Chapter 4 The Peak District karst

Introduction

The southern end of the Pennines contains the largest unbroken area of cavernous karst in the Carboniferous limestones in Britain (Figure 4.1). A limestone upland roughly 35 km by 15 km lies between Matlock and Chapel-en-le-Frith; it may be referred to as the White Peak, to distinguish it from the Dark Peak of the Millstone Grit moors to the north, the two combining to form the Peak District.

The limestone is of Dinantian age with most of the outcrops, karst and caves lying within rocks of the Asbian and Brigantian stages. Over 500 m of limestones are exposed across the Peak District karst, and another 1000 m of carbonates underlie these but have no outcrop. Thickly bedded, pure limestones of shelf lagoon origins dominate the heart of the Peak District, locally interrupted by dark, thinly bedded, impure carbonates of basinal facies. Massive reef limestones are important. They form a zone of marginal reefs, complete with their own debris slopes of the fore reef facies, which fringe a long-standing positive area; in Carboniferous times they bordered a shelf area of shallow water, and today they lie close to the perimeter of the main limestone outcrop. Patch reefs occur inside this fringe, and form low reef knolls on the karst plateau. The limestone succession is interrupted by discontinuous basaltic lavas and pyroclastic horizons; many of the latter are heavily altered and weathered, and are known locally as toadstones and wayboards. Secondary dolomitization is associated with some of the mineralized areas in the southern third of the karst outcrop.

Impermeable basement rocks are known only in a few deep boreholes. The cover rocks, forming an annular outcrop around the karst, are shales mostly of Namurian age, which are followed by the strong sandstones in the Millstone Grit Series. Only along a short section of the southern perimeter of the karst do Triassic sandstones overstep onto the limestone. Neogene sands and clays accumulated on the southern part of the karst as the adjacent Triassic cover retreated, but most were removed during the Pliocene. They only survive as the fills in about 60 solutional depressions, dolines and karstic collapses, where they are known as the Pocket Deposits of the Brassington Formation (Ford and King, 1969; Walsh *et al.,* 1972); overlain by Pleistocene till, these sites are features of a Tertiary palaeokarst (Ford, 1984).

Structurally the area may be known as the Derbyshire Dome; this is an oversimplified description of the distorted positive area on the southern end of the Pennine anticline. There are numerous crossing folds, but, except in some marginal areas, the limestone dips are mostly low. Faults are widespread across the limestone, and are extensively mineralized. The hydrothermal mineralization is of the Mississippi Valley type generated by the migration of connate fluids into the domed area from adjacent basins in late Carboniferous times (Ineson and Ford, 1982; Mostaghel and Ford, 1986; Quirk, 1986, 1993; Ixer and Vaughan, 1993). The main. ore deposits are in the long faults across the karst, aligned roughly east–west and known as rakes; ores also form bedded flats and cavity infills in palaeokarstic openings. Mineral working in. the Peak District has been continuous for over a thousand years, firstly for the lead ores and latterly for the fluorspar resources. Miners were the first to encounter and explore many of the caves, and they significantly modified much of the karst drainage as they endeavoured to lower the water table around their mines by cutting long drainage adits, known as soughs, close to base level.

The karst

The limestone forms a dissected plateau with local relief generally less than 200 m and nowhere more than 300 m, and the entire karst was overrun by ice sheets during the Anglian stage of the Pleistocene. The extent of glacial cover of the plateau by a 'Wolstonian' ice expansion is unknown, but till was introduced into some of the valleys by ice lobes from the west (Burek, 1991). The Peak District karst was not covered by ice during the Devensian, when it was subjected to a long period of periglacial conditions.

The Peak District plateau is essentially a fluviokarst, incised by dendritic systems of dry valleys which are the dominant feature of the landscapes. These were probably superimposed from a retreating cover of Namurian shales, and were initially desiccated by the maturing of the karstification (Warwick, 1964; Pitty, 1968). They were subsequently reactivated and deepened by summer meltwater flows when groundwater was frozen under the periglacial conditions of the cold Pleistocene stages.

The Rivers Wye and Dove maintain their surface flows right across the limestone outcrop, and a few other rivers have shorter surface courses within the karst. Most of this surface flow is in gently graded valleys at base level, aided by local perching of the water tables on impermeable volcanic horizons, and some stretches where the river beds have been artificially puddled with clay. Conversely, some stretches of valley are now dry only since their flow was captured by the miners' drainage soughs. Tufa barriers have formed below some of the karstic springs, and survive on a larger scale than at most other sites in Britain. Some valleys steepen into gorges where they descend the plateau margins through strong reef limestones; other gorges have been entrenched behind stratimorphic reef mounds which trapped valleys whose uniclinal shift was curtailed (Ford and Burek 1976). Throughout the Peak District karst, the landforms are strongly influenced by geological structure and lithology.

