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QUARTZITE TORS, STONE STRIPES AND SLOPES AT THE STIPERSTONES, SHROPSHIRE, ENGLAND

INTRODUCTION

Tors are known from a variety of lithologies and areas in Britain (table I and fig. 1) and various models of development have been proposed including LINTON's two-stage model (LINTON, 1955) involving a period of deep weathering followed by a period of stripping, the PALMER and RADLEY model (PALMER and RADLEY, 1961) involving one cycle of weathering and mass movement under periglacial conditions, the BUNTING model (BUNTING, 1961) involving the action of present-day seepage moisture, and the PALMER model (PALMER, 1956) involving "the disintegration of resistant stratum following the rejuvenation of a mature hill-slope". Definitions of tors have been influenced by circumstances of location and by individual workers' theories of origin. In this paper we follow PULLAN (1959, p. 54) who defined tors as "an exposure of rock *in situ*, upstanding on all sides from the surrounding slopes and ... formed by the differ-

Table I

Lithologies associated with British tors

Area	Lithology	Source
Dartmoor (Devon)	Granite	LINTON (1955) EDEN and GREEN (1971)
Exmoor (Valley of Rocks)	Sandstone	MOTTERSHEAD (1967)
Weald (Kent, Sussex)	Ardingly Sandstone (Lower Tunbridge Wells Sandstone)	ROBINSON and WILLIAMS (1976)
Charnwood Forest (Leics.)	Granite, Microdiorite and Hornstone	FORD (1967)
Pennines (Derbyshire)	Millstone and Gritstone	CUNNINGHAM (1964)
Derbyshire	Dolomite	FORD (1969)
Bridestones (N.E. Yorks.)	Passage Beds of the Corallian (silicified grits and calcareous beds)	PALMER (1956)
Cheviot Hills (Northumberland)	Granite	COMMON (1954)
Stiperstones (Shropshire)	Quartzite	This paper
Pembrokeshire (Wales)	Flinty Thyolite	LINTON (1955)
Prescelly Hills (W. Wales)	Dolerite	LINTON (1955)
Cairngorms (Scotland)	Caledonian Granite	LINTON (1955) KING (1971)
Ben Loyal (Scotland)	Syenite	LINTON (1955)
Caithness (Scotland)	Arkose of the Old Red Sandstone	LINTON (1955)

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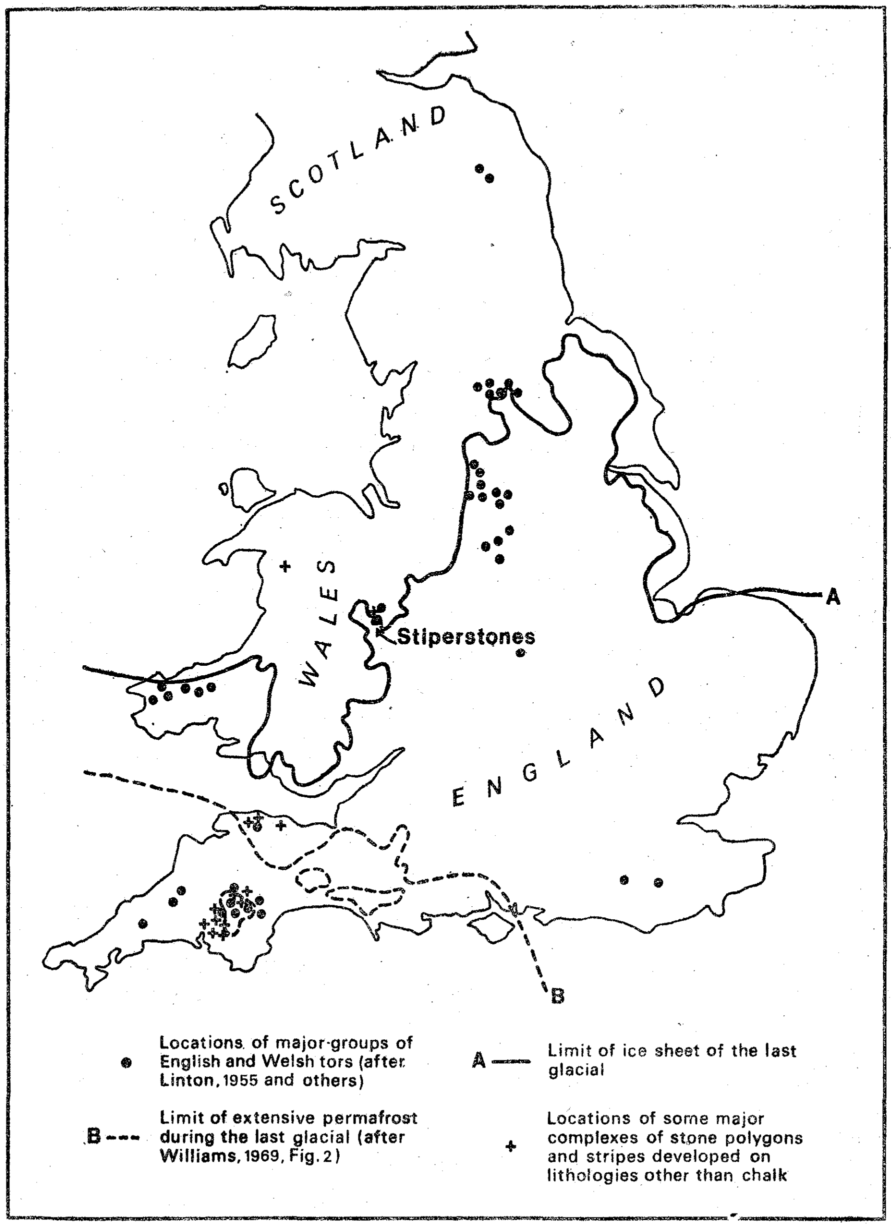

