 5m high and wide, which follows the fault for 400m about 50m below ground level. To the west it passes beneath the Big Meanie shaft entrance to a boulder choke. To the east its upstream limit is blocked by silt and sand; though heading towards Rumbling Hole, its source remains unknown. A small stream enters from the shafts and multiple inlets of the adjacent Long Drop Cave (Sutcliffe, 1969). This forms a waterfall down the lower part of the main shaft; along with an adjacent, excavated shaft, it then drops through a chaos of boulders and shafts into a short inlet that is a tributary to the lowest reach of the Leck Fell Master Cave (Nunwick, 2012). North of Long Drop Cave, Bumbling Hole has 250m of streamway that cannot be followed beyond a narrow rift sump at a depth of only 13m (Fig. 20.3), and further west Brunskill Pot has shafts that descend to a depth of 45m.

Gavel Pot and its inlets

The large collapse doline of Gavel Pot provides a window into a major, high-level, stream passage, with the upstream section forming Short Drop Cave (Brook, 1969). This has four, long, active inlets, including one from Coal Hole; all are small, meandering canyons that converge on a splendid main streamway of walking size. The high-level Ancient Highway and two more tributaries are elements of an earlier phase of passages. Both the old and the new systems have been guided by the gently plunging Leck Fell syncline, and therefore mimic

***Figure 20.40**. The bridge of wedged boulders across the main stream passage in Short Drop Cave (photo: Paul Deakin).*

the plan form of the Leck Fell Master Cave that lies 100m directly beneath. Water from more than 2500m of vadose passages in Short Drop Cave is lost into the huge boulder pile that floors the Gavel Pot doline, from which it emerges into a drained phreatic tube 30m below the vadose canyon.

Gavel Pot's main phreatic tube descends only gently, passes the debris pile beneath the Ashtree Hole doline, and appears to rise into Southbound Passage. Cross-rifts link it to Glasfurd's Chamber (Fig. 20.42) and another tube that is partially filled with clastic sediments and calcite deposits as far as a choke on the Death's Head fault. It is unclear where the original exit from these passages lay. The stream flows into a canyon cut into the floor of the old phreatic tubes, until it descends two shafts to a pool that is a window into a major, active, phreatic conduit (Fig. 20.43).

***Figure 20.41**. The Gavel Pot streamway where its vadose canyon has left the older high-level phreatic passages (photo: Paul Deakin).*

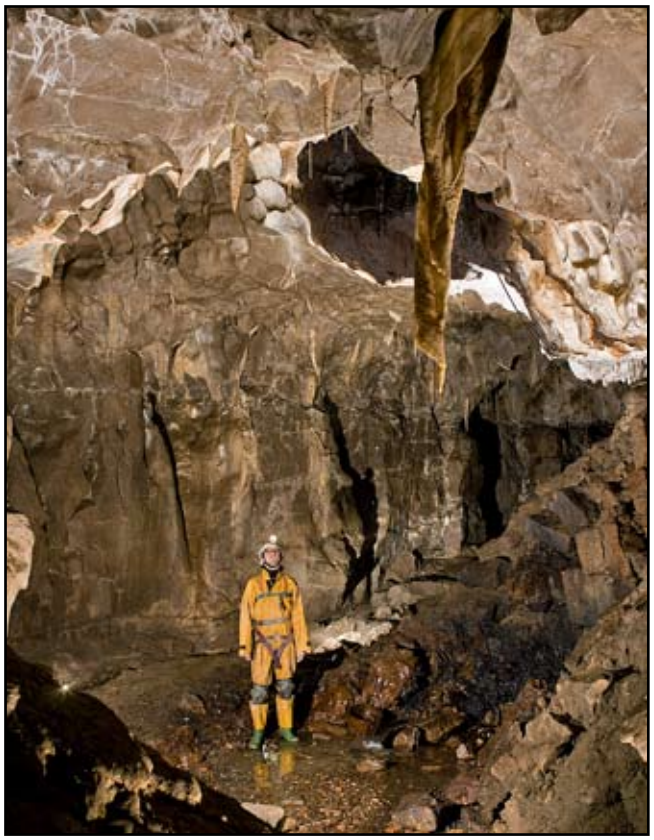


***Figure 20.42**. Glasfurd's Chamber, the largest section of the old high-level passages in Gavel Pot (photo: Mark Shinwell).*

***Figure 20.43**. The final waterfall shaft that descends to the terminal sump pool in Gavel Pot (photo: Paul Deakin).*

Upstream, the phreatic tunnel extends for 130m to the head of an underwater shaft 64m deep, which has only a very small opening above a gravel slope on its floor (Palmer, 1987). The shaft appears to be on a fault, and the water rising up it appears to be all or part of the flow from the Notts Pot Master Cave. In the latter, the exploration limit in Sump 4 is just 120m away, but is at a depth of just 2m and not 64m.

Witches Cave and Leck Beck Head

Downstream from the sump pool in Gavel Pot, the active phreatic tube extends northwards at shallow depth for 150m, where it is joined underwater by the passage from Lost John's Cave (Fig. 20.44). Some 500m further north, it steps down to a depth of 25m, shortly before meeting the Pippikin Pot inlet. The underwater junction is almost directly beneath, and 80m below, the furthest point yet reached in the high-level tunnel of Pippikin Pot (see Chapter 19). The downstream tunnel then passes only about 130m from the current limit of downstream exploration in Kirk Pot, which is also underwater and at about the same level (see Chapter 19).

