Ogof Ffynnon Ddu

[SN 848 152]–[SN 873 166]

Highlights

Ogof Ffynnon Ddu is the deepest cave system in Britain, and is also one of the most extensive. The complex network of large high-level passages, the exceptionally long vadose streamway, and the many inlets perched high above it, provide an unparalleled record of drainage evolution in the limestone.

Introduction

Ogof Ffynnon Ddu lies beneath the eastern slopes of the Tawe Valley (or Swansea Valley) at Penwyllt, upstream of Ystradgynlais (Figure 6.1). It is the second longest cave system in Britain, with around 50 km of explored passages, and is Britain's deepest cave with a vertical range of 308 m.

The cave is developed entirely within the Holkerian Dowlais Limestone, which is locally just under 100 m thick. This limestone has a broadly uniform dip of about 10° to the south, as it lies clear of the Cribarth Disturbance (Figure 6.3), and it forms an outcrop less than 1 km wide across the upland interfluve between the Neath and Tawe valleys. It is broken by numerous faults, mostly orientated north-south with displacements of up to 35 m, and the major joint sets trend roughly north-south and east-west. A series of gentle fold flexures have their axes aligned close to the regional dip. Allogenic water flows south from the Old Red Sandstone slopes, and the only large surface stream feeds the main sink at Pwll Byfre. Underground flow is westwards through Ogof Ffynnon Ddu to the resurgence of Ffynnon Ddu, close to the floor of the Tawe Valley. Most of the upland slopes have a thin veneer of till which obscures truncated passages known from inside the cave system.

The progressive exploration and understanding of Ogof Ffynnon Ddu has been documented primarily by Railton (1953), O'Reilly *et al.* (1969) and Smart and Christopher (1989), and the main cave passages are described by Stratford (1995). The relationship of the cave to the geology has been discussed by Glennie (1950) and Charity and Christopher (1977), while aspects of the hydrology have been investigated by O'Reilly and Bray (1974) and Bray and O'Reilly (1974).

Description

A main stream passage extends through the length of the Ogof Ffynnon Ddu cave system, but most of the 50 km of known passages constitute complex, three-dimensional networks of active and abandoned caves (Figure 6.7).

The main streamway is 5 km long, covering most of the distance between sink and rising. The upper end is in the large chamber of Smith's Armoury, where the water from the Pwll Byfre sink emerges through a choke of sandstone boulders. Most of the streamway is a magnificent, clean washed, vadose canyon, 2–5 m wide and 5–30 m high. The Marble Showers area is notably spectacular where the canyon walls, cut in dark limestone streaked by white calcite veins on small faults, are washed by inlets from the roof. The water cascades and swirls through numerous moulins and deep pools, and over ledges where dolomitic horizons have resisted solution more than the adjacent limestone. There are few waterfalls along the main streamway, for it descends 300 m largely by following the bedding obliquely downdip. At floor level, the stream follows a contorted course where meanders have enlarged as they have been entrenched. The higher levels of the canyon are commonly aligned on joints, so that they appear as straight rifts; the Traverses (Figure 6.8) are high in a spectacular straight canyon over 40 m high, now abandoned where the stream passes through a short flooded loop between the canyons of OFD3 and OFD2. From just below the Piccadilly junc tion, the stream route is again through a flooded the OFD1 streamway. This drains into a sump not far from the Ffynnon Ddu resurgence pool.

Extensive active and relict passages form networks at multiple levels, almost entirely on the north, updip side of the streamway. The Upper Series of OFD2 is the most complex, with a maze of interconnected phreatic tubes and vadose

canyons. Many of the caves are aligned on joints or faults, and some fractures guide three separate passages stacked vertically above each other. The largest passages are old trunk routes over 10 m wide, now broken into fragments by roof collapse. One deepens into a large vadose canyon forming the Chasm, and another has been truncated by surface lowering to create the Top Entrance. Sections of the old caves are beautifully decorated by calcite dripstone, of which the Columns are the most distinctive (Figure 6.9); a stalagmite floor over an eroded clastic fill in the Upper Series has been dated to 267 ka by uranium-series analysis (Smart and Christopher, 1989). Younger vadose canyons have been cut by invading streams right through the mazes of old passages; they drain down the dip to the main streamway. Even though these are deeply entrenched, their incision rates have not matched that of the main stream, and most are perched as roof inlets.

