
High Mark

[SD 91 68]–[SD 94 67]

Highlights

The dolines and closed basins of the High Mark plateau, east of Malham Tarn, are some of the best developed in Britain. The series of large closed basins, dolines and dry valleys constitute one of the country's finest examples of polygonal karst.

Introduction

The high ground of High Mark, between Littondale and Malham Tarn, forms a complex dissected plateau. Its surface is broken by closed depressions, dolines, rocky scars and shallow dry valleys. These include some of the largest closed basins in Britain. It constitutes an area of fine polygonal karst, and appears to be one of the most mature karst landscapes in Britain. It therefore has important implications for reconstructing the early evolution of this part of the Yorkshire Dales. The Great Scar Limestone reaches its maximum elevation in this area, which would have been one of the first areas of limestone to be exposed in the Yorkshire Dales, and it seems to have escaped the worst erosional effects of the Pleistocene glaciations.

The dolines of High Mark have been the subject of much discussion (Moisley, 1955; Clayton, 1966, 1981; O'Connor *et al.*, 1974; Sweeting, 1966, 1974). Trudgill (1985b) studied limestone solution rates in the area. The regional geology is documented by O'Connor (1964), Waltham (1974a), Shaw, J. (1983) and Arthurton *et al.* (1988).

Description

The dolines and closed basins of High Mark occupy the highest parts of the limestone outcrop a few kilometres north-east of Malham Tarn, at altitudes around 500 m. They are developed on a continuous succession of Carboniferous limestones; these are the Gordale Limestone from the upper part of the Great Scar, and the Hawes, Gayle and Hardraw Scar Limestones from the Wensleydale Group (Arthurton *et al.*, 1988). A very small outlier of Wensleydale Group shale and sandstone survives at the summit of Parson's Pulpit (Figure. 2.38).

The complex dissected plateau of High Mark includes over 20 large closed depressions. Most lie in two clusters: a group of 11 on Parson's Pulpit and Clapham High Mark, and another group of 9 on Proctor High Mark (Figure 2.38). Dendritic dry valleys lie between and around these clusters, but within them the entire land surface consists of basins, and forms two areas of polygonal karst. Within the depressions there are numerous small dolines and shakeholes in the cover soils and drift.

The area is devoid of surface drainage except after heavy rain, when temporary lakes may form in some of the outlying depressions around Middle House Farm (Clayton, 1981). The largest depression, south of Parson's Pulpit, is 800 m across and almost 100 m deep (Figure 2.39). Most of the depressions are saucer shaped, though some have deeper profiles with low scars on their steeper sides. Most of the dolines lie in undisturbed strata, though some west of Parson's Pulpit have more linear shapes dictated by small faults. They have varying amounts of fill whose depth is unknown, and none has exposed bedrock in its floor. The fill includes clastic debris from the eroded cover of Wensleydale Group rocks, remnants of old soil horizons, glacial till, and ponded silts and clays deposited in periglacial lakes. The latter are comparable with sediments in the closed basins of Brimble Pit and Cross Swallet in the Mendip Hills.

The watersheds and cols separating the basins are, in general, poorly defined across ridges of gentle relief. Some of the depression rims are broken by low cols, some of which lie at the heads of shallow dry valleys down the outer slopes. On the east side of Proctor High Mark, two depressions form a more linear feature emphasized by the line of three low points in the southern basin (Figure 2.38); these appear to represent the dissected remains of a once continuous dry valley,

which continues southwards outside the polygonal karst. The intervening ridges are generally mantled with thin soils, though patches of limestone pavement are distributed through the polygonal karst independent of the depression relief patterns (Figure 2.38). Some small shafts and hollows are the remains of lead mining about 200 years ago.

Interpretation

The dolines are solutional forms which appear to have developed over a long period of time, since the impermeable cover became thin enough to allow extensive solution to commence in the underlying limestone. The absence of any collapse features and marginal faults refutes any suggestion that the depressions were collapse features. Clayton (1966, 1981) proposed that they are a result of limestone solution, intensified by a layer of sediment holding water and generating carbon dioxide. He suggested that the high rainfall, low evaporation, acidic soils and peaty sediment created an 'acid sponge'. Solution of the limestone in the floors of the depressions occurs more rapidly than it does under the thin soils of the interfluvies, thus continuing to deepen the depressions. Limestone pill experiments by Trudgill (1985b) support this hypothesis. A depression is self-perpetuating, once this 'acid sponge' effect is initiated within it. The inward sloping sides of the depression ensure a continued supply of water and reduce solution on the interfluvies. In addition, transfer of material by creep, flow and soil wash into the depression further enlarges the 'acid sponge', increasing its solutional capability. As a basin enlarges and deepens, small limestone scars form around the rim, which then retreat as free-faces, widening the basin further.