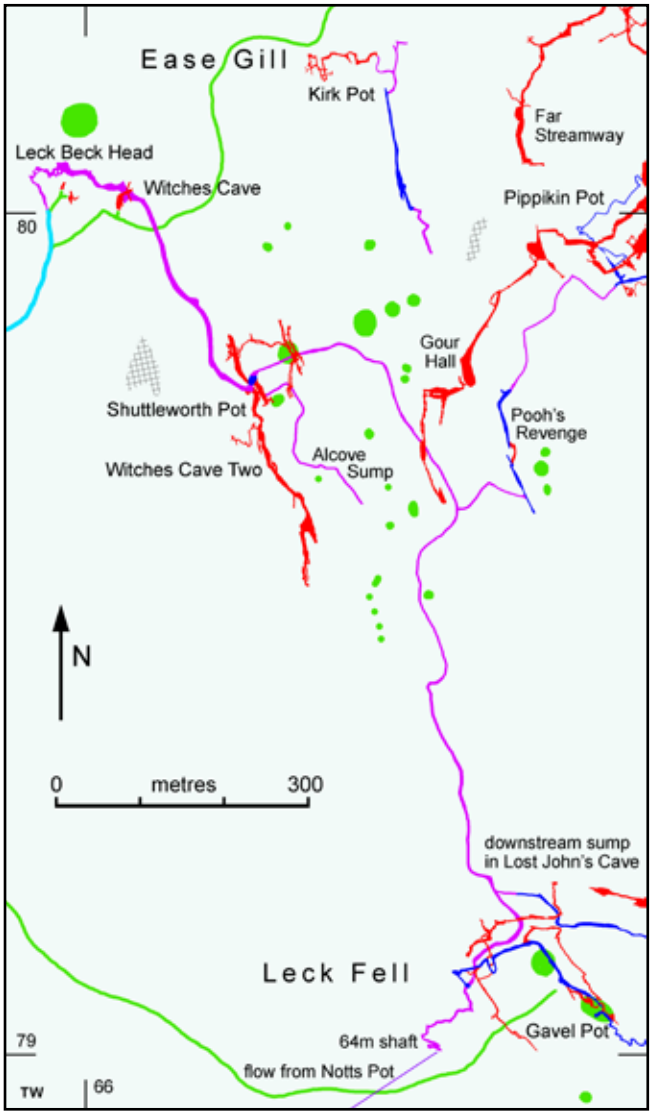


***Figure 20.44**. The known cave passages beneath the lower end of Leck Fell and their relationship to the southern extremities of the Ease Gill Cave System, where drainage from all the caves converges to flow from Leck Beck Head. Key as in Figure 20.8. (After surveys by CDG, MMMMC, HWCPC, RRCPC and others.)*

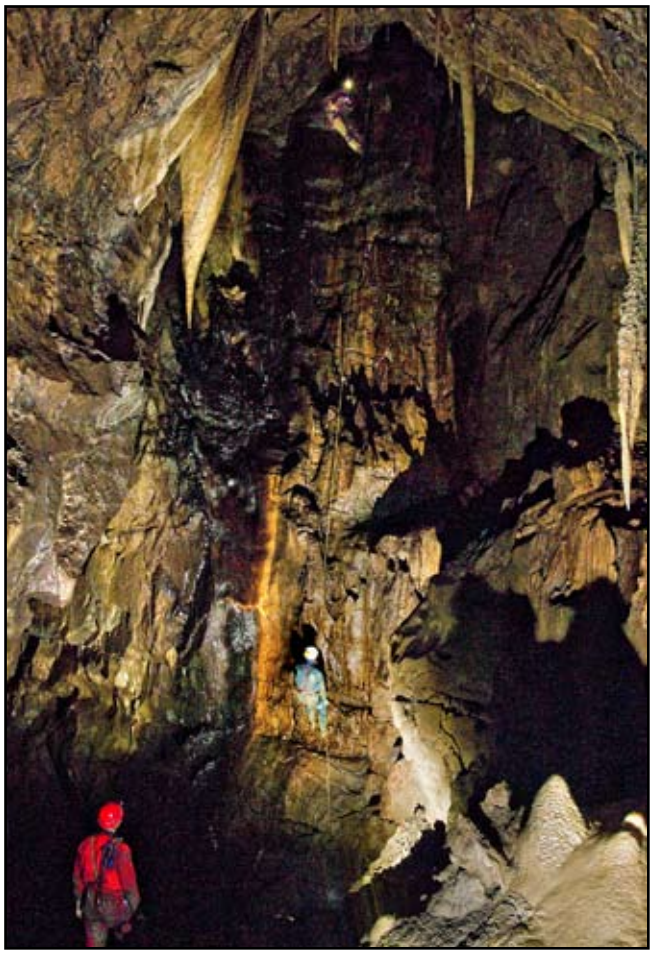


***Figure 20.45**. The shaft that descends from the Shuttleworth Pot entrance to provide access into the abandoned phreatic tunnels known as Witches Cave Two (photo: Alistair Shawcross).*

From the Pippikin junction, another kilometre of underwater passage continues towards Witches Cave, mostly as a tube about 4m in diameter at depths of around 30m. However, midway along the phreatic tunnel, a short upward loop rises above water levels and the stream tumbles over a waterfall a metre high (though this is reduced or even eliminated when the downstream water level is higher in wet conditions) within the 10m of streamway over its crest (Fig. 20.47).

The waterfall has cut back from a small fault, and above it the abandoned, phreatic, trunk passage of Witches Cave Two extends north–south for nearly 400m (Wood *et al*., 2011; Hinde, 2012). Most of this is 6m high and wide, but those are only its dimensions above considerable thicknesses of layered, clastic sediments within a much

***Figure 20.47**. The small waterfall in Witches Cave Two that is formed on the crest of a phreatic loop lying between two deep sumps (photo: Dave Checkley).*