Limestone pavements are rare in the Peak District; those which originated from the Anglian glaciation have either been destroyed by later frost action or have been buried beneath younger soils. Many of the deeper dry valleys are lined by rock scars which mark the outcrops of stronger beds of the limestone and especially the massive reef units. Rocky tors have formed by Pleistocene frost action in some of the dolomite outcrops (Ford, 1963). Most of the karst lies under a veneer of soil, derived from frost action and loess accumulation, both largely in the Devensian periglacial environments (Pigott, 1962, 1965). On the steeper valley sides this is widely soliflucted, and soil creep has initiated the formation of extensive areas of terracettes. Only isolated patches of glacial till have survived the erosion since the Anglian ice cover retreated.

Most of the limestone outcrop stands topographically higher than the surrounding outcrops of the stratigraphically younger shales, which are more easily eroded. Surface drainage is therefore predominantly towards the shale, and allogenic waters draining onto the limestone are limited in extent. Only where the escarpments of the Millstone Grit — the Edges of the Dark Peak — are close enough to the karst and high enough, do the surface streams cross the shale and sink into the limestone. Rushup Edge overlooks the northern tip of the karst perimeter, and supplies the water to the cave systems behind Castleton. Most water enters the karst aquifer from direct rainfall, constituting percolation input with little flow concentration.

Consequently, there are relatively few open sinkhole caves in the Peak District karst. Solutional dolines, subsidence dolines and collapse features do occur, but closed depressions are generally only details within the fluviokarst landscape. With no basement rocks exposed, many of the resurgences are vauclusian, offering only difficult access to submerged passages, and open cave passages at resurgences are few in number.

The caves

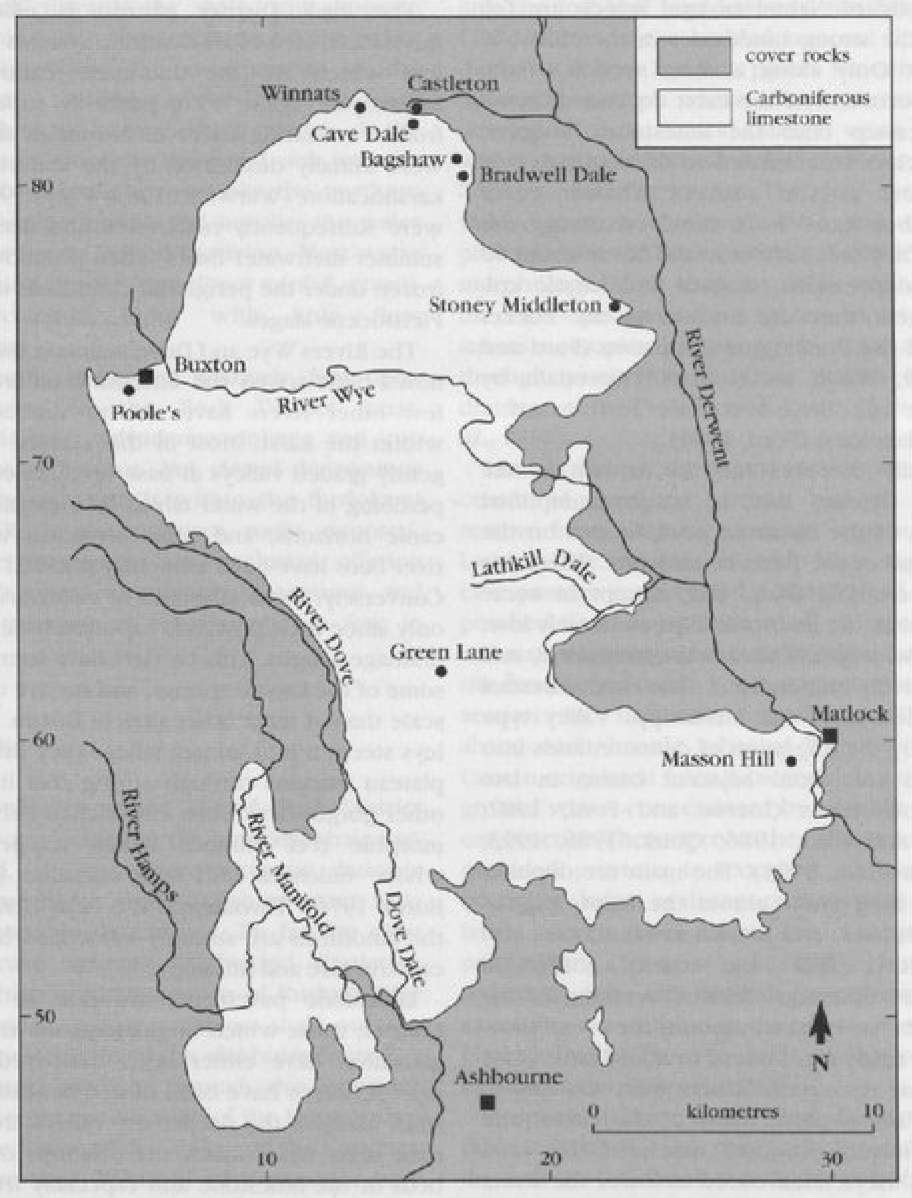
The great majority of the known Peak District caves are located close to the marginal shale outcrops (Ford, 1977b), where allogenic drainage creates stream flows large enough to create sinkholes of enterable dimensions. By far the most extensive cave systems lie behind Castleton, where the high sandstone scarp of Rushup Edge supplies drainage across a narrow shale outcrop onto the limestone; from the sinkholes there is a steep hydraulic gradient through the limestone into the deep glaciated trough of the Hope Valley. Between the Rushup Edge sinks and the Castleton risings, more than 20 km of cave passages have been mapped. They constitute an excellent karst drainage system, which exhibits a close control by the geology and reveals a long evolution through successive rejuvenation stages during the Pleistocene (Ford, 1986a). Dated stalagmites and sediments in successive cave levels yield a chronological framework which can be correlated with surface erosion from Anglian times to the present (Ford *et al.,* 1983).

