Chapter 6 Karst in Wales

Introduction

Carboniferous limestones have outcrops in various parts of both North and South Wales, but most of the significant karst and cave development is located in the narrow outcrop of limestone, known as the North Crop, which fringes the northern side of the South Wales coalfield. This outcrop is over 100 km long, though seldom more than 2 km wide (Figure 6.1). Within its sinuous belt and under the adjacent grit cover, a number of limestone caves include the deepest and many of the longest systems in Britain. Though the area is not distinguished by dramatic limestone landscapes and spectacular karst landforms, it does contain a turlough and an extensive interstratal karst with some large doline fields, both features which are not well represented elsewhere in Britain.

Stratigraphically the limestones of the North Crop range through much of the Dinantian, within the Lower Carboniferous, but erosional and non-depositional breaks mean that the full sequence is not found in any one section. The full thickness of the exposed carbonates varies from 120 m to 150 m along the outcrop (Ramsbottom, 1973; George *et al.,* 1976; Wright, 1986a; Barclay *et al.,* 1988; Barclay, 1989; Lowe, 1989b). All are of shelf facies, consisting of micrites, sparites, bioclastic limestones and oolites, and some horizons are extensively dolomitized. Most are well bedded, and they contain many thin shale, mudstone, sandstone and palaeosol horizons, the latter overlying shallow zones of palaeokarstic features (Wright, 1982, 1986b).

The North Crop limestones are underlain by the Lower Dinantian Lower Limestone Shale; this rests, with only slight unconformity, on the sandstones and shales of the Devonian, which rise northwards to form the escarpments of the Brecon Beacons and Black Mountain. In some places the limestone is capped by a thin Upper Dinantian shale. Elsewhere this is cut out, and the strong, coarse-grained Basal Grit, of Narnurian age, rests directly on the limestone. The permeability of this caprock has been responsible for the extensive interstratal karst which distinguishes much of the North Crop with its doline fields formed in the grit.

Along the North Crop, the limestone dips gently south into the coalfield syncline. Dips are generally less than 15°. Numerous north-south faults cross the outcrop, and there are local zones of more severe disturbance, orientated SW–NE, with major faults and steep folding (Lowe, 1989b).

The karst of the North Crop

Surface karst features are not conspicuous components of the limestone landscapes of South Wales, and there is none of the spectacular landmarks which distinguish the Carboniferous limestones in much of England. This is partly because the limestone is surrounded by topographically prominent sandstones which lie stratigraphically both above and below. Much of the limestone outcrop is little more than a line of scars backed by a narrow dip slope and overlooked by the scarp face of the strong Namurian Basal Grit.

The limestone outcrops were subjected to glaciation during the Devensian, but limestone pavements are developed on only a few of the interfluves where the dip is low; much of the karst is now veneered with till, and limestone pavements are not extensive (Thomas, 1970). Ice moved south from central Wales and the Devonian sandstone mountains, deepening pre-Devensian valleys right across the narrow limestone outcrop (Bowen, 1970: Bowen and Henry, 1984; Crowther, 1989; Campbell and Bowen, 1989). The modern drainage from the north is well organized to utilize these deep, gently graded valleys; the Rivers Taff and Tawe cross the limestone entirely above ground (Figure 6.1). The Hepste, Mellte and Nedd Fechan (Little Neath) all sink into the limestone, though only the Mellte fails to use an overground flood route. There are no deep gorges in the limestone, though lines of white scars line some of the smaller dry valleys on the limestone slopes.

There are some notable doline fields on the limestone, mostly of subsidence dolines developed in the thicker mantles of glacial till. These are overshadowed by the extensive fields of large dolines which have formed in the Namurian Basal

Grit where it forms a cap on the limestone dip slopes. The Grit dolines are the result of inter-strata! karst — where the limestone beneath has been removed by solution, followed by subsidence and collapse of the insoluble Grit cover (Thomas, 1974). The dolines occur on most of the Grit plateaus immediately south of the limestone outcrop of the North Crop, with the finest on Mynydd Llangynidr; they are unmatched anywhere else in Britain.