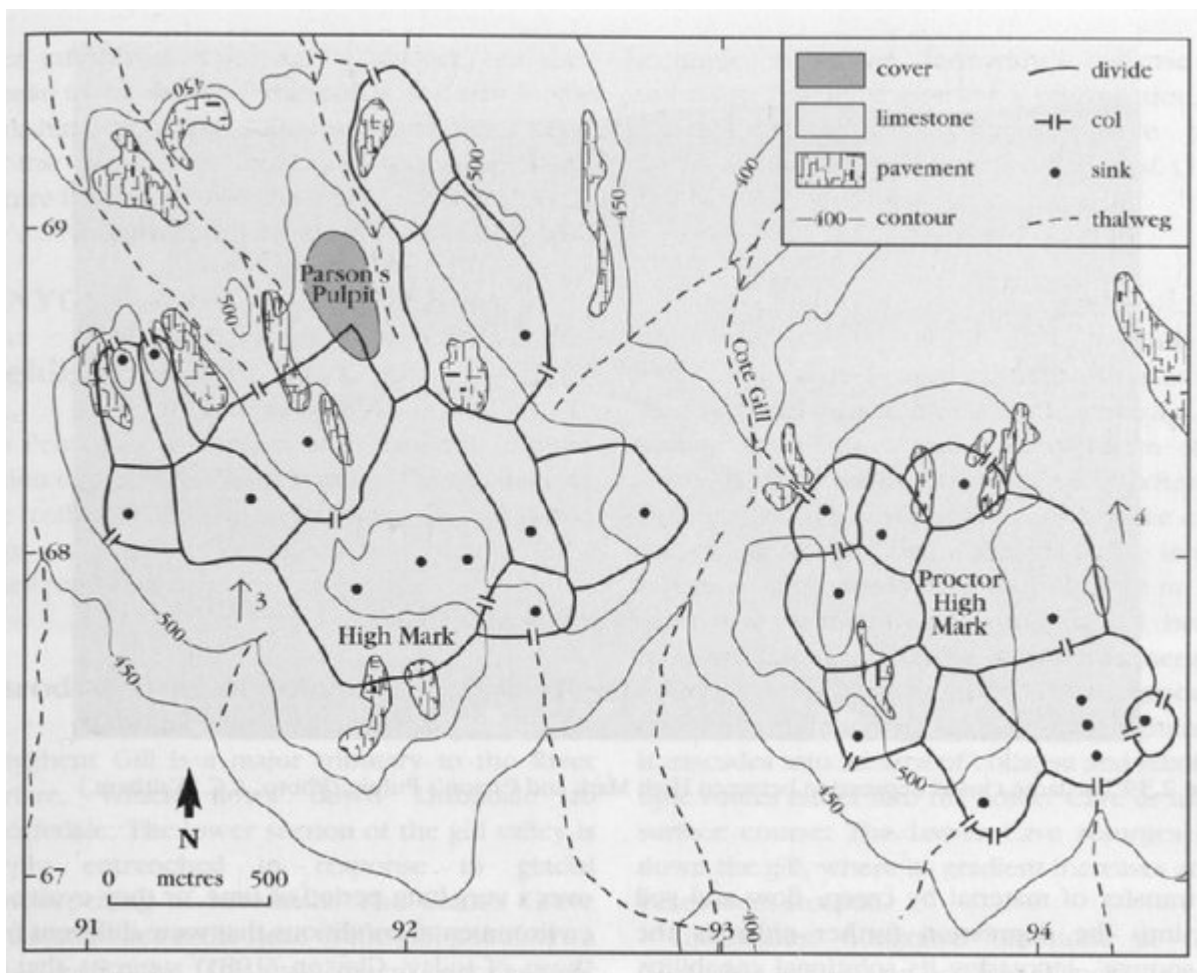
The chronology of these features' development is difficult to constrain. Size and depth may indicate the relative age of dolines, but modifications by glaciation and meltwater erosion make these data of limited value. Current estimates of limestone solution rates in the area suggest that these depressions may predate the Pleistocene glaciations (Sweeting, 1966; Clayton, 1981; Trudgill, 1985b), and Sweeting speculated that the marginal plains around the high limestone masses are also very old erosional features. They are located where the Great Scar Limestone of the Yorkshire Dales reaches its greatest elevation and was probably exposed earliest, and the karst subsequently attained the greatest maturity. Although the age evidence is circumstantial, Clayton (1981) maintains that other hypotheses are hard to erect; he argues that the form of the depressions is unlike those such as the Malham Tarn basin produced by glacial erosion, and that areas such as Ingleborough have been eroded by ice and have no comparable features.

