Stiperstones

[SO 367 985]

N.F. Glasser

Introduction

The Stiperstones, Shropshire, comprises a long quartzite ridge, capped by summit tors and with periglacial stone stripes and polygons developed on its slopes. This area supports one of the best assemblages of relict periglacial landforms in Britain and is an important site for studies of tor formation, patterned ground and slope development. The landform assemblage at the site includes the large summit tors, a series of well-developed blockfields on the surrounding slopes (including sorted stone stripes, polygons and nets) and rock platforms created by cryoplanation processes. The site therefore exhibits many of the key elements that have featured in papers on the development of tors and associated slope features in the British Isles.

Although the Stiperstones ridge is geographically separate from the main cluster of Pennine tors, the landforms at the site contribute much to the long-running debate concerning the origin of tors. Linton (1964) and Cunningham (1965) considered tors to represent the erosional remnants of deep chemical weathering of bedrock during Tertiary times in a subtropical climate. Palmer and Radley (1961), on the other hand, insisted that no deep rotting existed in the Pennines and that the tors represented mechanical weathering under periglacial conditions. The morphology of the Stiperstones tors and their associated slope features indicates intense frost shattering and the development of permafrost at the margins of the Late Devensian ice sheet. The evidence from the Stiperstones therefore points to a periglacial origin for these features since, although the ridge lay within the late Devensian ice limit, it escaped ice cover owing to its high elevation. A further aspect of the site is the recognition of well-developed crest-line cryoplanation platforms. The form and extent of these platforms have been used to argue that cryoplanation processes are significant in landscape change under former periglacial conditions. The site was discussed by Linton (1955). Goudie and Piggott (1981) and Clark (1994a) have described in detail the tors, rock platforms and slope debris at the site.

Description

The Stiperstones ridge, located to the southwest of Shrewsbury in Shropshire, runs for 12 km NNE from Black Rhadley Hill [SO 343 956] to Pontesbury [SJ 340 060]. Near its central point, the ridge takes the form of an irregular tract of elevated land rising to 536 m above sea level at its highest point on Manstone Rock [SO 368 987]. Throughout this 3 km long central section, land elevations are consistently above 450 m and the landscape is dominated by a group of large, quartzite, skyline tors protruding from a well-developed, crest-line rock platform (Clark, 1994a). Beneath the tors is a complex assemblage of associated slope debris that includes sorted stone stripes, boulder runs, polygons and nets (Goudie and Piggott, 1981; Clark, 1994a). At its maximum extent, the Late Devensian ice sheet in this region reached the vicinity of Craven Arms, some 17 km to the south-east of the Stiperstones (Jones and Keen, 1993). Thus, although the Stiperstones ridge probably lay within the limits of the Late Devensian ice sheet, its altitude ensured that the ridge remained ice-free during this time (Dwerryhouse and Miller, 1930; Pocock *et al.,* 1938). Further evidence for this assertion comes from two detailed studies of the geomorphology of the central part of the ridge, both of which have failed to produce any evidence of ice cover during the Late Devensian (Goudie and Piggott, 1981; Clark, 1994a).

Geologically, the ridge is part of the Shelve Inlier, an area of Arenig (Lower Ordovician) rocks (Cocks, 1989). The ridge is formed predominantly of massive, resistant quartzites belonging to the Stiperstones Member (Whittard, 1931). The quartzites are moderately well-bedded and usually white or light grey in colour. Colour banding is sometimes evident in the form of alternating blue-grey and fawn beds. The strata dip north of west, mainly in the range 25 to 80°. Two principal joint directions have been identified in the quartzite; one striking along the outcrop and dipping east, the other near-vertical and normal to the strike (Dines, 1958). The landform assemblage at the Stiperstones comprises three main components: the tors, rock platforms and slope debris (Figure 7.6). These are described in detail below.

Tors

Along the Stiperstones escarpment, the quartzite is weathered into a series of prominent tors (Figure 7.7). These project above the ridge to varying heights, rising to a maximum of 20 m above the surrounding ground surface at the tor known as the 'Devil's Chair'. Both Goudie and Piggott (1981) and Clark (1994a) describe the tors as 'crestal' or 'skyline' tors because they all rise steeply from the gently sloping summit of the ridge. The long axes of individual tors follow the trend of the ridge and direction of strike. Typical slope angles on the ridge summit are 5 to 13° (Goudie and Piggott (1981), although slopes on the tors themselves are much greater, between 50° and the vertical.