The caves of the North Crop

The most important feature of the North Crop drainage is the southward flow off the higher slopes of Devonian Old Red Sandstone in the north. Though the limestone outcrop is only narrow, its position across the regional trend of slope and surface drainage allows it to capture very large supplies of allogenic water. Where a valley outlet exists in the same bed, the favourable hydraulic gradients through the limestone have created conditions ideal for cave development. Compared with the Yorkshire Dales karst, the caves of South Wales are few in number, but those that do exist are notably long and deep (Ford, 1989a).

A characteristic of many North Crop caves is that allogenic water sinks into them at or near the stratigraphic base of the limestone. The immediate underground drainage is then downdip, until the contemporary water table is reached close to the level of the adjacent valley breaching the limestone outcrop. Phreatic flow then develops broadly along the strike. This situation still exists at the western end of the North Crop, where drainage, locally from both sides of the narrow limestone outcrop, is along the strike to the flooded resurgence of Llygad Llwchwr (Figure 6.1) (Ford, 1989a). At most other sites, new systems of phreatic strike drainage have developed further downdip, in response to subsequent rejuvenations. New vadose inlets, extending considerable distances down the gentle dip, have intersected the old phreatic trunk caves, creating the very extensive passage networks which give these Welsh caves their great length. The North Crop has four of the five longest cave systems in Britain (Table 1.1), and also the deepest where Ogof Ffynnon Ddu drains obliquely downdip into the Swansea Valley.

Most of the North Crop caves can be ascribed to one of three broad types, which are characterized according to the relationship between the narrow limestone outcrop and the local topography. Valley floor sites with major stream sinks include the caves of Porth-yr-Ogof and the Little Neath River where large passages are developed beneath or close to the normally dry surface valleys. Where streams sink into the limestone outcrops high on the major interfluves, caves develop down the hydraulic gradient and obliquely to the adjacent valley floor; the caves of the Swansea Valley are of this type, and the contrasting patterns of Ogof Ffynnon Ddu and Dan-yr-Ogof reflect a relationship between geological structure and valley orientation. The third cave type underlies the gently sloping Grit plateaus, and carries drainage from sinks in the marginal limestone outcrop on the higher, updip side through to risings in the lower side; the caves of Llangattwg have this pattern, where the lower edge of the gentle dipslope has been trimmed by recession of the Clydach Gorge.

The sheer size of the North Crop caves give them a special place in any review of Britain's karst. They also have an exceptional diversity of passage morphology and depositional detail, and their long Pleistocene histories are recorded in their complex passage networks.

The karst and caves in outlying areas of Wales

Apart from the North Crop, the Carboniferous Limestone forms outcrops scattered across North and South Wales. They all have their own distinctive limestone sequences, structure and karst features, but the surface landforms and the caves are more limited in scale than those of the North Crop.

The Wye Valley

Carbonates nearly 300 m thick crop out around Chepstow, and continue eastwards to the Forest of Dean, over the border into England (Chapter 7). A few small stream sinks, and some shallow dry valleys in the farmed lowland, are almost the only expressions of karst processes, though the incised meanders of the River Wye do have some cliffs of dolomite shrouded in vegetation. The one truly remarkable feature of the area is Otter Hole, a substantial cave system cut in the Lower Dinantian Lower Dolomite. This cave is unique in that both its resurgence and its only accessible

entrance passage lie in the intertidal zone, but it is especially renowned for the very large calcite stalagmites in one of its chambers. These are on a scale unmatched elsewhere in Britain, and are more comparable to caves in Mediterranean environments; they probably reflect higher solution and deposition rates beneath a soil-covered karst further south and at lower altitude than other major caves in Britain's Carboniferous Limestone.

The Gower Peninsula

The limestones along the southern margin of the main South Wales coalfield syncline have been broken into two fragments by the coastal incursion of Swansea Bay. The western fragment forms the Gower Peninsula, and contains the only notable karst features. The Dinantian limestones thicken to the south and west in South Wales (Lowe, 1989b), and Gower has a sequence of pure limestone more than 400 m thick. Hercynian compression increased along the syncline towards the west; the limestone was steeply folded, and now forms a series of narrow outcrops between belts of sandstone.