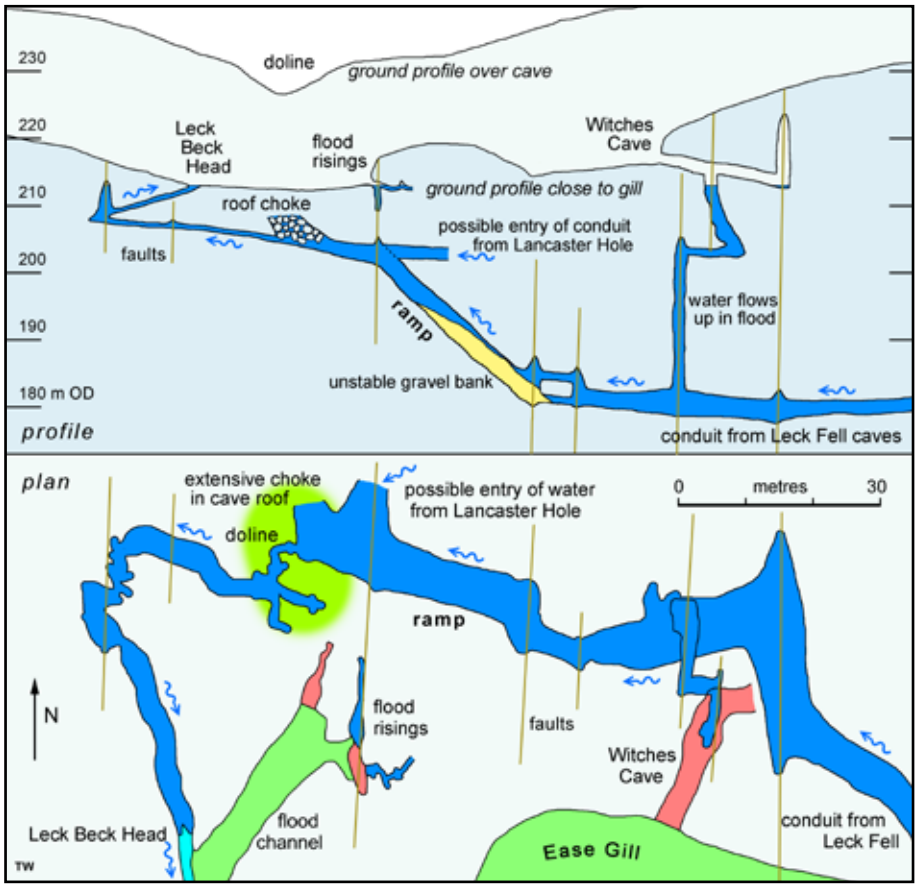


***Figure 20.46**. The tall underwater ramp that is an active phreatic lift inside Leck Beck Head, in sketch profile and plan. The main conduit from Leck Fell lies about 30m below the level of Leck Beck Head until it rises more than 20m as a steeply inclined ramp, which is normally almost choked by an unstable bank of gravel. The ramp's downstream continuation appears to be completely choked beneath a large doline on the hillside north of the flood risings. Not differentiated on the ground profile over the cave, and through the doline, is an unknown thickness of glacial till that is probably contiguous with the debris choke within the cave. The water escapes through a younger and smaller bedding-guided passage to the rising, and via unseen fissures to the adjacent flood risings. In flood, water also rises out of Witches Cave. The exact point of entry of water from Lancaster Hole is uncertain because poor visibility has prevented searches of the passage walls. Observed fractures are interpreted as minor faults, though displacements have not been proven. (After surveys by CDG.)*

***Figure 20.48**. The cloud of straw stalactites towards the southern end of what is known of the abandoned trunk passage that forms Witches Cave Two (photo: Alistair Shawcross).*

***Figure 20.50**. One of the coloured, volcano-like stalagmites in the Painter's Alley section of the main passage in Witches Cave Two; distinguished by its central drip-pocket, the formation is less that 10 cm tall, (photo: Pete Monk).*

larger passage (Fig. 20.49). It contains an abundance of straw stalactites, stalagmites and coloured flowstone, and its roof is broken by the rifts that descend 60m from the Shuttleworth Pot entrance (Fig. 20.45). From a pool close to the streamway waterfall, Alcove Sump extends for 330m into a large underwater passage at a depth of 22m, which appears to be a loop off a conduit draining in from the Leck Fell caves (Mallinson, 2015).

Downstream from Witches Cave Two, the underwater conduit descends almost vertically for 27m, to a bedding plane that is followed down-dip for 400m, to a depth of 33m (Cordingley, 2012). It then rises up a massive, underwater ramp choked with pebbles and debris that are remobilised during flood events (Fig. 20.46). This ramp appears to bore obliquely upwards where it crosses heavily fractured and veined rock within a 30m-wide zone associated with the nearby Dent Fault; there is no evidence of it developing along the plane of any fault. At a depth of 9m, a bedding passage diverges to the Leck Beck Head rising, and the main ascending tunnel is choked short of its truncation beneath glacial till on the hillside above the risings (Cordingley, 2015). Somewhere in that area, water from Lancaster Hole is believed to join that from Leck Fell, to pour out of the permanent resurgence and its two adjacent flood risings. Just upstream of the phreatic lift, underwater rifts rise 30m to the short entrance passage of Witches Cave, opening into the north bank of Ease Gill.

***Figure 20.49**. The large main passage in Witches Cave Two beneath the shafts of the Shuttleworth Pot entrance (photo: Dave Checkley).*

***Figure 20.51**. Helictites in Witches Cave Two (photo: John Forder).*

Evolution of the caves

Little can be identified of the earliest stages of cave development beneath Ireby Fell and Leck Fell, but the main theme within the later stages was of three successive trunk routes that all, probably, drained towards the Ease Gill valley. The recognisable elements of these three stages are the Eastern Front and Duke Street tunnel, the Notts Pot Master Cave and the Leck Fell Master Cave. Each stage lay further to the northeast, further down-dip and at lower altitude. This was in response to surface denudation that deepened the valleys, exposed more of the limestone, and stripped the Yoredale cover back on the high ground. Cave systems evolve, not in successive steps, but in a continuum of processes, though stages (which can overlap) are recognised where individual passages have their time as trunk drainage routes. It might then be reasonable to relate those stages to interglacial intervals, separated by glaciations when karstic processes were minimised and landscapes were rejuvenated.