Downstream in OFD2, another series of large, abandoned, phreatic passages forms a high level, reaching towards a truncation at the Cwm Dwr Entrance. Cwm Dwr 2 is an isolated fragment of tributary streamway (Herbert and Langford, 1991).The relict passages from Cwm Dwr to Piccadilly also extend downstream to form a passable link over the flooded section of streamway into OFD1. These continue through the spacious passages of the Rawl Series, which are the only extensive old passages on the downdip side of the present stream route. They continue into another very complex maze which can be followed above the modern stream canyons, to emerge from the original OFD Entrance where the abandoned passage is truncated by the side of the Tawe Valley.

Pant Mawr Pot lies 1500 m east of Pwll Byfre (Alexander and Jones, 1959; Moore, 1989). In the floor of a large shakehole, a shaft drops into a single passage up to 8 m wide and 5 m high, with extensive clastic sediment fills. Though this largely abandoned passage may once have related to Ogof Ffynnon Ddu, its underfit stream now drains into the Neath Valley further east.

Interpretation

The evolution history of Ogof Ffynnon Ddu is long and complex. The narrow outcrop of dipping limestone, from the interfluve ridge to the valley floor, has dictated the overall pattern of karst drainage — obliquely down the dip to the contemporary valley floor resurgence. This pattern has survived through successive deepening of the Tawe Valley, creating consecutive series of passages superimposed into each other. The overall drainage oblique to the dip has been developed by utilization alternately of downdip and strike fractures. Passage development further down the dip has been inhibited where longer loops would have passed beneath the Grit cover into limestone less favoured by authigenic solutional enlargement of its fissure network. New downdip drainage paths have therefore developed largely in response to the surface lowering and downdip shift of the outcrop, with simultaneous lowering of the valley floor. The valley deepening also permitted the development of new, lower resurgence sites, while the downstream ends of the older, higher phreatic passages, which had also discharged to the west, were progressively destroyed by surface erosion.

Solutional fissure enlargement in the well bedded and well fractured limestone of Ogof Ffynnon Ddu has led to an uncommonly large number of drainage captures in both the phreatic and vadose parts of the aquifer. This has led to the development of a complex multi-level network cave quite distinct from predominantly two-dimensional maze caves, such as Mossdale Caverns (Figure 2.48), in which passage capture has played only a minor role. The local relief on cave drainage routes created sections of steep downstream gradients; these became the sites of rapid updip vadose entrenchment of the phreatic loops, leading to the gradual elimination of phreatic segments with a corresponding increase in total length of the vadose streamways. This is an important mechanism of passage evolution in many caves in dipping limestone, and (Figure 1.7) is based on detailed observations in Ogof Ffynnon Ddu. The process is well demonstrated in the main streamway, where the vadose catiyons are exceptionally deep; the original passages are preserved over many crests of the old phreatic loops, and new phreatic loops are developing beneath some of the old canyons. The result is a hybrid cave, intermediate between water table and vadose drawdown caves (Ford and Ewers, 1978; Smart and Christopher, 1989).

The rectilinear pattern of so much of Ogof Ffynnon Ddu is ample evidence of the role of the tectonic fractures in the establishment of the karst drainage and the cave passages. There are further expressions of geological control in the caves. The major networks of high-level passages coincide with gentle anticlinal structures which plunge down the

regional dip, while the intervening synclines house far fewer cave passages (Charity and Christopher, 1977); this may be due to either the tensional opening of fissures over the fold crests, or the earlier exposure of the limestone on the structural highs. Bedding of the limestone has also influenced passage morphology, where projecting ledges are formed by more resistant dolomite horizons, and where passages with square sections and flat roofs have been modified by collapse. In the upper part of the Dowlais Limestone, the *Composita ficoides* bed is more sparsely jointed than most; roof collapse and upward stoping frequently stop at this horizon, which forms the roof in many parts of OFD2 Upper Series. The Pwll Byfre sink is close to the base of the limestone, but the cave system climbs stratigraphically in numerous phreatic lifts, so that the past and present resurgences lie at the top of the Dowlais Limestone.