Dry valleys cross the limestone outcrop where drainage is underground. The known caves are mainly small, but there are some larger old chambers; these could be remnants of more extensive pre-Devensian cave development which is also responsible for some recent collapse features in the Bishopton Valley (Ede and Bull, 1989). A number of caves open in the coastal cliffs of Gower; Bacon Hole and Minchin Hole, both on the southeast coast, are very old solution cave fragments, now most notable for their extensive sequences of Pleistocene sediments and archaeological material (Stringer, 1977; Sutcliffe, 1981; Stringer *et al.,* 1986; Bowen *et al.,* 1989).

South Glamorgan

East of Swansea Bay, the Carboniferous Limestone underlies part of the lowland of southern Glamorgan. Much of it is covered by Triassic and Jurassic mudstones or glaciofluvial sediments. The outcrops bear few signs of a karstic landscape, and there are no significant caves. Palaeokarstic fissures in these limestones contain Triassic and Jurassic sediments, and comparable, larger karst conduits contain the hematite ore deposits once worked at Llanharry (Simms, 1990). Thin, nearly horizontal limestones within the Mesozoic cover support limited karstic development around Bridgend.

Solution fissures, potholes and subsidence dolines have been recorded in the Liassic limestones, and a cave in Triassic limestone was found to have over 100 m of rifts and phreatic tubes (North, 1952). Holocene and modern tufas lie in valleys cut into the coastal cliffs of Lias limestones south of Bridgend (Campbell and Bowen, 1989).

South Dyfed

The Carboniferous Limestone thickens to over 1000 m in the south-western corner of Wales, but much of the succession is thin bedded with high proportions of intercalated shale. The limestones are tightly folded in the Hercynian compression zone, and form only narrow outcrops. Inland, the glaciated platform has little sign of karst, except for a few small caves largely choked with sediment (Davies, 1989). The high cliffs of the south coast contain numerous caves; many of these have karstic origins, and have been breached or modified by marine action. Some caves in the wave-battered cliffs contain evidence of human occupation, which must have occurred when the sea was far from its present position during the Devensian (Davies, 1989).

The Clwydian Hills

Carboniferous Limestone forms high ground on both sides of the Vale of Clwyd, at its most conspicuous on the great escarpment of Egiwyseg Mountain, just north of Llangollen (Figure 6.2). The Asbian Loggerheads Limestone is the dominant unit, only 100 m thick at Egiwyseg, but over 500 m thick further north.

East of Clwyd, Halkyn Mountain is part of a limestone belt with poorly developed surface karst, whose natural underground drainage all flowed to St Winifride's Well at Holywell. The limestone is laced with mine workings, developed to extract the rich ores of lead and zinc (Richardson, 1937; Warwick, 1968; Appleton, 1989); the main production was from about 1800 until 1958. The mines intercepted many stream caves and large phreatic chambers extending above and below sea level; Powell's Lode Cavern is 70 m long and over 30 m high and wide. Drainage adits, mined through the

impermeable Namurian cover towards the east, lowered the water tables throughout the limestone. This action permanently dried up the natural resurgence at St Winifride's Well, a vauclusian rising in a faulted anticline of Brigantian black limestones and chert beds at the top of the main carbonate succession (the rising is an important religious site and its flow has been reinstated by a concealed diversion of water from another nearby drainage tunnel). The adits also drained extensive phreatic cave systems beneath the Alyn Gorge, where the middle course of the River Alyn is normally dry in summer. Halkyn Mountain has a number of pocket deposits where subsided Tertiary sediments are preserved in solution depressions; the Rhes-y-Cae pit is the best documented (Walsh and Brown, 1971). Postglacial tufa deposits at Caerwys are the most extensive in Britain; they have been heavily quarried, but this has revealed the structure of the barrage, pool and cave deposits (Pedley, 1987).