Fig. 1. The study area

ential weathering of a rock bed and the removal of the debris by mass movement." This definition is also essentially that of SELBY (1972, p. 74).

The purpose of this paper is to describe the morphology of some tors, with associated slopes and patterned ground phenomena, from the Stiperstones area. Hitherto they have not been described in detail although they are among the most striking in Britain.

THE AREA

The Stiperstones is an irregularly shaped ridge of Ordovician Arenig Quartzite, capped by upstanding tors, located in western Shropshire. The ridge runs approximately from north east to south west from the Lordshill Valley (SJ 385020) through The Hollies, Blackmoorgate, The Paddock, Shepherd's Rock, Scattered Rock, The Devil's Chair, Manstone Rock, Cranberry Rock and Nipstone Rock to The Rock (SJ 351963). It reaches an altitude of about 525 m above sea level in the vicinity of the Manstone Rock, and rises some 150—180 m above the level of the surrounding valley bottoms, some of which are cut in less resistant shales (fig. 2). The Stiperstones quartzite, which occurs at the base (Mytton stage) of the Arenig Series, is a hard white or grey siliceous sandstone with beds of conglomerate and occasionally thin shale bands. It is moderately to highly jointed and where exposed in the tors dips at high angles to the north west. This feature, associated with the presence of important strike-faulting, accounts for the overall form of the Stiperstones escarpment (WHITTARD, 1931).

THE TORS

The tors which outcrop along the Stiperstones ridge are essentially *crestal tors* which rise up above smooth slopes with a modal slope angle class of 9—11.5°. On Traverse A (fig. 3) over a distance of 340 m, slope angles measured at 10 m intervals ranged only from 5—13°. The tors themselves frequently display slope angles in excess of 50°, and some vertical faces are exposed. The steepest and largest tor is the Devil's Chair (Traverse F) which rises between 12 and 20 m above the smooth slope segments radiating away from it. The tors are not always symmetrical sky-line features, occurring mostly to one side or other of the summit (see for example Traverse E, which crosses one of the tors of the Devil's Chair group). No consistent pattern of asymmetry was evident between the north-west and south-east facing sides of the ridge.

The tors are all essentially composed of *in situ* masses of jointed quartzite, surrounded by angular boulders. No trace of core stones, rounded boulders, or logan stones was found (in contrast to the Dartmoor tors) nor were there any signs of glacial decapitation of the type encountered by CUNNINGHAM (1965) in the southern Pennines.