The tors are all composed of in-situ stacks of jointed quartzite, beneath which the slopes are littered with locally derived, angular, quartzite boulders, with long axes predominantly in the range 0.2 to 0.8 m. The overall form of the tors is controlled by lithological characteristics such as bedding thickness, together with the pattern and spacing of joint planes (Clark, 1994a). The extent to which these bedding planes influences detailed form is controlled by aspect. On the western tor faces, bedding planes exert a major influence by controlling the tor ends and transverse divisions. On the eastern faces, steep longitudinal and transverse joints are more important in controlling tor morphology. Good examples of this contrast can be seen at Scattered Rock where the joints oblique to strike intersect at high angles, and to the north of Shepherd's Rock where individual rock faces reflect the influence of several joint directions and of bedding planes dipping at angles of 70–80°. Many of the tors rise directly from the bedrock ridge beneath and development of undercutting is only sporadic.

Finally, it is perhaps significant that previous studies of the Stiperstones tors (including shallow excavations on the surrounding slopes) have found no evidence of a weathering cover surrounding the tors themselves (Goudie and Piggott, 1981; Clark, 1994a).

Rock platforms

Crest-line rock platforms are common along the ridge crest of the Stiperstones (Clark, 1994a). These features form almost level rock surfaces wherever they abut the ends and sides of the tors. The lower margins of the platforms consist of either vertical or steep rock cliffs between 1 and 2 m in height, or a transition to continuous clast cover on the debris-covered slopes below. The platforms occur both singly and in series, where low rock cliffs separate individual platforms. In some places the platforms constitute the crest line of the ridge, whereas elsewhere the inner margins of the platforms are small rock plinths and piles of loose boulders up to 2 m in height. Individual platforms tend to be narrow, with maximum widths of 10 to 20 m. Clark (1994a) has argued that the form of the cliff margins, including irregular fracturing on the platform surfaces, is indicative of platform extension by retreat of the outer rock edges. Further evidence for this assertion comes from the platform surfaces, which do not appear to be frost-shattered to a great depth and generally are free of loose debris. Clark (1994a) regards the weathering along the rock edges to be the result of frost shattering under former periglacial conditions.

Slope debris

The slopes flanking the ridge are generally of a lower angle (ranging from 3 to 15°) than those on the summit (ranging from 5 to 13°). Along much of the length of the Stiperstones ridge, quartzite debris from the tors and rock platforms has moved down the ridge flanks to a level below the quartzite outcrop. Thus the slopes immediately downslope of the tors and rock platforms are littered with surface boulders to a distance of some 200 to 300 m below the crest line. Subsurface exposures are rare and the nature of this slope debris is known only from surface observations and shallow excavations east of Cranberry Rock (Clark, 1994a). This debris is clast-supported, even at depths of 1.2 m, and distinctly lacking in fine-grained material. Where fine material does occur, it is a powdery, humic clay. The excavations also demonstrate that there is a marked downward reduction in clast size. No detailed clast macrofabric data exist for the site.

Alternating downslope stripes of vegetated ground and bare quartzite boulders cover large areas of the ridge flanks (Figure 7.7). These stripes, termed 'sorted stripe systems' have been mapped in detail by Goudie and Piggott (1981). The stripes are particularly evident in the area between Cranberry Rock and the Devil's Chair (Figure 7.8). Individual stripes attain lengths of 50 to 70 m, and in places the stripes descend 200 to 300 m down the flanks of the ridge. The unvegetated boulder stripes range in width from 0.8 to 9.8 m (mean 3.2 m), whereas the vegetated stripes range in width from 0.8 m to 9.5 m (mean 3.0 m). Clasts in the stripes are exclusively locally derived, angular quartzite and are up to 2.5 m long. According to Goudie and Piggott (1981) many of the elongate clasts in the bare boulder stripes are aligned preferentially in a downslope direction, although Clark (1994a) has noted that there are also clasts with long axes trending across slope. Furthermore, there are sites where preferential alignment of clasts is well developed, suddenly giving way locally to apparently random clast orientations. There also are sites where clasts appear to be arranged roughly concentrically around the upslope edges of larger surface boulders. Clark (1994a) has used this evidence to argue that although there are sporadic concentrations of preferentially aligned clasts, the overall impression is one of no general dominance of organized fabrics.