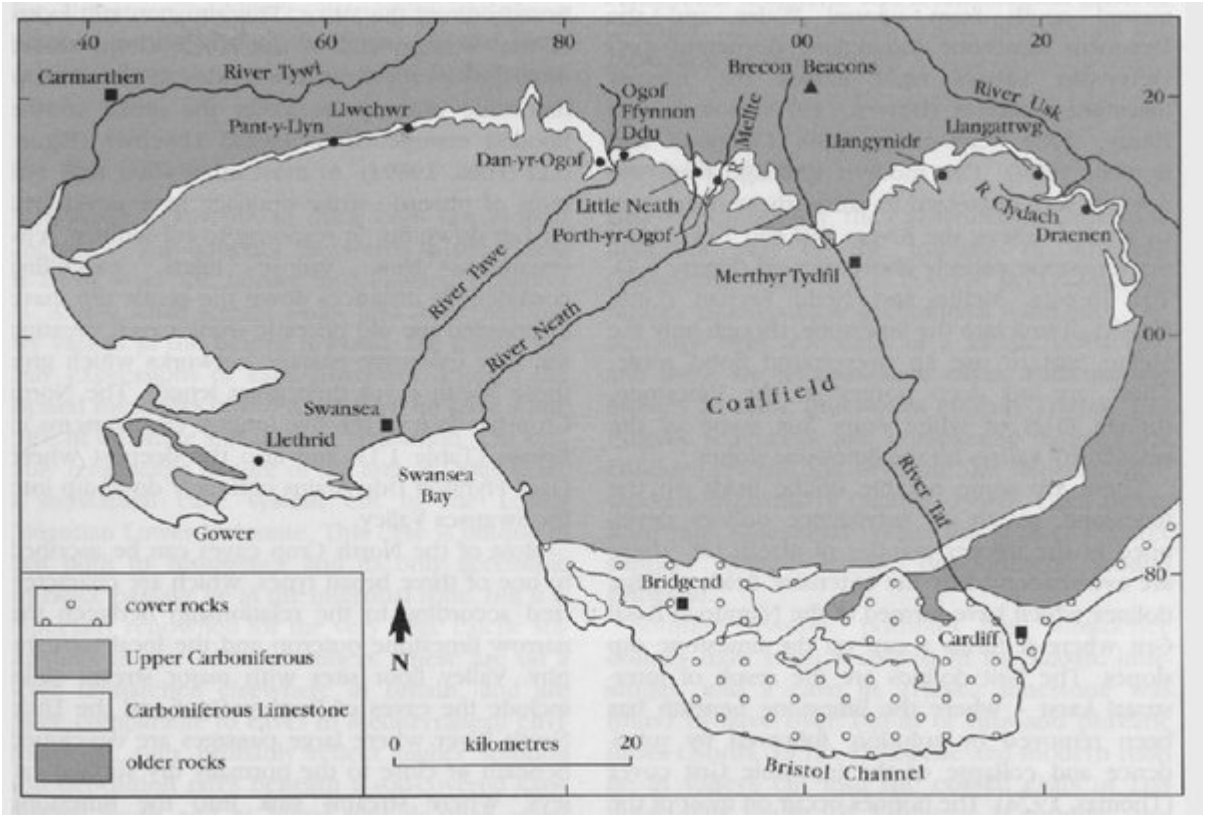
South of the Llanelidan Fault, the splendid Minera cave system lies beneath the northern slopes of Esclusham Mountain; it also has its lower phreatic passages partially drained by the mining activity. To the south, Eglwyseg Mountain has towering limestone cliffs and some of the finest limestone pavements in Wales. The outcrop is a topographic high, so no allogenic drainage reaches it, and there are no influent caves; its autogenic waters collect in a karstic drainage system feeding sediment-choked risings in the Dee Valley.

West of Clwyd, the limestone outcrops are smaller, and the karst is poorly developed. The River Elwy crosses the limestone in a gently graded, alluviated valley. In its northern slope, Pontnewydd Cave is a truncated fragment of large cave passage which was almost full of sediments; excavation of these has revealed a record of Pleistocene environments and human occupation extending back 240 ka (Green, 1984) — it is the most northerly site in Europe with human remains of this age. The limestone continues through broken outcrops to the Great Orme, at Llandudno, where the karst drainage is so poorly integrated that adits were driven to permit mining down to sea level.