THE STRIPES

Two traverses were made across areas with well developed sorted stripe systems, consisting of alternations of lines of angular boulders (rock stripes) and lines of heather and other plants (vegetation stripes). The first traverse (Traverse I) was made along the slope leading down from the Devil's Chair and ran at a bearing of 170° on the south-east facing side. It extended over a distance of approximately 130 m, and 21 pairs of stripes were measured to ascertain widths. The second traverse (Traverse II) was made along the slope leading down from the Manstone at a bearing

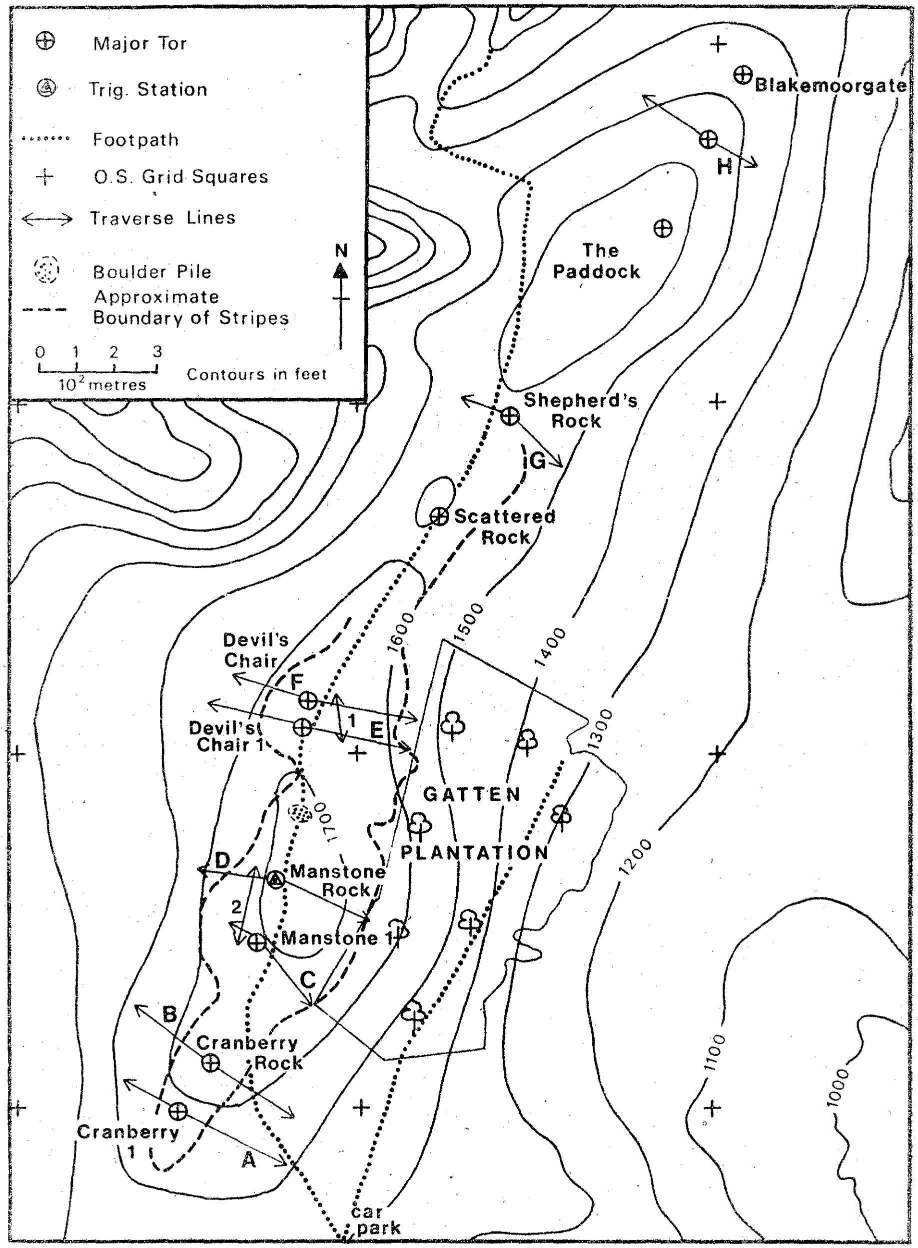

Fig. 2.

of 196° on the north-west facing side. This traverse extended over a distance of approximately 200 m and 31 pairs of stripes were measured.