The Castleton caves have developed in all the major environments found in the Peak District karst. They traverse rocks of both the reef and lagoonal facies of the Carboniferous Limestone. In the reef masses, the caves are mostly irregular complexes of chambers, with some extending into the fore-reef boulder beds, notably at Treak Cliff Cavern. In the bedded lagoonal limestones, the caves follow bedding planes for considerable distances, except where deep phreatic loops developed on faults and mineral veins, some of which may have had solutional cavities relict from Tertiary or earlier events. The deep meandering vadose canyon of Giant's Hole and the relict phreatic tubes of Peak Cavern are classics of cave morphology. More than any other site in Britain, the Peak–Speedwell Cave System clearly demonstrates a complex hydrology with flood diversions through parallel routes; this typifies the deep drainage of the Peak District karst (Christopher *et al.,* 1981).

Little is known about cave development in the centre of the karst plateau, beneath outcrops remote from allogenic drainage supplies. Upper Lathkill Dale contains the only large segments of cave passage yet revealed. Lathkill Head Cave is a perched flood route with small passages feeding to a natural resurgence, but the other caves in the site have been revealed only through chance intersection by old mine workings. The large abandoned phreatic tubes of Water Icicle Close Cavern originated from substantial flows of underground water, concentrated by sizeable upstream catchments. These were either allogenic supplies provided previous to extensive removal 'of the overlying shales, or distant coalescences of percolation water. The caves are known to be pre-Anglian (Ford *et al.,* 1983) but further sediment data are needed to determine their exact origin and the role they have played in the plateau hydrology, especially during periods of Pleistocene meltwater activity.

A special feature of the Peak District caves is their relationship to the hydrothermal mineral deposits in the limestone. Some palaeokarst features predate the late Carboniferous mineralization, which has subsequently influenced the Tertiary and Pleistocene development of the modern caves and karst; large solutional rifts lie along the mineral veins (the rakes) in many cave systems. In the Matlock area, caves intersect and follow some of the mineral orebodies, where mining has re-exposed some of the palaeokarst features (Ford, 1984). Combined with sediment sequences which include fluvioglacial material more than 730 000 years old (Noel, 1987), the Masson Hill caves offer fragmentary evidence covering an exceptionally long timespan of karstic evolution. A second equally long record of Pleistocene events is provided by the fossil caves and sediment fills exposed by the quarry in Eldon Hill (Farrant, 1995).

References



(Figure 4.1) Outline map of the Peak District karst, with locations referred to in the text. The cover rocks are Namurian shales and sandstones, and younger stratigraphic units.