Anglesey

The upper Dinantian limestones form two outcrops in southern Anglesey, but the lowland aspect and the thick cover of glacial and glaciofluvial debris preclude significant karst development. The island's limestones are most notable for the spectacular palaeokarst exposed in the wave-cut platform and low cliffs of the east coast (Baughen and Walsh, 1980; Walkden and Davies, 1983). Cylindrical sandstone pipes, about 1 m in diameter, penetrate the limestone for up to 3 m. The sandstone fills are Dinantian; they lie in hollows which appear to be solutional features excavated in a temporarily uplifted coastal platform, though some may be moulins developed by wave action.

References

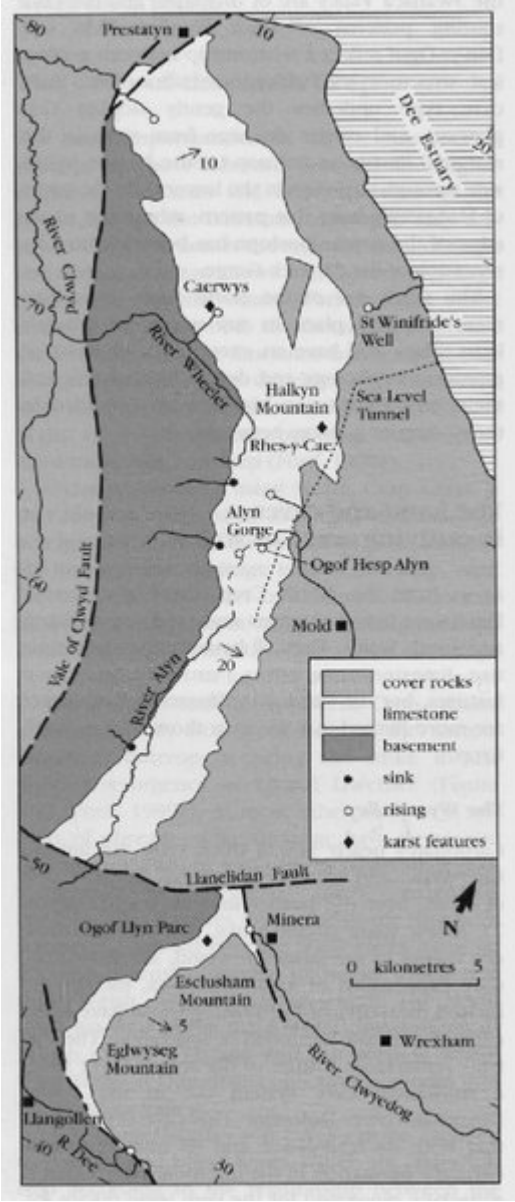


(Figure 6.1) Outline map of the karst areas around the perimeter of the South Wales coalfield, with locations referred to in the text. The cover rocks in the south are Triassic and Jurassic mudstones and thin limestones.