Close to the ridge crest, the stripes are interlinked into networks that enclose islands of vegetation, termed 'stone polygons' by Goudie and Piggott (1981). The 'polygons' are best developed on flat and low-angled ground (up to 4° maximum slope angle) and are composed of angular, quartzite boulders, centred on vegetated heather ground. They are of an irregular shape and have diameters of 7 to 9 m. They are best developed on the ridge crest, notably between Cranberry Rock and Manstone Rock, and to the south of the highest tor, the Devil's Chair. Other polygons are found on the ridge crest around the Paddock. With increasing slope angle the polygons become more elongated in form (at slope angles of 7–10°), before giving way to sorted stone stripes as the slope angle rises to the maximum of 15°. Overall, the stone stripes are more common than the polygons. Finally, bifurcations of the bare stripes in both upslope and downslope directions are found, again creating small islands of vegetated ground between bare boulders. In a detailed study of these features, Clark (1994a) found that linkages between individual stripes are rare.

Interpretation

The geomorphological significance of the tors at the Stiperstones was first noted by Linton (1955). Linton observed that tors occurred on a variety of lithologies in the UK and he contrasted the quartzite tors at the Stiperstones with the granitic Dartmoor tors and the rhyolitic and doleritic examples in the Preselis (Campbell and Bowen, 1989). Linton proposed a two-stage model for the formation of tors, involving a period of deep chemical weathering followed by a period of stripping. Other models of tor formation also exist, including the Palmer and Radley (1961) model involving a single cycle of weathering and mass wasting under periglacial conditions, the Bunting (1961) model involving the action of contemporary seepage moisture, and the Palmer (1956) model involving 'the disintegration of resistant stratum following the rejuvenation of a mature hill-slope'. More recently, Battiau-Queney (1980, 1984) has suggested that the tors of south-west Wales formed in response to deep chemical weathering (in Tertiary times) followed by stripping in response to local uplift along older structural axes.

Of these various models, both Goudie and Piggott (1981) and Clark (1994a) considered the Palmer and Radley (1961) model to be the most applicable to the Stiperstones. The angular nature of the tors, the substantial quantities of angular debris around their bases and the associated slope features strongly indicate a periglacial origin for the landforms at the Stiperstones. No weathering cover or regolith occurs in association with the tors, and there is no evidence of the corestones or rounded boulders indicative of chemical weathering (Linton, 1955). It is likely that the form of the tors therefore dates from the periglacial conditions during the Late Devensian. At this time, the Stiperstones lay close to the ice margin. Given its altitude the ridge may even have been elevated above the ice sheet as an ice-marginal nunatak (Rowlands and Shotton, 1971). The large numbers of well-developed lichens on both the tors and the stone stripes suggest that contemporary frost action is relatively ineffective by comparison. The logical interpretation of the tors at the Stiperstones is therefore that they are relict periglacial weathering features. As there is no evidence for a former weathering cover around the tors or in the sediments downslope of the features, it seems reasonable to conclude they are not remnants of a former weathering cover, as proposed by Linton (1955) for other British tors.

The surface patterned-ground features at the Stiperstones also fit with this overall palaeocli-matic interpretation. The term 'patterned ground' refers to terrain that exhibits regular or irregular patterning in the form of circles, polygons, irregular networks or stripes (Ballantyne and Harris, 1994). Landforms of this type commonly are associated with cold environments, where ground freezing and thawing is the dominant formative mechanism. As such, they are often regarded as indicators of former permafrost conditions (French, 1996). Following the original classification of Washburn

(1956), a distinction is commonly made between sorted patterned ground and non-sorted patterned ground. Sorted patterned ground is defined by the alteration of fine- and coarse-grained debris, whereas in non-sorted patterned ground the pattern is formed by microrelief and/or vegetation cover. Clearly there is evidence for both types at the Stiperstones, with the polygons and stone nets demonstrating the formation of sorted patterned ground and the alternating downslope stripes of vegetated ground and bare quartzite boulders illustrating the development of non-sorted patterned ground. The scale of the sorting and the existence of polygons 7 to 9 m in diameter suggest that they developed in association with widespread permafrost (Ballantyne and Harris, 1994). Again this is consistent with the observation that the ridge stood close to the margin of the Late Devensian ice sheet in this area. Frost sorting, downslope mass movement and frost weathering therefore would have been active on the Stiperstones ridge throughout much of the Devensian.