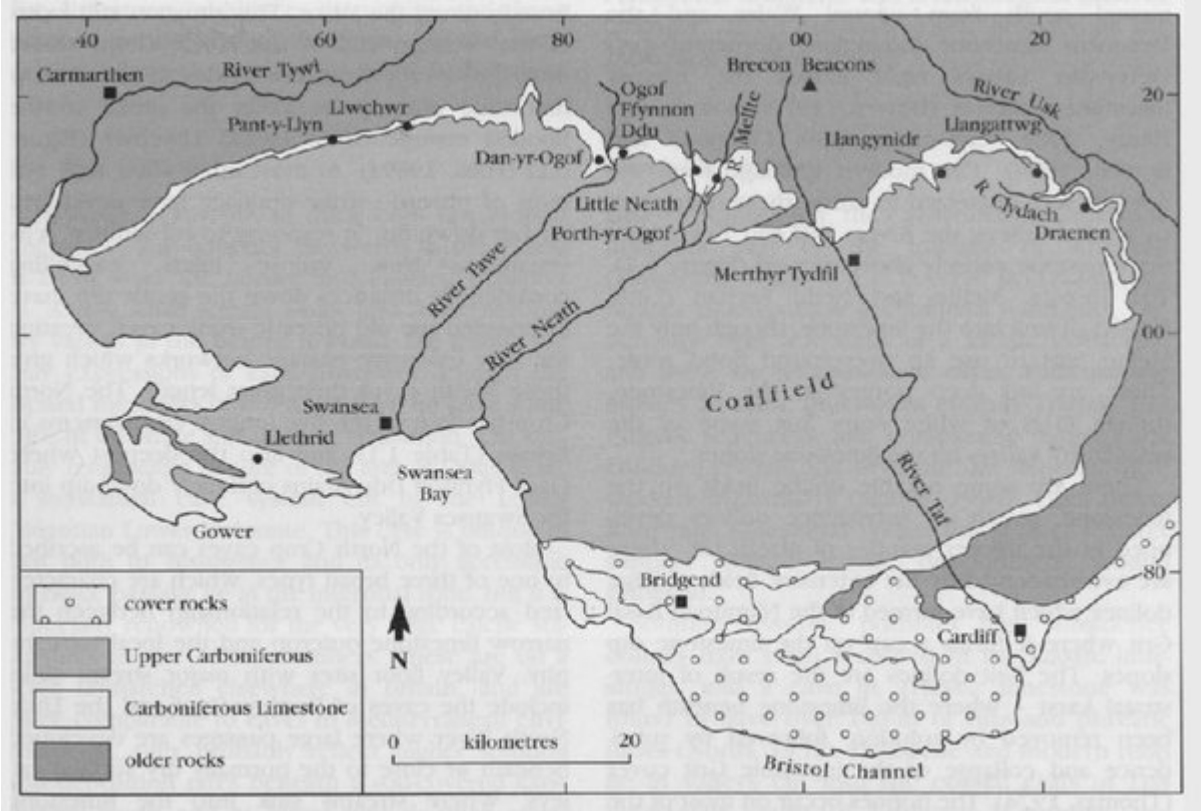
Although evidence of only the last two glaciations has been recognized in this area it is probable that the development of the cave system has been influenced by earlier ones, surface evidence of which has been entirely removed by later glaciations. The effects of these glaciations include truncation of near-surface passages, vadose entrenchment consequent on base-level lowering, and subsequent infilling of passages with glaciofluvial sediments. Solutional enlargement of the cave passages takes place more rapidly in warm interglacial environments, and some of the cave levels may correspond to resurgences at interglacial valley floor levels, though no detailed correlations have yet been made. The one dated flowstone from the OFD2 Upper Series shows that these passages were drained by the Hoxnian stage (267 ka), but these passages are among the oldest in the cave and were probably dry long before this flowstone was deposited. Vadose entrenchment in the Traverses of OFD3 totals about 75 m, and a mean entrenchment rate of 100 mm ka^{-1} may be interpreted from comparable dated sites elsewhere in Britain (Gascoyne *et al.,* 1983a). This suggests an age of about 750 000 years for the OFD3 streamway, and a history for the whole cave is likely to span more than a million years (Smart and Christopher, 1989).

The sequential cross-cutting relationship of many passages and the extensive sediment and speleothem deposits which Ogof Ffynnon Ddu contains gives this system enormous potential for elucidating the Pleistocene history of the upland area, evidence for the early part of which has been entirely removed from the surface landscape. Pant Mawr Pot may represent a fragment of large passage which was once related to the older components of the high levels in Ogof Ffynnon Ddu. This would imply that the Tawe Valley was deeply entrenched before the Neath Valley was excavated, but further speculation is inappropriate until more is known of the interfluve caves so heavily choked with sediment.