Beneath Leck Fell, the three stages appear to demonstrate the transitions from deep phreatic conduits, to shallow phreatic flows, and then to largely vadose drainage, all in response to progressively lower resurgences becoming available as outlets into deepening valleys. Clearly, this trilogy of stages is a huge simplification of just the later part of a long evolution, as numerous side stories and multiple sub-stages are required to complete the picture. But the bare bones of the three stages synthesize a classic evolution of underground drainage in a karst terrain.

Stage 0: the inception cavities

There clearly must have been an initial Stage Zero with micro-conduits that developed as groundwater first flowed through fractures and bedding weaknesses within a rock that was lithified and essentially impermeable in its intact form. But these original flow-paths are all too small to enter, and therefore remain unmapped and largely unknown. The stage is best described as Zero because it pre-dates caves that are defined as enterable. Its timescale stretches to many millions of years, and it is debatable as to how much of this karstic permeability developed during the expulsion of formation water and by hypogene fluids rising from depth. But it is likely that cavity enlargement increased greatly when the limestone was first exposed at outcrop, and matured into Stage 1 when it became accessible to the larger flows of meteoric water.

Stage 1: the initial phreatic network

Working back from the large and obvious trunk routes that characterise Stages 2 and later, the debate is open as to how much of a Stage One ever existed as a network of phreatic tubes. These would have evolved from the initial cavities as braided systems of tubes on multiple, bedding-plane inception horizons, interlinked by fissures or tubes on joints and faults. Some of them may be recognisable as the long, metre-diameter, phreatic tubes that follow bedding horizons for significant distances beneath the fell with no clear relationship to known sinks and risings.

Three of these small phreatic tunnels are known over lengths of around a kilometre: forming the link between Rift Pot and Ireby Fell Cavern (Fig. 20.52); the Glory Holes and Cripple Creek passage within Ireby Fell Cavern; and in the roof of the upstream half of the Notts Pot Master Cave. Others may be recognised over shorter distances, but are difficult to ascribe to this Stage 1 with any degree of certainty. Tubes of this age and nature then suffered a variety of histories. The Rift–Ireby link was probably abandoned when flow was captured by a more successful route; one might have lost its identity when it evolved into the much larger trunk route of Eastern Front; the one in Notts Pot had a canyon developed in its floor; and others unknown may have been choked with sediments.

Alternatively, all these small phreatic tubes might have been just parts of later stages, and there is no evidence as yet that they are even contemporary. There is therefore room for debate as to whether Stage 1 is even worthy of designation, but it is helpful to recognise the evolution of a passage network prior to development of the obvious trunk caves.

Stage 2: Duke Street and Eastern Front

The most conspicuous, old, abandoned, phreatic, trunk route beneath the Leck and Ireby fells is seen as the two fragments known as Eastern Front (and through to Coates Cavern) and Duke Street (including Duke Street Two). Eastern Front is accessible between two large boulder chokes, one at its southeastern end, and one just west of Coates Cavern. Though parts have been modified by roof collapse, with comparable piles of breakdown on the floor, and much is obscured by thick clastic deposits, this passage is recognisable as a long-abandoned, phreatic trunk route. With a diameter of 10m

***Figure 20.52**. The route through from Rift Pot to Ireby Fell Cavern, following one of a number of small phreatic tunnels that were developed along a single bedding-plane inception horoizon (photo: Neil Pacey).*

***Figure 20.53**. The Eastern Front phreatic tunnel that was once a trunk cave draining between Kingsdale and Ease Gill (photo: Jeff Wade).*

or more in its original form, this is likely to have carried a substantial flow. Although a few hundred metres of passage may await discovery, as far as truncation of the Eastern Front by the steep flank of Kingsdale, any southern part of the cave system was removed during the glacial deepening of the dale.

The northerly extension of this trunk route is the Duke Street tunnel within Ireby Fell Cavern and its continuation beyond the sump as Duke Street Two. This follows the same bedding horizon as Eastern Front, though it descends to a slightly lower altitude due to the limestone's gentle dip. It is also a little smaller, typically less than 10m in diameter, but that is still indicative of a major flow. The role and chronology of the smaller passages that link Eastern Front to Duke Street remain uncertain. They could have formed a contemporary loop within a braided system of passages before capture by a larger tunnel that remains unknown between the chokes; alternatively, roof morphology at the confluence suggests that they might have formed later, perhaps after a collapse blockage in the larger tunnel. The inaccessible stream link from Temple of Doom to East Inlet could occupy another braid. The trunk route from Duke Street Two towards the northwest is currently unknown. Both these sections of the old trunk route developed on an opportune inception horizon that now lies a little above 300m OD. Phreatic features along them indicate a resurgence level somewhere above 320m OD.

Originally phreatic, and close to horizontal, there is doubt over the direction of flow through these passages (see page 326). There is also debate over whether the continuation of this trunk route towards the southeast terminated at Kingsdale or continued to Chapel-le-Dale. Kingsdale is and always has been a minor valley, with a small catchment and minimal Quaternary ice flow over the saddle from Deepdale, whereas Chapel-le-Dale has a much larger catchment and captured significant flows of southward-moving Quaternary ice. When the trunk cave was developed beneath Gragareth, it could well have passed beneath the floor of a contemporary Kingsdale that then stood at a higher altitude, prior to subsequent deepening (see Chapter 21). It is reasonable to assume that Chapel-le-Dale was the source or outlet for the trunk cave. Witches Cave Two, beneath Ease Gill, and Expressway–Perfidia, beneath Kingsdale, are two further remnants of large old trunk passages, but are unlikely to be related to the high-level trunk route.

The age of these Stage 2 caves is unknown. They are certainly older than low-level phreatic tunnels within the Kingsdale Cave System; those date from more than about 350,000 years ago when a subsequent phase of sinks was formed with exposure of the limestone further up the dale floor (see Chapter 21). Based on estimates of denudation rates (see Chapter 4), the surface lowering of around 100m that is required to follow cave drainage in either direction between Ease Gill and Kingsdale suggests that the caves date from at least 700,000 years ago. Any better assessment of the chronology awaits Al/Be dating of the stratified quartz sands in Duke Street Two and Witches Cave Two (Fig. 20.54).