Region	Yorkshire Dales[1]	Northern Pennines[2]	Peak District	Mendip Hills	South Wales	Rest of Britain[3]
Geology						
Karst area[4]	320 km²	220	420 km²	110 km²	220 km²	9000 km² (mostly chalk)
Karst relief[5]	270 m	70 m	260 m	260 m	330 m	200 m (chalk)
Limestone thickness[6]	200 m	40 m	400 m	700 m	150 m	200 m (chalk)
Typical dip	1°	1°	5°	30°	10°	Varies between areas
Last glaciation	Devensian	Devensian	Anglian[7]	None	Devensian	Varies between areas
Karst[8]						
Glaciokarst	• • •	• •				• (Scotland)[9]
Fluviokarst			• •	• •		• • (chalk)
Interstratal karst			•		• •	
Pavement area[10]	677 ha	613 ha	0	0	8 ha	28 ha (Scotland, North Wales)
Dry valleys	•		• •	•	•	• • (chalk)
Karst gorges	• •	•	•	• •		
Collapse features	•		•			
Doline fields	• •				• •	• • (covered chalk)
Ephemeral lakes					•	• (chalk)
Polygonal karst	•			•		
Famous sites	Malham Cove Gaping Gill	Hutton Roof Crags	Dove Dale Peak Cavern	Cheddar Gorge Wookey Hole	Dan-yr-Ogof Porth-yr-Ogof	
Caves						
Major passage types	Vadose joint shafts, phreatic on bedding	Joint mazes	Phreatic on veins and bedding	Downdip phreatic loops	Downdip vadose, strike phreatic	Vary between areas
Number of caves[11]	1420	620	210	220	270	410
Total cave length[11]	325 km	65 km	50 km	55 km	195 km	45 km
Caves over 1 km long	50	9	9	10	12	6
Longest caves[12] (km)	Ease Gill System 71 Kingsdale System 24 Gaping Gill System 18 Ireby-Notts System 12	Goyden Pot 6 Knock Fell Caverns 5 Fairy Hole 4 Devis Hole 2	Peak-Speedwell System 14 Giants Hole 5 Bagshaw Cavern 4 Carlwark Cavern 2	Swildon's Hole 9 St Cuthbert's Swallet 7 Wookey Hole 4 Gough's Cave 2	Ogof Ffynnon Ddu 50 Ogof Draenen 48 Ogof Agen Allwedd 34 Ogof Daren Cilau 30	Slaughter Cave 11 (Forest of Dean) Ogof Llyn Parc 4 (North Wales) Uamh an Claonaite 5 (Scotland) Ogof Llyn Du 2 (North Wales)
Deepest caves[12] (m)	Ease Gill System 211 Mercgill Hole 206 Pen y ghent Pot 196 Gaping Gill System 195	Goyden Pot 61 Scrafton Pot 44 Pate Hole 33 Aylebarn Mine Cave 30	Giants Hole 214 Masson Cavern 1 90 Peak-Speedwell System 184 Nettle Pot 180	Eastwater Cavern 180 Longwood Swallet 175 Swildon's Hole 167 Manor Farm 151	Ogof Ffynnon Ddu 308 Ogof Daren Cilau 217 Ogof Agen Allwedd 177 Dan-yr-Ogof 140	Ogof Llyn Parc 115 (North Wales) Slaughter Cave 99 (Forest of Dean) Cnoc nan Uamh 90 (Scotland) Ogof Hesp Alyn 90 (North Wales)

1 The main southern Dales area on the Askrigg Block, including Dentdale, and excluding Nidderdale.
2 Including Nidderdale, the karst east of Morecambe Bay, and the eastern fringe of the Lake District.
3 Mostly the weakly cavernous karst of the chalk and oolitic limestones; including the cavernous karst of Devon, Forest of Dean, North Wales and Scotland.
4 Approximate area of karstic landscapes; does not include all the limestone outcrops.
5 Approximate values for the local relief within the limestone, which dictates the maximum descent from sink to rising, added to any depth of karstification beneath the resurgence level.
6 Geological data are generalized for purposes of comparison.
7 Or possibly Wolstonian – see text.
8 Most karst features are found to some extent in all the main karst regions, but their importance is assessed in relative terms:
• = significant, but minor;
• • = important and widespread;
• • • = internationally important.
9 Location of the major features noted in parentheses.
10 From Ward and Evans (1976).
11 Recorded caves longer or deeper than 5 m; figures rounded to nearest 10 caves and 5 km of passage; from unpublished database of Limestone Research Group, University of Huddersfield.
12 Subject to continuous revision, as lengths (and less frequently depths) are increased by newly discovered passages or by links found between known caves.

(Table 1.1) A comparison of the major features which give the individual character to each main karst region of Britain



(Figure 6.2) Outline map of karst features in the Carboniferous Limestone of eastern Clwyd, North Wales, with locations referred to in the text. The main rivers and risings are shown as they were before disturbance by the mine drainage. The basement is Ordovician shale; the cover rocks are Upper Carboniferous and Triassic clastics. Many of the steps on the boundaries are due to minor faults.