Great Asby Scar

[NY 64 09]–[NY 68 09]

Highlights

Spectacular expanses of limestone pavement lie on the dip slope of Carboniferous limestone forming the Orton–Asby escarpment. The pavements are the most extensive outside the Ingleborough karst, and have a wide variety of well developed pavement morphologies.

Introduction

Asbian limestones from the Lower Carboniferous succession form a long, rounded escarpment north of the Howgill Fells, where they dip off the Lake District dome beneath younger rocks flooring the Vale of Eden (Figure 3.1). The crest of the south-facing escarpment reaches an altitude of only 412 m; the main pavements, separated by grassland grazed by sheep, extend down into farmland to the north. The regional dip of 5–10° north is interrupted by shallow flexures with axes aligned roughly downdip. All the pavements are formed on the massively bedded limestones of the Asbian Great Scar. They are underlain by the mixed sedimentary sequence of the Holkerian Orton Group; limestone beds within the Orton Group are the cause of the numerous shakeholes in the lowland below and south of the Great Scar escarpment, but they form no pavements. Brigantian shales and limestones of the Yoredale facies overlie the Great Scar; the lowest of these limestones is the Robinson, but its karstic expression is minimal.

There has been little research into the geomorphology of the Asby pavements, though they are briefly described by Goldie (1986, 1993) with reference to their damage by exploitation for rockery stone. The best developed and least damaged pavements are now protected within a National Nature reserve, and this also reflects the high botanical value of the pavements (Ward and Evans, 1975, 1976; Ratcliffe, 1977).

Description

Extensive and varied pavements cover much of the dip slope along the escarpment east of Orton. The highest and most spectacular area is known as Great Asby Scar, rising to a summit near Castle Fold (Figure 3.19). The limestone extends east through Little Kinmond to poorer pavements on Grange Scar, beyond which a shallow col breaks the escarpment along the line of a fault. East of the fault, the pavements of Little Asby Scar reach to Potts Beck, in a deeper valley through the escarpment. Pavement morphologies vary along the outcrop, and are best reviewed in sequence from west to east.

Gaythorne Plain lies low on the dip slope, with a large outcrop of thinly bedded limestone, of which about 80% of the original surface rock has been removed or disturbed. Clints are small, and runnels are poorly developed; there are scattered sandstone erratics. Just to the south, a higher and stronger bed forms a more massive pavement, with large clints and deep runnels, sloping northwest off a stratimorphic ridge on a gently plunging anticline. Grikes are mostly less than 1 m deep, but some are up to 2 m wide where close, parallel joints originally enclosed a blade of limestone or a calcite vein now totally removed by solution. Some clints within these pavements stand on pedestals about 100 mm high, which they overhang by about 100 mm. There are also areas of cleanly scoured bedding slabs with simple systems of large, sharp-edged rinnenkarren runnels.

Great Asby Scar has the most varied and best preserved pavements of the escarpment, with the greatest variety of solution features on the outcrops near Shining Stones and Castle Fold. Variations in slope, aspect, joint density, lithology and length of exposure to subsoil or subaerial solution are responsible for the enormous range of small karstic landforms. Long clints between joint grikes aligned on the strike have spectacular sets of deep parallel runnels cut into their downs-lope edges (Figure 3.20). Across the centre of the area, a synclinal valley contains the best of the pavements, and the anticline to its west provides structural variety within them. From the trough of the plunging syncline, excellent pavements rise towards Castle Fold where an ancient settlement stood on a low knoll formed by a remnant of a higher limestone bed. Massive, large rounded clints are underlain by pedestals of well fractured limestone to form mushroom-shaped features. These change eastwards through a development sequence, as the pedestals become less developed, the top clint less runnelled, and the grikes narrower, until a pavement of massive clints disappears under the debris cover around the Castle Fold outlier. The west side of the synclinal valley has pavements with deep rinnenkarren sloping east at about 15°, while gently sloping clints on the anticlinal crest are cut by deep, convergent rundkarren runnels. Further down the main dip slope, an area of very large clints with smooth surfaces, little scored by solutional runnels, is aptly known as the Shining Stones.

Little Kinmond and Grange Scar have less continuous pavements in bands along the crests of bedding scars continuing east along the escarpment. North of Little Kinmond, there are areas of massive pavement sloping north at 3–10° with some undulations over shallow plunging folds. The larger clints have kamenitzas and convergent runnel systems.

Interpretation

Pleistocene ice flowed from the Howgill Fells north-east across the limestone outcrop (Mitchell, 1991, 1994). Its flow against, then up and over the escarpment precluded the development by ice plucking of terraced limestone scars and capping pavements on the scarp face, which presents a very rounded profile. Ice flow down the dip slope efficiently stripped the exposures down to bedding planes on the stronger beds, where postglacial solutional fretting has created the finest and largest pavements. An iceway over the low point on the scarp crest produced deeper scouring along the fault line trough east of Grange Scar, while more selective scouring in the lee of the high point on the escarpment created the stratimorphic topography on Great Asby Scar. Pavements survive right across the synclinal valley floors which have never carried subaerial stream drainage.