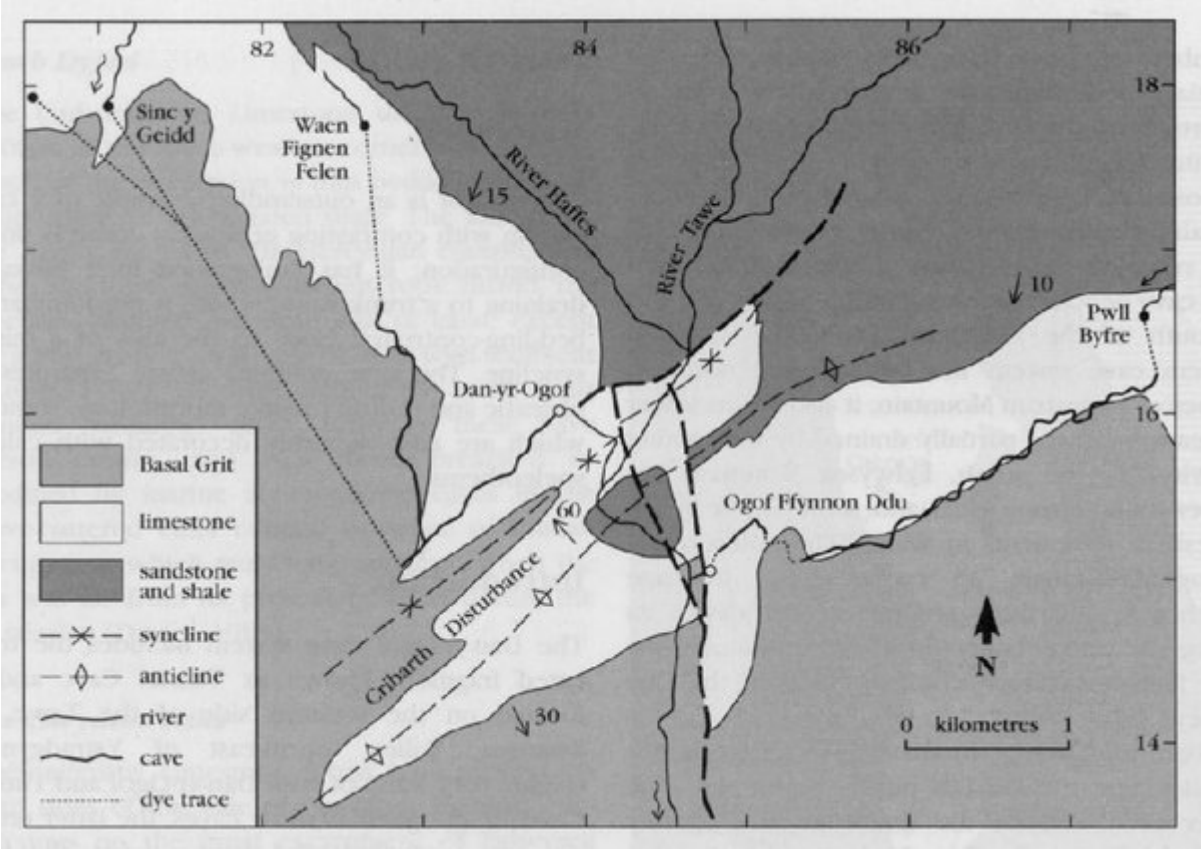
Conclusion

Ogof Ffynon Ddu is a very extensive cave system developed by drainage obliquely through a dipping bed of limestone. The prevailing southerly dip, the minor folds and the joint sets have all exerted a strong control on the configuration of the cave passages. Continued incision through a large depth range has allowed the passages to evolve within these geological constraints over a very long timespan. The morphology of the passage network provides a striking contrast with the nearby cave system of Dan-yr-Ogof, and provides many features of detail which are among the finest in Britain.