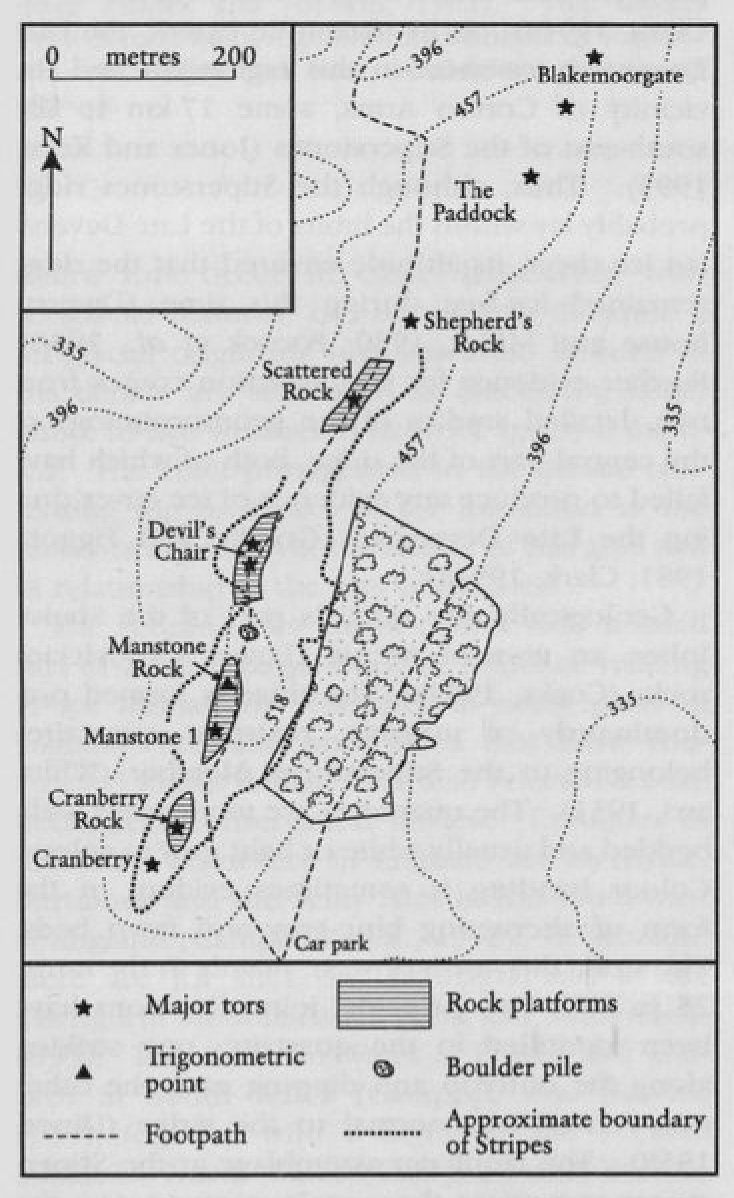
Large-scale, sorted patterned ground is common on higher British mountains, where essentially it is a Late Devensian relict (Ball and Goodier, 1968; King, 1971; Ballantyne, 1984). This type of patterned ground is, however, less common in lowland areas. In addition to the Stiperstones, large stone stripes have been described only from lowland sites on the chalklands of East Anglia that remained outside the limits of the Late Devensian ice sheet (Williams, 1964; Watt *et al.,* 1966; Evans, 1976; Nicholson, 1976; Ballantyne and Harris, 1994) and beneath the granite tors of Dartmoor (Te Punga, 1957). The slope-related transition from sorted polygons to stone stripes noted by Goudie and Piggott (1981) is consistent with observations from modern periglacial environments (Ballantyne and Harris, 1994; French, 1996).