Some of the larger runnels on the pavements appear to exceed the dimensions that can be realistically attributed to solution at modern rates throughout the Holocene. The survival of pre-Devensian relics appears to be incompatible with the site's glacial history and exposure to scouring, and the rounded forms of the karren ridges can not be attributed to rapid and deep excavation by meltwater during glacial retreat. The well rounded rundkarren are indicative of slow evolution beneath a cover of acidic soil and vegetation, but could have been formed by the postglacial rounding of older, subaerial features with sharper profiles. Past solution rates could have been higher in an environment of enhanced levels of biogenic carbon dioxide in soil waters from beneath a denser cover of shrubs and trees. The presence of early settlements at Castle Fold and other sites on the limestone suggest that there has been a richer soil and vegetation cover in the recent past, and pollen profiles from Sunbiggin Moor, south of the escarpment, support this concept (Webster, 1969).

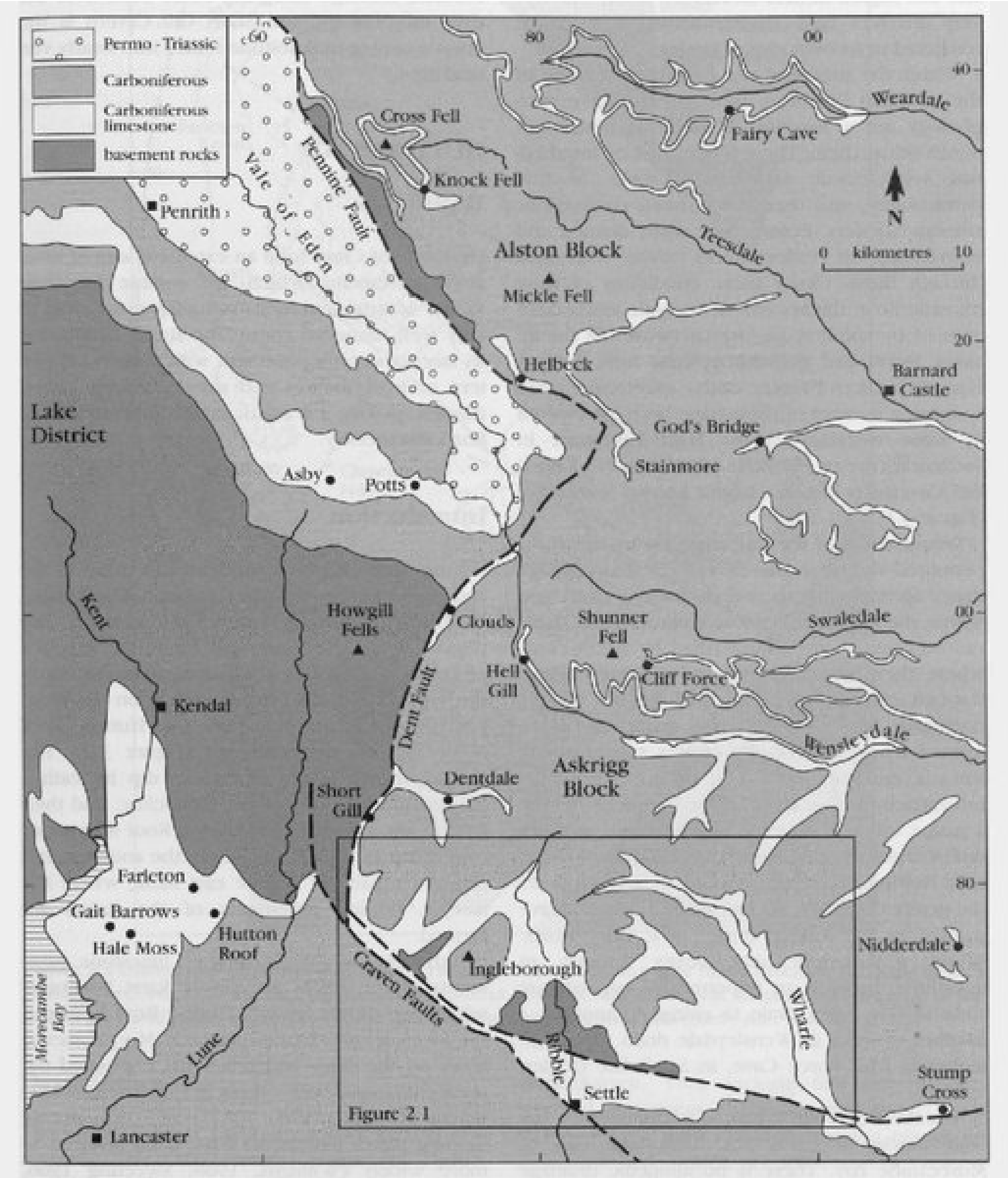
The pavements east of Castle Fold are broken by numerous pits, each up to 7 m in diameter and several metres deep. They are unrelated to the tectonic joint patterns, and may be exhumed palaeokarstic features of Carboniferous age; these would have formed on calcretes which developed in sabkha environments during short periods of emergence from the shallow shelf seas (Vincent, 1995). The origin of their clay fills is not yet known, but may be Carboniferous soil evolved from volcanic ash, rather than Permo-Triassic loess or Devensian till.