The earliest phases of the caves beneath Ireby Fell and Leck Fell formed beneath a cover of shales and sandstones that was continuous from the Gragareth ridge to the Craven Lowlands. The caves merely linked the adjacent valley-floor inliers, in similar style to the River Nidd's current route beneath a grit cap (see Chapter 29). Subsequent development of the trunk cave may also have occurred beneath the impermeable cover. Alternatively, this enlargement could date from the exposure of more limestone over the cave, perhaps when tributary streams formed an earlier stage of Trippple Creek, and possibly North East Inlet, within what is now part of Ireby Fell Cavern. Though Marble Steps Pot appears to be a large, old sink, it probably formed later when the shale cover had been stripped back even further.

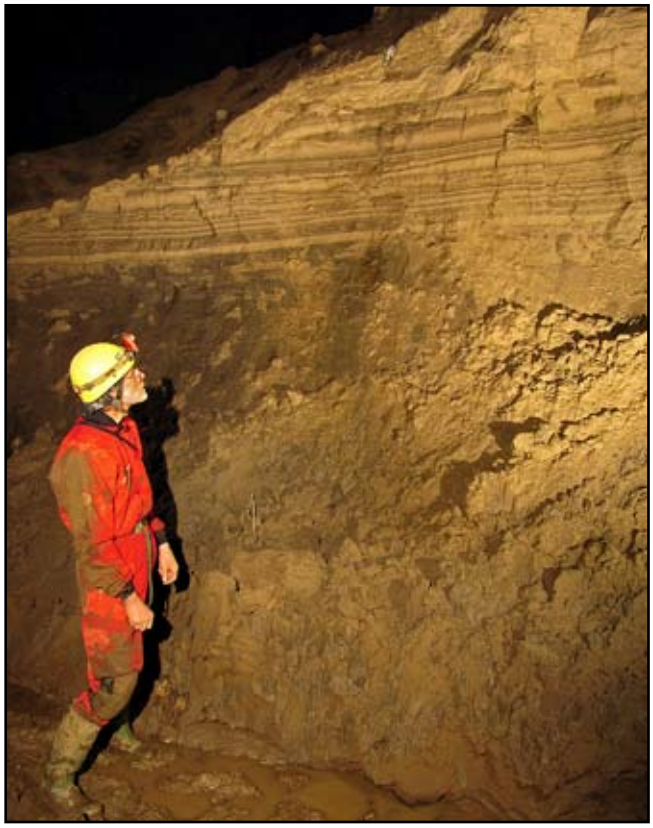


***Figure 20.54**. A section through layered, clastic sediments in Witches Cave Two, which could one day yield a chronology of earlier events in the evolution of the Leck Fell area (photo: Dave Checkley).*

Flow direction in Duke Street and Eastern Front

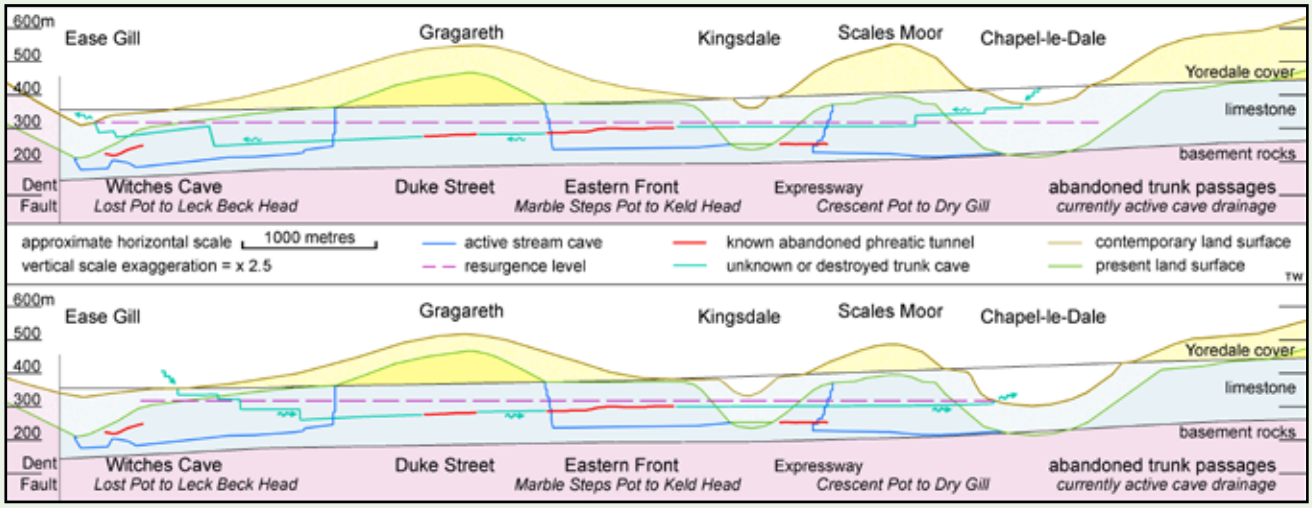
Evidence from the cave morphology is unclear over flow direction. Large old scallops that are poorly developed and difficult to interpret in Duke Street Two appear to indicate flow towards Kingsdale. However, there is no consensus of interpretation among their observers, and they could have been formed by eddies within the conduit. Passage size may also give some indication of flow, in that the larger cross-section of Eastern Front makes it likely to have lain downstream of the rather smaller Duke Street.

An overview of possible scenarios for Quaternary denudation of the area offers options as to evolution of the karst drainage, shown in the two profiles below. Regional dip of the limestone is towards the NNE, so the trunk cave lies close to the strike, though its slightly oblique alignment does mean that the geology and the caves are slightly lower towards Ease Gill. This is irrelevant to phreatic drainage direction, but creates relief within the limestone so that sites in Chapel-le-Dale are at higher altitudes than those in Ease Gill.