A final factor to consider is the relative importance of the different periglacial processes in the formation of the Stiperstones landforms. For example, Clark (1994a) has recently stressed the importance of cryoplanation (the formation of near-level rock-cut platforms by frost action in periglacial conditions) in the formation of the crest line rock platforms. Cryoplanation surfaces have been reported from other sites in the UK (Guilcher, 1950; Te Punga, 1956; Waters, 1962; Gregory 1966; McArthur, 1981) but a comprehensive explanation for the processes responsible for the formation of these surfaces has never been produced. Doubts remain about the location and manner of platform initiation, the production of low-angle platform surfaces and the evacuation of debris over gentle slopes as platform growth proceeds (Czudek, 1964; Demek 1964, 1968, 1969). These doubts were sufficient to lead Budel (1982) to dismiss altogether the ability of these processes to create level bedrock surfaces.

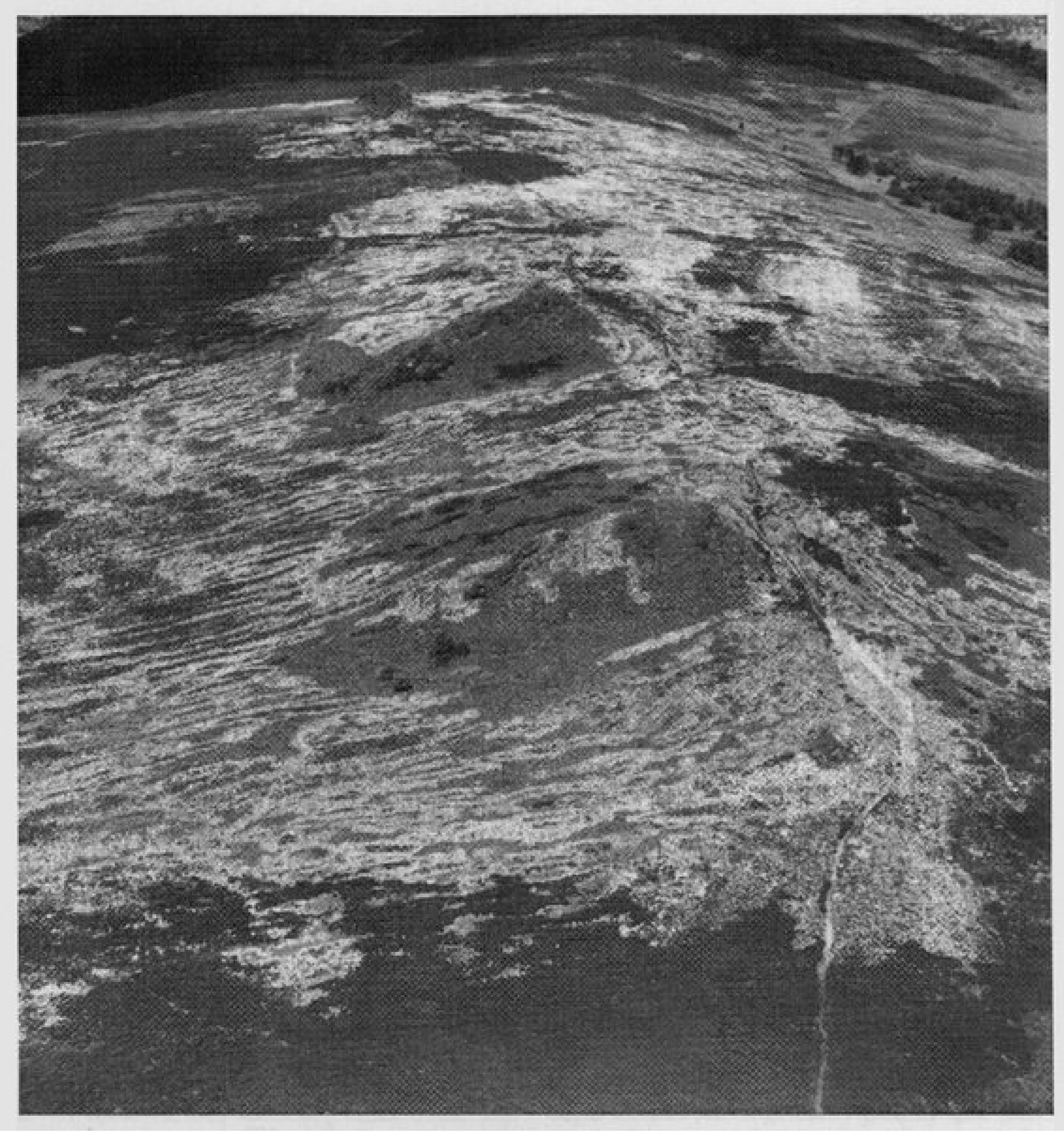
Conclusions

The tors, rock platforms, patterned ground and slope deposits at the Stiperstones are among the finest in Britain. The angular quartzite tors and associated blockfields illustrate neatly the role of lithology in determining detailed morphology, and the absence of a weathering cover around the tors strongly suggests that the tors and blockfields developed concurrently. The Stiperstones tors therefore provide evidence to support the