Many clints stand on pedestals which are about a quarter of the height of those beneath the Norber glacial erratics on Ingleborough (Sweeting, 1966). This may suggest that solutional lowering of the surface has only lasted about 2500 years, if Holocene erosion rates are comparable at the two sites, and therefore conflicts with the environmental evidence of the large runnels. However, the evidence of some of the pedestals is invalid where they are lithologically defined by undercutting in bands of weaker, rubbly limestone. The extent and role of past soil covers on the Great Asby pavements are not yet fully defined.

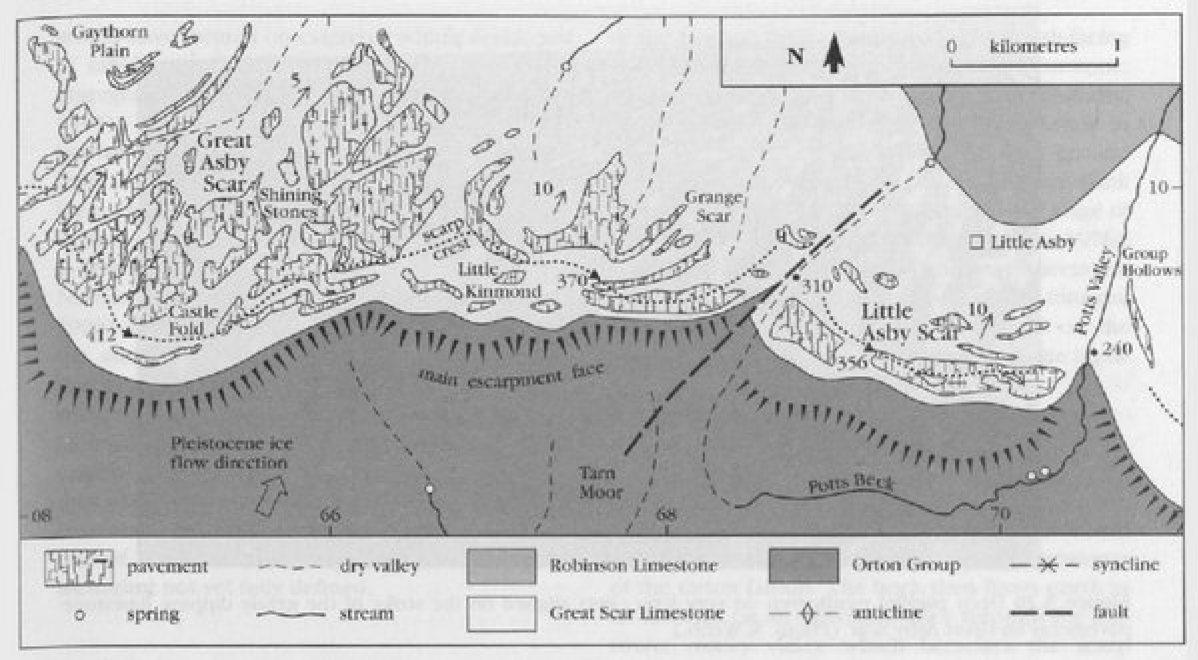
Conclusions

The pavements at Great Asby Scar are nationally outstanding for their very large expanses of bare solutionally fretted limestone, and their wide range of morphologies related to the gently folded limestone structure. Past environments of contrasting soil and vegetation cover have also influenced the details of the solution features. Despite a sad record of destructive clint removal from large parts of the outcrop, much very beautiful and very varied pavement remains intact.

References



(Figure 3.1) Outline map of the karst regions in the northern Pennines, with locations referred to in the text. The other Carboniferous rocks are the non-carbonates of the Orton Group and Yoredale facies of the Dinantian, and the Namurian, but they include thin bands of limestone with lesser karst features not shown on this map. The Carboniferous limestone includes the Dinantian Great Scar Limestone, the Yoredale limestones with significant karst, and the Main or Great Limestone of Namurian age. The basement rocks are Lower Palaeozoic non-carbonates. Details and locations in the southern Dales are shown in (Figure 2.1).



(Figure 3.19) Outline map of the karst features on the limestone escarpment between Great Asby Scar and Potts Valley. The Robinson Limestone includes a thin shale separating it from the Great Scar.

(Figure 3.20) Deep parallel rundkarren on very long clints aligned on the strike of the gently dipping limestone pavements on Great Asby Scar. (Photo: S. Webb.)