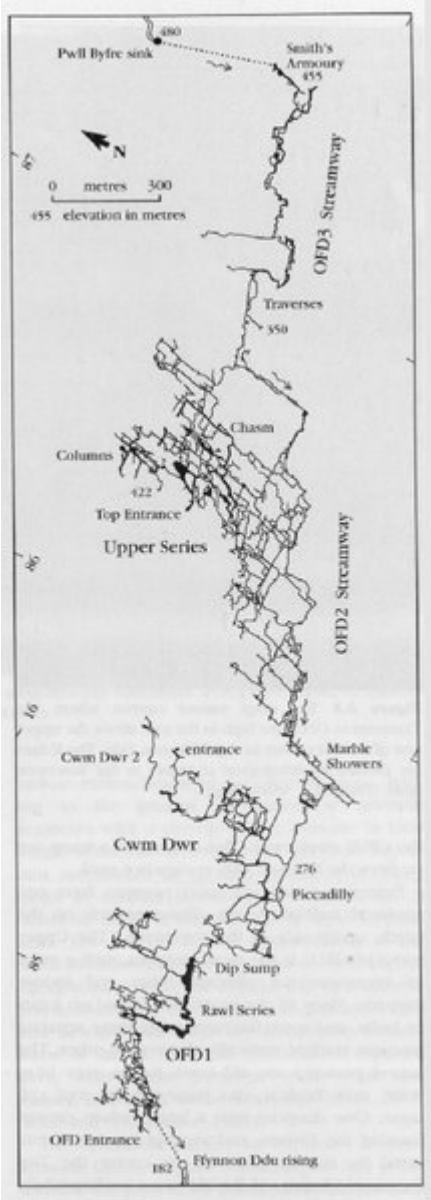
References



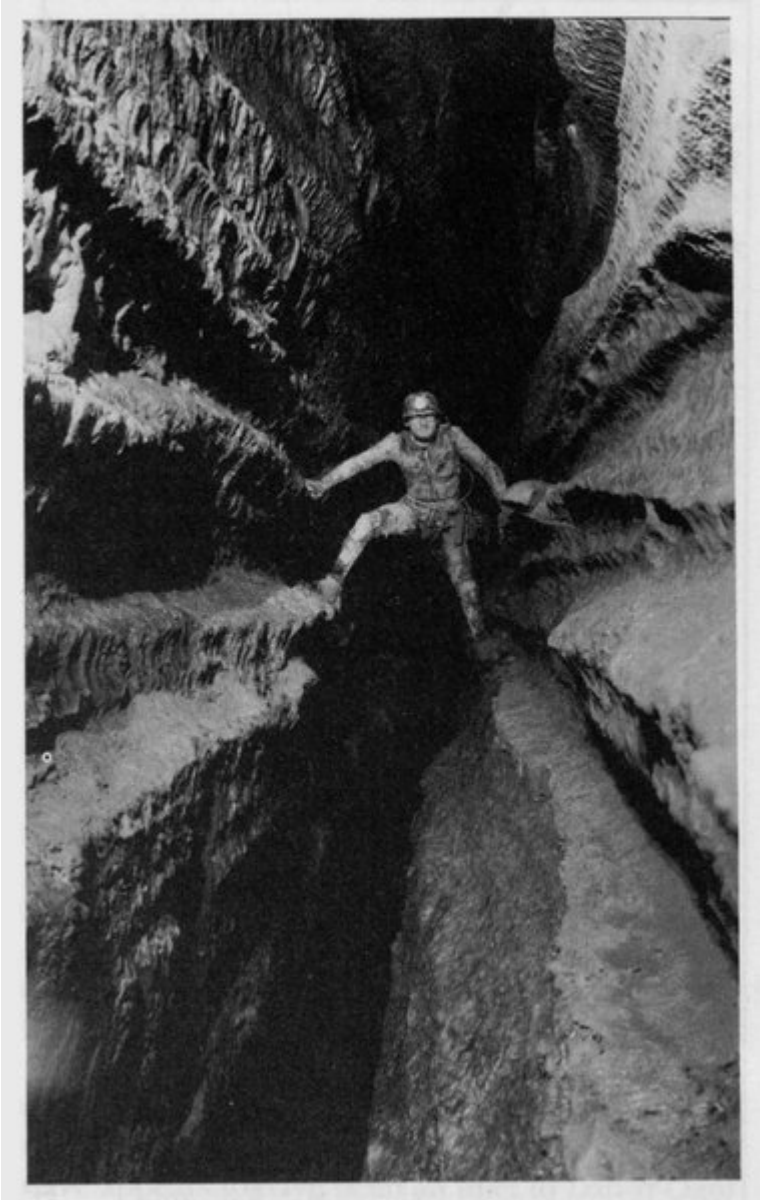
(Figure 6.1) Outline map of the karst areas around the perimeter of the South Wales coalfield, with locations referred to in the text. The cover rocks in the south are Triassic and Jurassic mudstones and thin limestones.