The results of these traverses are shown in table II. The widths of the two types of stripe are on average remarkably similar. Rock stripe widths averaged 3.18 m (standard deviation 2.08) and 3.38 m (standard deviation 2.03) and vegetation stripe

Table II

Widths of rock stripes and vegetation stripes (m)

Traverse I		Traverse II	
Rock	Vegetation	Rock	Vegetation
3.4	7.1	2.6	5.9
4.5	2.6	5.6	4.7
2.1	1.6	4.6	1.4
3.1	3.4	0.8	1.8
2.5	1.5	2.3	1.8
1.6	5.1	1.0	4.6
0.9	7.6	4.9	2.4
2.1	3.3	3.1	2.8
1.2	1.9	8.9	2.3
5.9	2.5	3.1	2.2
6.3	1.6	3.4	3.2
2.1	1.3	3.9	4.9
4.5	1.7	4.7	2.0
9.8	1.5	6.1	1.9
3.7	4.7	2.8	1.9
3.8	1.9	0.9	1.4
2.2	1.4	0.8	5.2
1.3	2.5	1.7	9.5
2.5	1.8	3.1	2.5
1.1	5.2	3.8	1.5
2.1	1.9	2.0	2.3
$\bar{x}$ 3.18	$\bar{x}$ 2.96	1.5	2.5
σ 2.08	σ 2.03	1.5	9.1
Range 0.9—9.8	Range 1.3—7.6	5.9	0.8
		2.1	2.6
		2.3	2.3
		6.7	2.3
		1.3	1.6
		4.9	3.2
		6.6	1.4
		2.0	4.2
		$\bar{x}$ 3.38	$\bar{x}$ 3.03
		σ 2.03	σ 2.04
		Range 0.8—8.9	Range 0.8—9.5

widths 2.96 m (standard deviation 2.03) and 3.03 m (standard deviation 2.04). Individual values, however, show considerable variability, partly as a result of stripe bifurcation. Thus ranges of widths were 0.9—9.8 m and 0.8—8.9 m for rock stripes. These results indicate no obvious difference in stripe spacings and widths between the north-west and south-east facing sides of the Stiperstones Ridge.

The rock stripes are composed of boulders of angular quartzite derived from the tors above. No foreign material was noted. Some of the blocks attained considerable size: long axis lengths reached 2.5 m though most blocks had long axis lengths of 0.2 to 0.8 m. Long axes were frequently down slope and individual slabs often arranged on edge rather than flat.