single-cycle periglacial model of tor formation advocated by Palmer and Radley (1961). Many of the tors rest on crest-line rock platforms that have been used to argue for the effectiveness of cryoplanation as a landscape modelling process in the periglacial environment. Beneath the tors are a family of patterned ground features and associated slope deposits including polygons, nets and stone stripes. The sorted polygons are amongst the largest in the UK and indicate the existence of widespread permafrost conditions. The stone stripes are illustrated by alternating downslope stripes of vegetated ground and bare quartzite boulders and are strong indicators of permafrost conditions. Although no absolute dates exist for this period of periglacial conditions it seems reasonable to assign the features at the Stiperstones to a Late Devensian age, when the site lay close to, or at, the margins of the ice sheet.

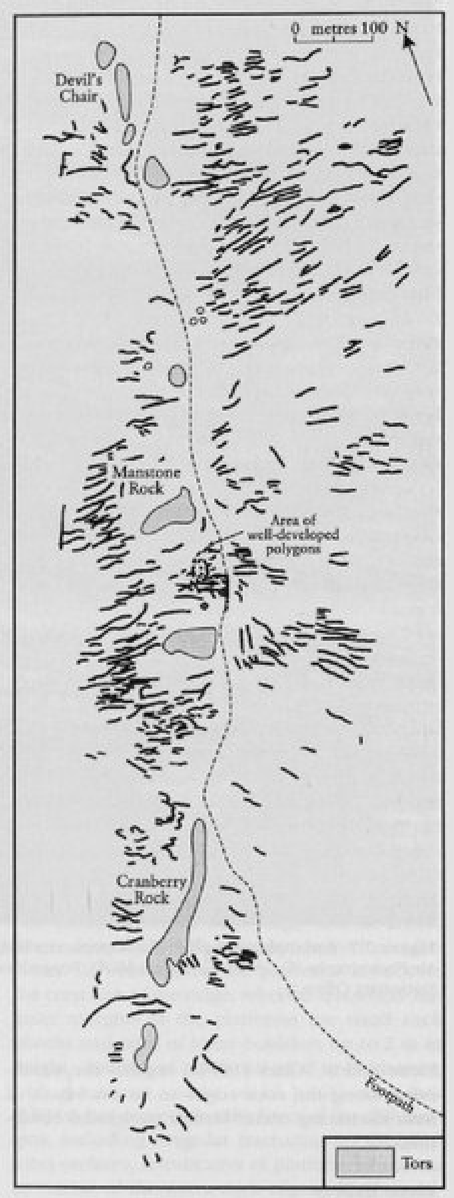
References



(Figure 7.6) Map showing the principal geomorphological features of the Stiperstones ridge (after Goudie and Piggott (1981) and Clark (1994a)).



(Figure 7.7) Aerial photograph of the Stiperstones Ridge (Photo: WQ 32 of Cambridge University Collection of Air Photographs. © Crown Copyright/MOD. Reproduced with the permission of the Controller of Her Majesty's Stationary Office.)



(Figure 7.8) Map of the distribution of stone stripes and polygons in the area between Cranberry Rock and Devil's Chair (after Goudie, 1990).