One option has sinks in a proto-Chapel-le-Dale draining to the contemporary Ease Gill valley (upper profile). The resurgence was probably vauclusian at an altitude not far below 350m in the eastern slope of Ease Gill, west of the modern Lost John's Cave entrance, and could have been on or close to an element of the Dent Fault. Its truncated end is probably now beneath the thick glacial till nearer to the fell road. The level of this resurgence could vary by some tens of metres at different positions, as the limestone in the small inlier dips away from the line of the profile, and the situation is also complicated by the Dent Fault's oblique crossing of the lower valley. This option is favoured by the lower early level of Ease Gill (nearer to its base level at the Irish Sea) and the greater subsequent excavation of Chapel-le-Dale by its powerful Quaternary glaciers. Sinks in Chapel-le-Dale, and perhaps in Kingsdale, were in the upper limestone beds, probably not far below 400m OD.

The second option has sinks around an early Ease Gill draining to a resurgence in the contemporary Chapel-le-Dale (lower profile). This is possible, though the cave streams would have to drain up-dip and away from any part of the lower Ease Gill that lies upstream of the Dent Fault. Subsequent deepening of Ease Gill would then have to have been greater than the deepening of Chapel-le-Dale, and this is unlikely to have been the case. Ease Gill lies in the lee of Crag Hill and sheltered from erosion by the main flow of southbound ice, whereas Chapel-le-Dale carried powerful glaciers. Tectonic rotation during the on-going uplift could have occurred, but would be unlikely to contribute more than a few metres to the changing relief.

A third option is that flow within the caves switched directions, either once or on more occasions, during surface lowering that saw variable erosion levels in the valleys and temporary occupations by ice. In a comparable situation, flow between Chapel-le-Dale and Kingsdale is known to have switched directions through the Expressway trunk passage beneath Scales Moor (Murphy *et al*., 2001). Speculative overview favours drainage of Duke Street and the Eastern Front towards Ease Gill, but the evidence is thin and conflicts with the equally sparse evidence from the caves' morphology. There is still much to understand about these early caves.



Alternative diagrammatic profiles showing how the trunk passage through Eastern Front and Duke Street could have drained in either direction during its early stages of development. Both profiles are drawn roughly along a line parallel to, and about a kilometre to the northeast of, the North Craven Fault. The upper profile shows palaeo-cave drainage towards Ease Gill, and the lower shows the alternative flow towards Chapel-le-Dale. Both profiles of the contemporary land surface are conjectural, and the steps in the profiles of the unknown caves are entirely arbitrary. The modern cave drainage routes are shown only for context, and the link from Crescent Pot to Dale Barn is highly probable but not proven.

The old phreatic tunnel of Duke Street, in the lower reaches of Ireby Fell Cavern, where poorly formed wall scallops give no clear indication of flow directions in the past (photo: Paul Deakin).

Stage 3: Notts Pot Master Cave

Inevitable surface denudation, by alternating phases of rivers and ice sheets, deepened both Kingsdale and Ease Gill, but also lowered the shoulder of Gragareth. Consequently a narrow limestone outcrop linked the two ancestral, valley-floor inliers adjacent to the North Craven Fault, south of which the cover of Yoredale rocks was only removed in a later stage. Streams from Gragareth sank at the limestone margin, and converged on a new trunk cave draining towards the northwest. This replaced the flow from Kingsdale since the glaciers had deepened that dale and allowed surface drainage out towards Ingleton.

Within Stage 3, the Notts Pot Master Cave is the recognisable part of the trunk conduit. This developed as a phreatic tube at around the 260m level. Much of it is almost horizontal where it follows a single inception horizon along the strike of the limestone that dips very gently towards the northeast. The upstream half of the Master Cave is the tube that is still only partially drained. It continues upstream through the sumps on either side of a step on the Notts Pot faults. The conduit appears to derive from its outlet from Duke Street Two, upstream of which it had invaded the older trunk passage of Duke Street, with a source that may be a choked sink above the older passages on the North East Inlet. Water could also have cascaded down some of the shafts in Notts Pot, but the relative age of these two sources is unclear. By this time, it is likely that Marble Steps Pot was also an active sink, but it probably drained to the newly deepened Kingsdale.

***Figure 20.55**. Calcite deposits hint at the antiquity of some parts of the Notts Pot Master Cave (photo: Clive Westlake).*

***Figure 20.56**. Within the Lyle Cavern High Levels of Lost John's Cave, a bank of flowstone is probably too young to be a useful indicator of the age of the passage (TW).*

The downstream half of the Master Cave is dominated by its canyon, but this only follows the old tube for about 100m, to where the tube turns away into Sir Digby Spode's Inlet. The continuation of the tube is lost in breakdown and faulted ground, and its relationships with the tributary tube from Mincemeat Aven and the smaller tube in the lower part of the Master Cave is uncertain. The main passage in the Lyle Cavern High Levels was probably a contemporary tributary within a phreatic system of passages at multiple levels, all lying below the level of the rising at about 300m OD in the floor of Ease Gill, not far upstream of where it meets the Dent Fault.

Two major tributaries appear to be contemporaneous with the Notts Pot Master Cave. One was Short Drop Cave, where South Inlet is the old passage at the head of a long vadose canyon. This continues into the phreatic tubes of Gavel Pot, with the transition providing the best evidence for the water table and resurgence position at somewhere close to the 300m level (Fig. 7.22). The second inlet was the phreatic tunnel along the Death's Head Fault, probably originating from a sink at Rumbling Hole. The downstream continuations of all three passages remain unknown, but it is likely that some or all of them drained through the large tunnel of Witches Cave Two, now accessible beneath Shuttleworth Pot. The relationship between this fragment of very large, old, abandoned, phreatic cave and Leck Fell's other large conduits, all at higher altitude, is unclear. It is perhaps most likely to have carried all the drainage northwards to a resurgence in Ease Gill where the barrier of impermeable rocks beyond the Dent Fault prevented drainage of the karst direct into to lower reaches of the Ease Gill valley.