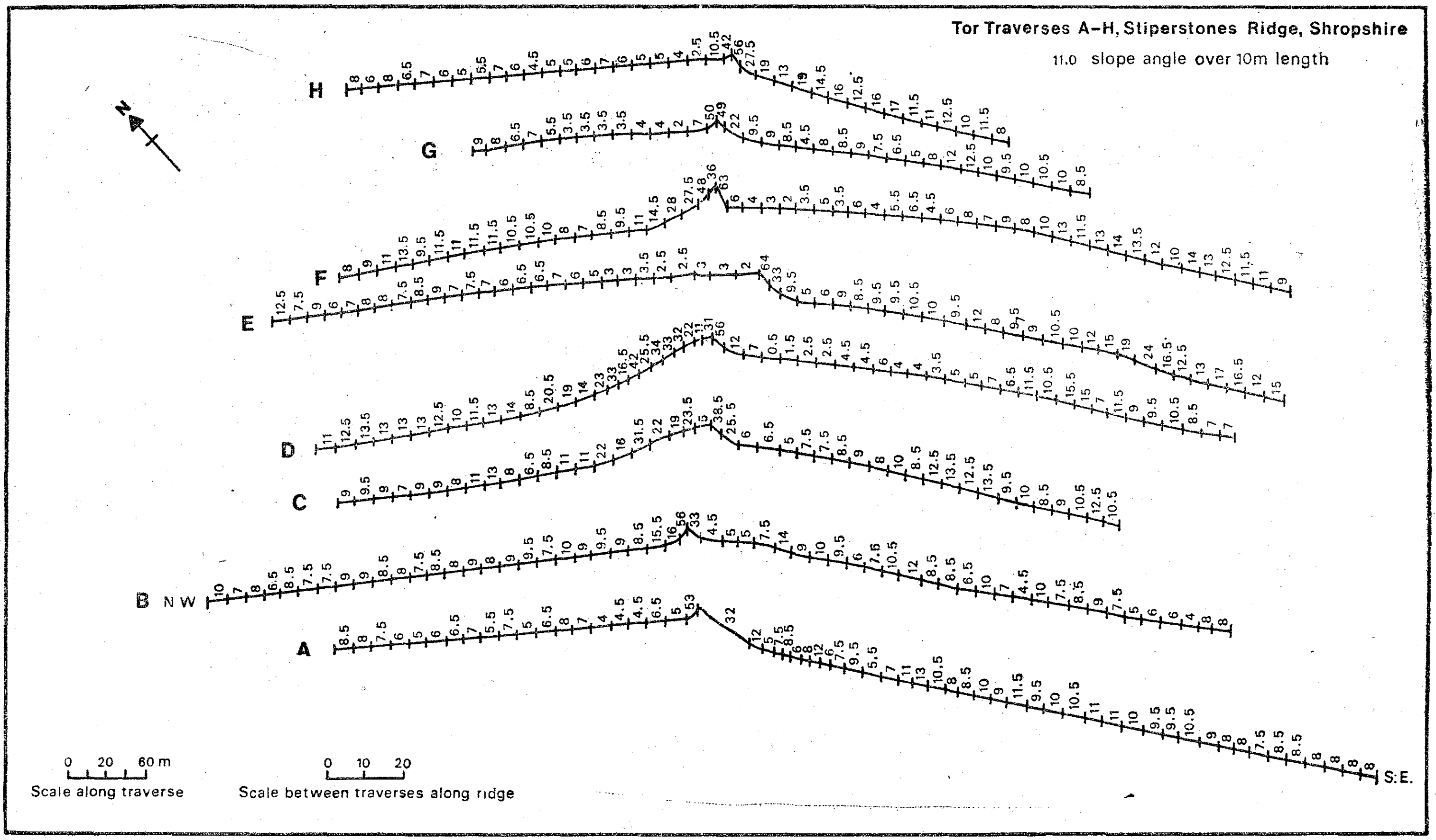

Fig. 3. Tor traverses A–H, Stiperstones Ridge, Shropshire

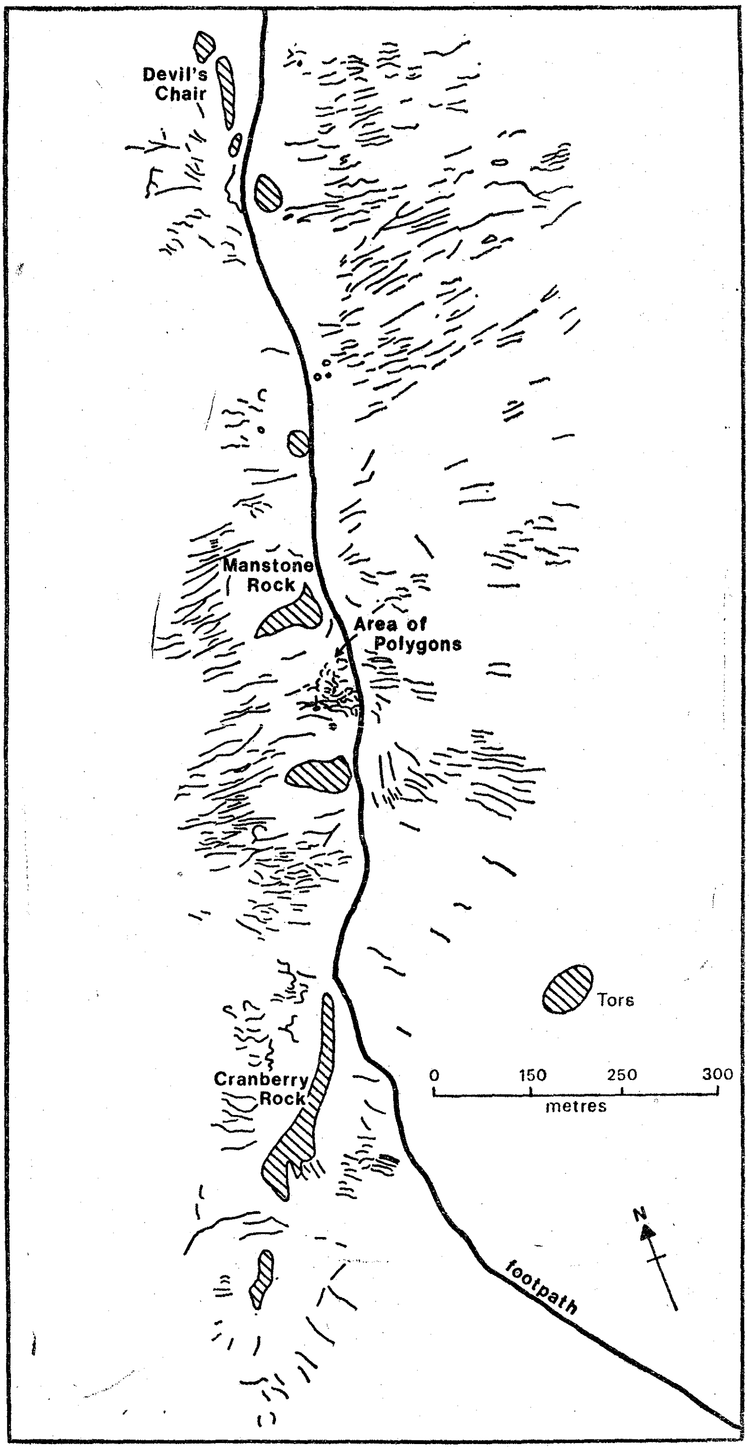

Fig. 4. Distribution of the stripes between Cranberry Rodek and the Devil's Chair

On some parts of the ridge, stone polygons, composed of similar boulders to the stripes, occur, their centres being composed of vegetated ground with heather predominating. Elongated polygons may lead down to stripes. The most striking polygons occur on the crest of the ridge, notably between Cranberry Rock and the Manstone, and also to the south of the Devil's Chair. Others were noted on the crest of the ridge in the vicinity of the Paddock. The polygons are of irregular shape and limited distribution in comparison with the stripes, and have diameters of around 7—9 m. Of this the central core of vegetation constitutes about one third.

The polygons are best developed on flat and low-angled ground but do occur on slopes of moderate steepness (e.g. 4° on Traverse A, 4.5—7.5° on Traverse B; 2.5—4.5° on Traverse D, 4° on Traverse F). Elongated polygons occurred on higher angle slopes (up to 14° on Traverse B, and 5—7° on Traverse E). Stripes occurred on slopes from 6° to 16°. GALLOWAY (1961, p. 80) has noted from Ben Wyvis in the Highlands of Scotland that the transition from polygons to stripes there occurred at about 6°, while KING (1971) has found stripes on slopes up to 18° in the Cairngorms, although less common at angles greater than 10°, and polygons occurring on slopes of 5° or less.

Stripes of this morphology, type and size have not been widely recorded so far in Britain although very similar examples were described in America as early as 1932 (ANTEVS, 1932). The major exceptions to this are the complex of stripes in the Rhinog Mountains of North Wales (BALL and GOODIER, 1968), and the sorted clitter stripes on Dartmoor.