The age of the depressions is also relevant to their unusually large sizes. Either they formed over a very long period of time, or they evolved in environmental conditions that were different from those of today. Clayton (1981) suggests that the warmer climate of the Late Tertiary was more favourable for the formation of large dolines and polygonal karst; similar conditions could also date from the earlier Pleistocene interglacials. A pre-Devensian age is undeniable, and it appears that glaciations only caused minimal modification, by ice or meltwater, to the karst depressions. They lie away from the zones of powerful glacial scour, as the main ice flow from the north was obliquely deflected into the Littondale iceway to the east (Figure 2.1). It is significant that these areas of polygonal karst occur on the only limestones in the Yorkshire Dales which form a topographic summit area.

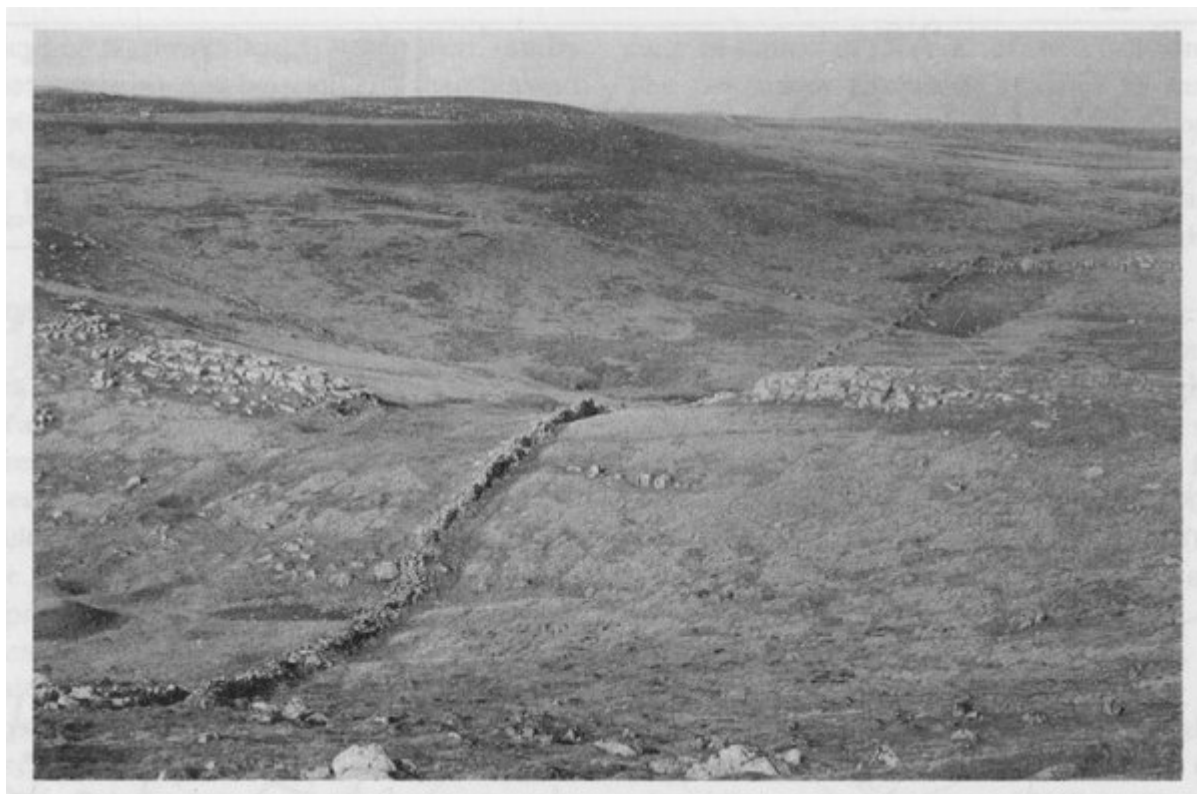
Conclusions

The high limestone plateau of High Mark features an unusual range of karst landforms, including dry valleys, rocky scars and dolines, with some of Britain's largest closed basins. The area provides a rare example of polygonal karst. The closed depressions were formed by solutional processes operating on the limestone underneath a blanket of wet acidic soil, which accentuates erosion in the centre of the basin compared to the higher drier interfluvies. Their age is unclear, but they appear to be some of the oldest features in the Yorkshire Dales karst. The polygonal karst housing the depressions constitutes one of the most mature limestone landscapes in Britain.