Dated stalagmites from the Gavel Pot and the Lyle Cavern High Levels indicate only that these phreatic tubes were drained prior to about 130,000 years ago, which merely pre-dates the rejuvenation induced by the Devensian glaciation. However, the subsequent stage featuring the Lost John's Master Cave also pre-dates the Devensian. The extensive phreatic caves of Stage Two were developed behind a resurgence at 300m OD in an ancestral Ease Gill well above the present thalweg, and this must have been active prior to the Wolstonian glaciation. Furthermore, due consideration of Quaternary denudation rates suggest that an Ease Gill profile at that elevation could date back to before the Anglian glaciation and rejuvenation. Further dating, of stalagmites or clastic sediments, is needed to establish a reliable chronology of these old and abandoned caves.

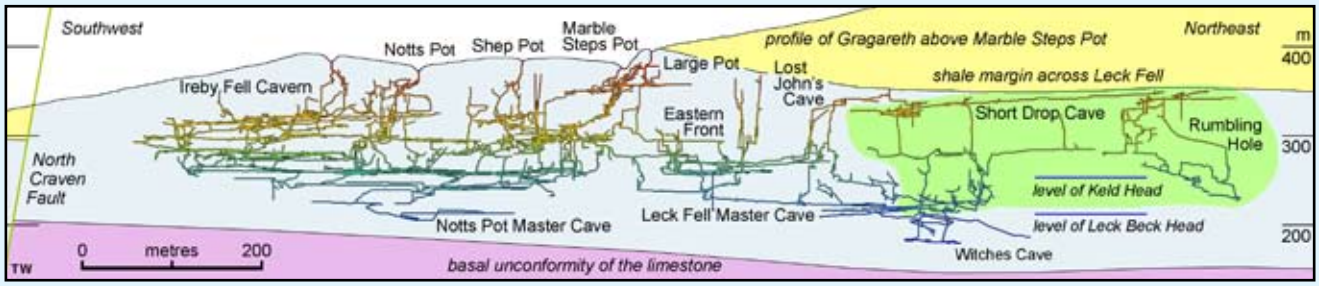
Geological influences on caves under Leck Fell

As elsewhere in the Dales, the positions and nature of the caves have been greatly influenced by both the stratigraphy of the limestone and its sub-vertical fractures. The large extent of high-level passages beneath Leck Fell is due to their confinement within the dark, thinly-bedded Hawes Limestone. All the deeper caves are formed in the underlying Malham Formation of the Great Scar Limestone, where numerous shale beds form the main inception horizons. However, the two most conspicuous horizons, containing the two Master Caves, are unusual in that they have negligibly thin shale beds and appear to lie within the Cove Limestone, therefore between the main boundaries within the stratigraphy. The regional dip within these fells is so low that a very shallow syncline could catch all the vadose drainage under its sector of Leck Fell, so that the dendritic Short Drop Cave lies directly above the dendritic Lost John's Cave. Lacking gravitational flow, phreatic passages have not been guided by this syncline.

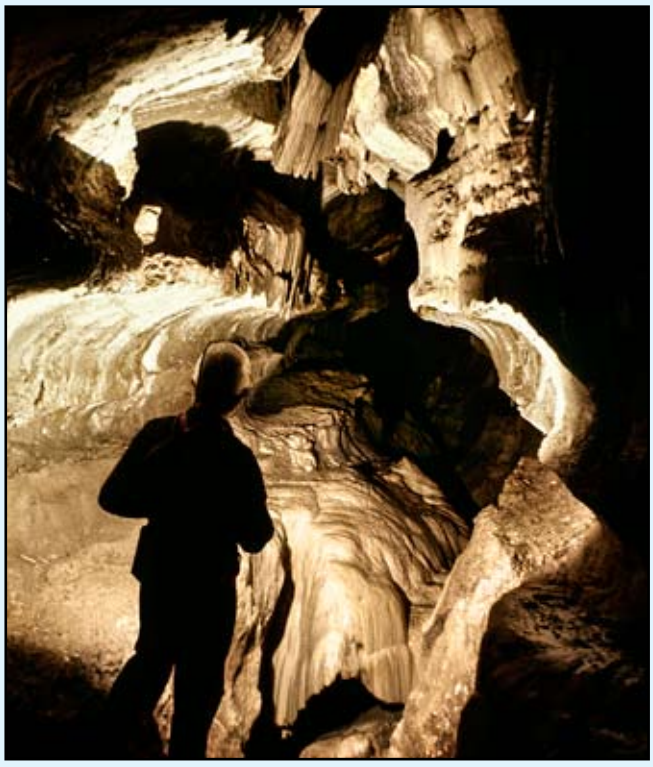
The cave drainage has intersected a number of minor faults that have small displacements within the limestone. They lie both parallel to and oblique to the elements of the North Craven Fault, which forms the southwestern margin of the cavernous ground. Some faults have guided cave passages that are largely tall, vertical rifts, notably at Rumbling Hole and Lyle Cavern. Others have deep shafts on them, notably the cluster of parallel shafts in Notts Pot, formed within a zone of intersecting faults. In contrast, some faults create broken ground where trunk passages break into smaller elements or are lost into zones of extensive breakdown. The fault crossed by the downstream continuation of the Lyle Cavern High Levels is one example.

The Entrance Series of Lost John's Cave, the shafts around Lost Pot, and the far passages in Marble Steps Pot are formed on nets of intersecting fractures. In each case, one major set of fractures is intersected by a minor set at about 20° from it; these appear to be major joints, but may be minor faults with unrecognisably small displacements.

No caves have yet been found to cross the North Craven Fault. The local nature of this fault is poorly known as its outcrop is buried by glacial till across the flanks of Gragareth where it appears to split southwards into multiple elements. No caves have yet been found in the fault blocks exposed at Tow Scar, and none is known in the slice of limestone against the southern end of the Dent Fault. It is unlikely that any caves exist between the North and South Craven faults in the down-faulted limestone that is probably entirely covered by a shale cap across the lower slopes of Ireby Fell.