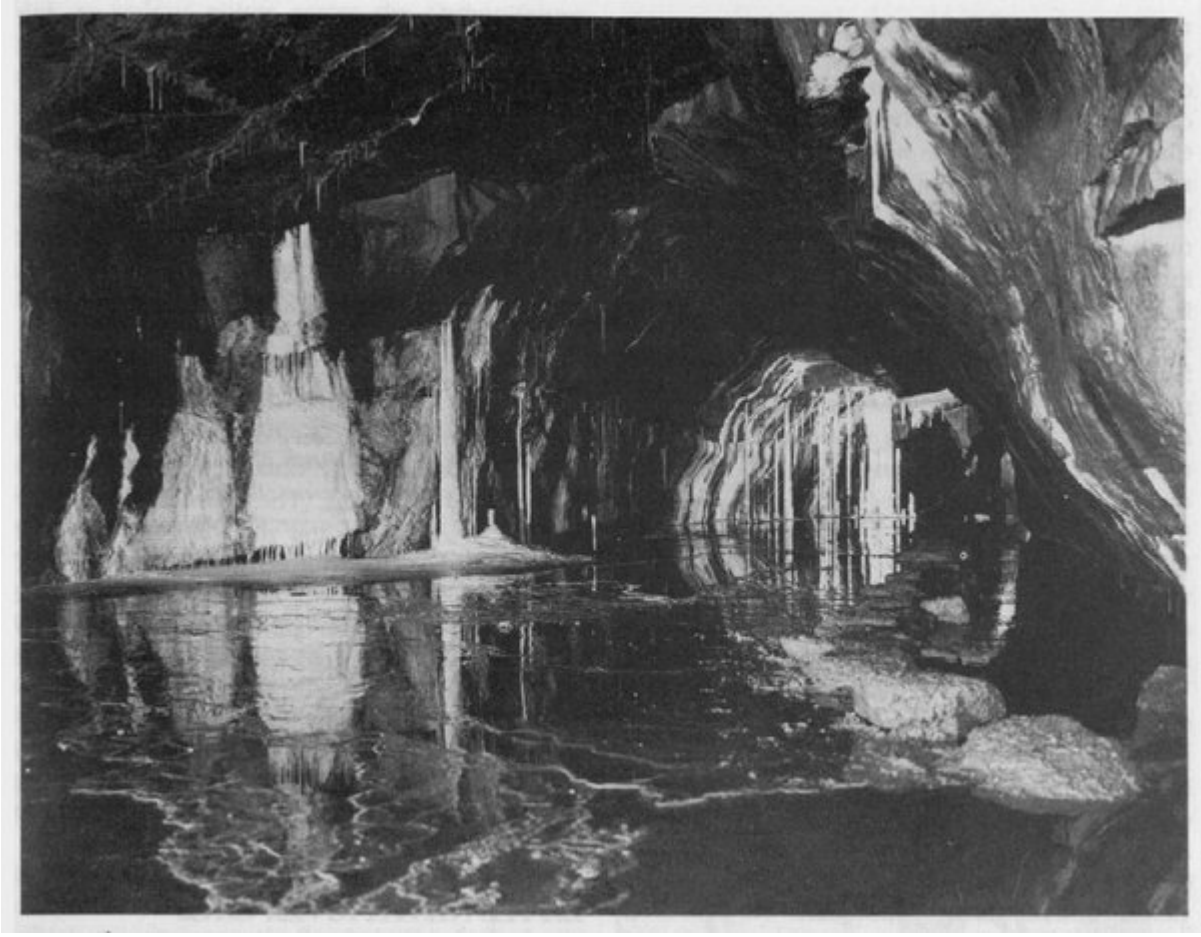
(Figure 6.3) Geological map of the North Crop of the Carboniferous Limestone where it is crossed by the River Tawe in the Swansea Valley. Many small faults are omitted to improve clarity. The sandstones and shales below the limestone are mainly Devonian but include the Lower Limestone Shale from the Carboniferous. The only caves marked are the main stream passages in Dan-yr-Ogof and Ogof Ffynnon Ddu.