The extent of the stripes and their distribution are shown in Figure 4. The distribution was obtained from 1:10,000 air photographs (RAF, August 26th, 1964). It can be seen that stripes extend down from the crest along most of the ridge, but they can be distinguished particularly clearly between the northern end of Cranberry Rock and the Devil's Chair. Both on the ground and on the air photos the stripes are evident over a distance of 200—300 metres from the ridge crest, though individual stripes can generally only be traced over distances of less than 50—70 metres.

THE ORIGIN OF THE STIPERSTONES

Of the models of tor origin outlined in the introduction to this paper the one-cycle periglacial model (PALMER and RADLEY, 1961) seems the most applicable to the Stiperstones. The substantial quantities of angular debris arranged in sorted stripes indicates that much of the shaping of the tors took place under cold 'periglacial' conditions, probably during part of the Devensian (Last) Glaciation, when the Stiperstones were immediately adjacent to the southern margins of the Ice Sheet (fig. 1), as the Geological Survey Map of the British Quaternary (South Sheet) demonstrates. Climatic conditions would have been extremely severe on the ridge, since it escaped local engulfment by the glacier ice moving across the surrounding area only because of its superior altitude. The heavy development of miscellaneous species of lichen both on the tors and on the stone stripes indicates that contemporary frost action, in comparison, is relatively insignificant in its effects. Some seepage lines occur on the slopes which radiate out from the tors, but they do not head into the tors and they occur at levels generally beyond the zone of stripes. This would tend to suggest that present-day seepage moisture is also not a major factor in the development of the tors. With regard to the LINTON model of tor origin it is unlikely to be relevant in this situation for quartzites and quartzitic conglomerates of the Arenig series have not apparently been subjected to deep chemical weathering and it is unlikely that rocks of their lithology would develop the weathering front, core stones, and deep regolith of the LINTON model. It is suggested, therefore, that the group of landforms discussed in this paper reflects the action of freeze—thaw processes in a former, periglacial, environment.

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