Projected profile of cave passages within Leck and Ireby Fell, viewed along the strike towards the northwest, so that the major bedding planes and inception horizons can be seen dipping gently towards the northeast. This is essentially a print-out of the line surveys in Survex, so only has the passages surveyed and digitally recorded to date, and does not show chambers or passage dimensions. The top and bottom of the limestone are highly generalised as they cannot account for structural irregularities and minor fault displacements. The green cloud surrounds the passages that dip towards the southwest because they lie within the northern limb of the gentle syncline that crosses Leck Fell, though Rumbling Hole drains against the dip where it is developed on a fault.



Passage profile, in the Lost John's Lyle Cavern High Levels, probably determined by contrasting dissolution rates of limestone beds (TW).

The fault-guided entrance shaft of Death's Head Hole (seen at night without daylight pouring down) (photo: John Forder).

Stage 4: Leck Fell Master Cave

Following a glacial rejuvenation of the terrain, a new resurgence became active at an altitude of 221m within the Ease Gill valley. Extensive vadose drainage of the limestone beneath Leck Fell therefore became possible. Streams sinking into Lost Pot, Lost John's Cave and Rumbling Beck Cave each descended joints and faults to drain into the Leck Fell Master Cave. Further inlets probably drained through the older, high-level passages and descended into Lyle Cavern. This would account for the increase in streamway size downstream of that chamber, where a long vadose canyon developed beneath a single bedding plane, with only a paper-thin shale parting, which dips gently towards the northwest. Midway along the passage now known as the Master Cave, this dipped below resurgence level, and the passage continued for another kilometre as a phreatic tube along the same inception horizon. Within the phreas, the passage changes level at a few places; whether this is due to switching between bedding planes or following the same horizon across minor faults is uncertain. Its water then rose about 40m in phreatic lifts to the original resurgence now truncated in the till-covered hillside just above Leck Beck Head.

The stream sinking into Ireby Fell Cavern formed a vadose canyon, interrupted by waterfall shafts, which looped round and invaded the old phreatic tunnel of Duke Street. It then occupied the Notts Pot Master Cave and cut the vadose canyon in the floor of its downstream half. Within the phreas, the water now turns away from the older passage, where details remain unseen, and rises 64m in the Gavel Pot upstream sump, to reach the bedding horizon on which it converges with the Leck Fell Master Cave.

***Figure 20.57**. The joint-guided rift passage below the Centipede shaft in the entrance series of Lost John's Cave (TW).*

***Figure 20.58**. The last waterfall in the entrance series of Lost John's Cave, only a short way upstream of its confluence with the Leck Fell Master Cave (photo: Paul Deakin).*

Further cave developments within this stage included Shep Pot and others draining into Notts Two, the Lost John's Entrance Series and the tributary route from Long Drop Cave via the older passage in Death's Head Hole. A sequence can be recognised within the canyons and shafts that create the alternative routes down (Waltham, 1974), though the absolute chronology of the sequence cannot be confirmed. Streams sinking into Coal Hole and other inlets into Short Drop Cave, formed long high-level streamways in an area of Hawes Limestone that was relatively free of major fractures. They converge on the older passage downstream from South Inlet, and eventually reach deep joints on which they form shafts in Gavel Pot to join the low-level trunk route. Vadose streamways in Marble Steps Pot, Low Douk Cave and Large Pot are also contemporaneous, but they drain to Keld Head.

***Figure 20.59**. Downstream in the Leck Fell Master Cave where the phreatic roof development dates from a stage when the resurgence level was about 7m higher than it is now (photo: Paul Deakin).*

A further rejuvenation of the Ease Gill valley allowed Leck Beck Head to develop as the new resurgence at a level 8m lower than its predecessor (Fig. 7.22). It is possible that the earlier exit was upwards through the choke and doline just upstream of the present rising (Fig. 20.46). A one-metre-high waterfall has developed on the crest of an old phreatic loop beneath Shuttleworth Pot. Water levels are still ponded behind this feature, so the phreatic tubes at the lower end of the Leck Fell Master Cave have been drained to a depth of only 7m. This has been enough for incision of a late-stage vadose canyon to cause partial drainage of the shallow phreatic loop formed where the passage crosses the syncline and is now occupied by The Lake.

Stalagmite from the Leck Fell Master Cave, just upstream of Groundsheet Junction, has been dated from around 100,000 years BP, suggesting that the main caves of Stage Three were formed during the Ipswichian Interglacial, or possibly earlier. The resurgence altitude for Leck Fell and Ireby Fell was lowered from around 300m to below 230m by the Wolstonian glaciation, or more probably by the combined action of the Anglian and Wolstonian glaciations. The Devensian glaciation then lowered Ease Gill by just 8m, to bring airspace, and vadose incision, into just some of the downstream phreatic tubes of Stage Three.

A three-fold, or even a four-fold, division of the caves that underlie the fells of Ireby and Leck has to be a gross over-simplification of a complex suite of drainage routes that evolved through multiple phases. Changes were driven by surface lowering and glacial rejuvenations, while new stream sinks were forming along the margins of Gragareth's retreating Yoredale cover. It is likely that a large proportion of the cave passages between Ireby Fell Cavern and Gavel Pot are now known. But there are significant lengths of cave as yet undiscovered that lie beneath the fell between Marble Steps Pot and Ireby Fell Cavern, and also further towards the northwest, beyond Duke Street Two and south of Witches Cave Two. However, the lower slopes of Leck Fell are mantled by thick glacial till. The main, active drainage route beneath is now known, but that part of the limestone fell must contain large, old, abandoned passages that remain unseen, though they are probably well choked with clastic sediment.

***Figure 20.60**. When they can be sampled from obscure locations, stalagmites like these, in the North East Inlet of Ireby Fell Cavern, yield the best records of past events (photo: Neil Pacey).*

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