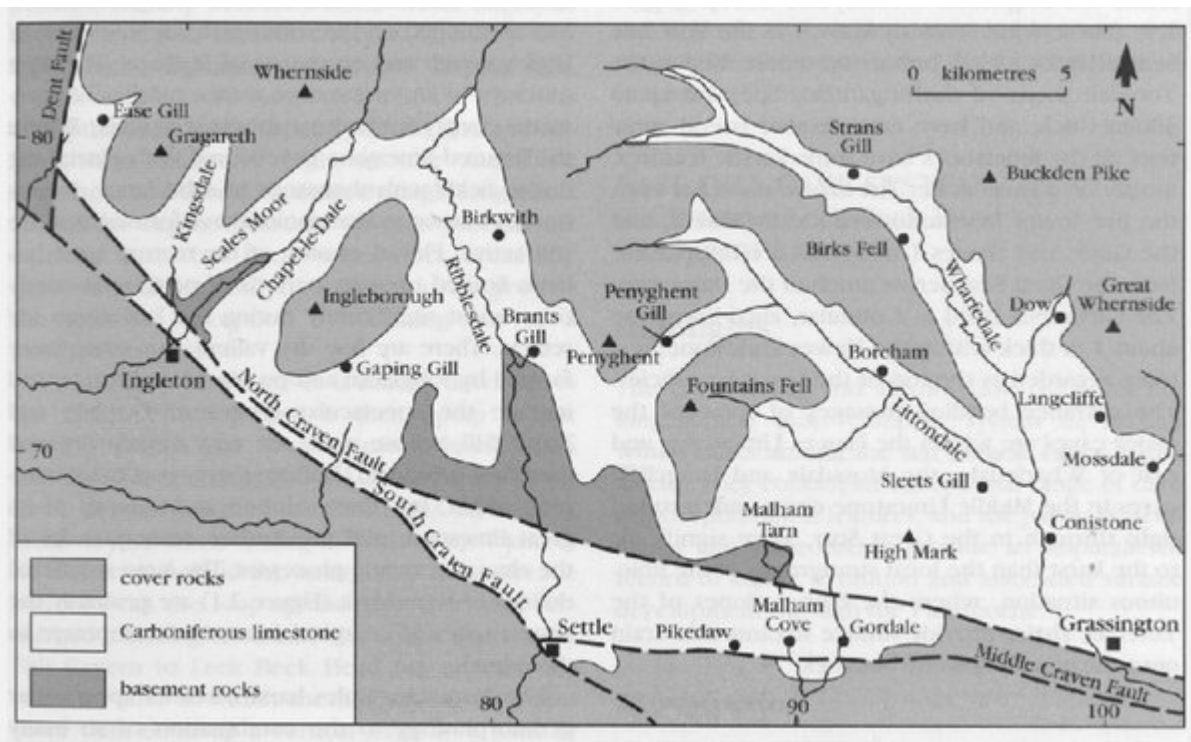
[References](#)



(Figure 2.38) Outline geomorphological map of the polygonal karst developed on the limestone crests around High Mark.



(Figure 2.39) The large closed depression between High Mark and Parson's Pulpit. (Photo: A.C. Waltham.)



(Figure 2.1) Outline map of the Yorkshire Dales karst, with locations referred to in the text. The Carboniferous limestone shown includes all the Great Scar Limestone (Kilnsey, Cove and Gordale Formations) and also the lower Yoredale limestones (of the Wensleydale Group) where they are hydrologically linked to the Great Scar and are therefore part of the same karst unit. Higher limestones within the Yoredale Series are not marked. Basement rocks are Palaeozoic slates and greywackes. Cover rocks are the Yoredale facies of the middle and late Brigantian Wensleydale Formation and various Upper Carboniferous and Permian clastic formations.