(Figure 6.7) Outline map of Ogof Ffynnon Ddu (from loop beneath the Rawl Series, until it emerges in survey by South Wales Caving Club).

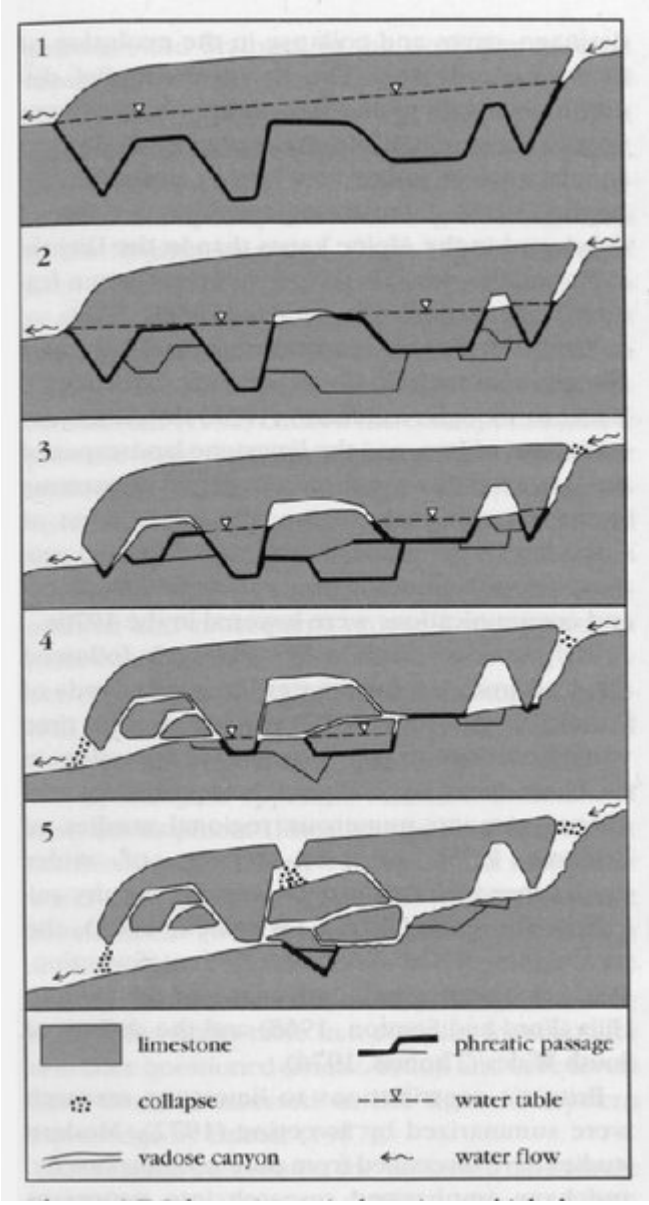


(Figure 6.8) The deep vadose canyon where the Traverses in OFD3 are high in the roof above the upper end of the streamway in Ogof Ffynnon Ddu. The ledges are created by lithological contrasts in the limestone beds. (Photo: J.R. Wooldridge.)



(Figure 6.9) The Columns in Ogof Ffynnon Ddu — calcite stalactites and stalagmites which have grown to connection in a fossil phreatic tube. (Photo: South Wales Caving Club.)

(Figure 2.48) Outline map of Mossdale Caverns and Langcliffe Pot, which both drain to Black Keld. The limestone includes the Great Scar Limestone and the Yoredale facies limestones of the overlying Brigantian Wensleydale Group; the latter are separated by thin shales and sandstones that are not marked (from surveys by University of Leeds Speleological Association and others).



(Figure 1.7) Schematic vertical sections which demonstrate five stages in the evolution of a cave system in response to time and a falling base level. The early stages are mainly of phreatic re-routing and captures; the middle stages are dominated by the entrenchment of vadose canyons through the crests of the phreatic loops; the later stages continue the deepening of the vadose canyons. The model is based on Ogof Ffynnon Ddu, which is developed close to the strike direction in dipping limestones. The principles could apply to many other cave systems if the geometry of the passages was adapted to the local geological structure. (After Smart and Christopher, 1989.)