Norber Erratics

[SD 765 700]

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Introduction

The Norber ridge (Figure 5.72) and associated Robin Proctor's Scar and Nappa Scars, in North Yorkshire, have become a classic area for glacial geomorphology as they demonstrate an assemblage of perched glacial erratic blocks, resting on limestone pavement and pedestals, which may have important repercussions in demonstrating the amount and rate of post-glacial weathering on limestone. They have been described many times, by Phillips (1827, 1855), Howson (1850), Mackintosh (1883), Hughes (1886), Kendall and Wroot (1924), Brumhead (1979), Waltham (1987) and Waltham *et al.* (1997).

Description

The principal interest in the site is the spectacular erratic train from the west side of Crummack Dale, which contains hundreds of large, angular erratics of Austwick Formation sandstones and siltstones (of Silurian Wenlock age) from outcrops to the north-west (Arthurton *et al.,* 1988). These erratics occur on various scales up to boulders with long axes up to 4 m and intermediate axes up to 2 m (Figure 5.73). Many of the erratics are perched on the underlying limestone pavements, but the latter are poorly developed and the erratics usually are scattered over thinly drift-covered limestone grassland surfaces. Occasional limestone boulders are perched on pedestals of limestone and they usually can be recognized by their 'cockly' or crinkled weathering caused by the direct atmospheric action of rainwater. It is clear that the erratics have been transported glacially by ice moving from the north, and transported across the limestone outcrop for more than 1 km and more than 120 m above their source outcrop. At Norber, the erratic boulders stand on pedestals of limestone up to 30–50 cm above the surrounding pavements and it always has been assumed that erratic-bearing pedestals demonstrate the amount of surface lowering of the limestone since the erratics were deposited.

The area overall is a classic example of glacio-karst where the initial stage of pavement formation was by glacial scour to give a relatively planed surface (Sweeting, 1966; Trudgill 1985). Although much of the limestone pavement shows no evidence of glacial scour, this occasionally can be seen beneath erratic blocks, where the limestone surface is smoothed, polished, furrowed and striated, as at Norber (Hughes, 1886).

Interpretation

The subaerial dissolution of limestone, or corrosion by direct rainfall, has been suggested as an important erosional process (Arthurton *et al.,* 1988) and its amount can be estimated by measuring the height of erratic-bearing limestone pillars standing above the surrounding pavement levels. If the age of emplacement of the erratics is known then the rate of subsequent dissolution of limestone can be deduced. Thus, if one assumes that the pedestals of limestone have been protected from corrosion by direct rainfall whilst the surrounding limestone surface has been lowered by subaerial and subsoil solution then as the pedestals are mostly 40–50 cm high, the mean rate of lowering of the exposed surface has been about 30–40 mm ka¯1 since the Devensian ice retreat (Sweeting, 1966). Very little quantitative work, however, has been attempted to test this assumption and there appear to be several problems related to its accuracy as a technique.

Perched blocks of limestone, which are common on the north-west side of Ingleborough at Scar Close and on Harry Hallam's Moss, show that the clint surfaces have been lowered by about 50 cm since their formation (Sweeting, 1966). However, many are probably what Corbel (1957) has called 'pseudo-erratics', that is residuals left by stripping of the beds by solution as described by Sweeting (1966), and on Scar Close there is a height variation of 20 cm within a relatively small area, which probably indicates a process other than a subaerial one in their formation. It also could be envisaged that erratics on pedestals could be uncovered by chance as a glacial drift cover was stripped away from the limestone pavements, and hence their exposure to subaerial processes could be of different post-glacial ages.

At Norber, conditions for solution under prevailing peaty drainage are less favourable than for those at, for example, Twistleton Scars and Scar Close in Chapel-le-Dale, and many erratics are raised above the surrounding limestone on the downslope side only (Sweeting, 1966). On the upslope side they are at the same level as the limestone, a fact which led Sweeting (1966) to suggest that soil creep was a contributory factor in the development of the Norber pedestals. Hughes (1886) suggested that the pedestals seem to be gradually perishing and that there must be a natural limit to their height. Using the umbrella analogy, he thought that an umbrella held too high will shelter only from perfectly vertical rain so when the pedestal has attained such a height that the rain can beat in under the boulder, the pedestal gets eroded at its base. This occurs more on one side than on another according to the prevailing winds. Eventually the boulder topples and the result of this can be seen at Norber.

As Corbel (1959) had devised a formula to calculate the number of millimetres of limestone per 1000 years that was removed by unaided solution, it was applied to the figures for northwest Yorkshire by Sweeting (1966) at the present rates of limestone solution and with the present rainfall. Solution of the rock is equivalent to a lowering of the surface by 0.083 mm year^{-1} (0.04 mm year^{-1} by solution at the surface and 0.043 mm year^{-1} by solution underground). The rate of lowering of the surface in this way is about 41 mm in 1000 years. This result can be used in discussion of the development of pavements and the location of perched erratic blocks. Sweeting (1966) suggested that the erratics may be regarded as dating from the Late Devensian period about 12 000 years ago, although 14 000 or 15 000 years seems a more likely figure. Assuming the rate of dissolution of the limestone at the surface to have remained much the same over time as it is now, the amount of lowering of the surface would be about 49 cm. This result is of the same order of magnitude as the height of the pedestals that support the perched erratic boulders. However, the rate of surface solution might not have remained the same because we know that climate, including both rainfall and temperature, which both affect the rate of solution, have varied though the post-glacial period.

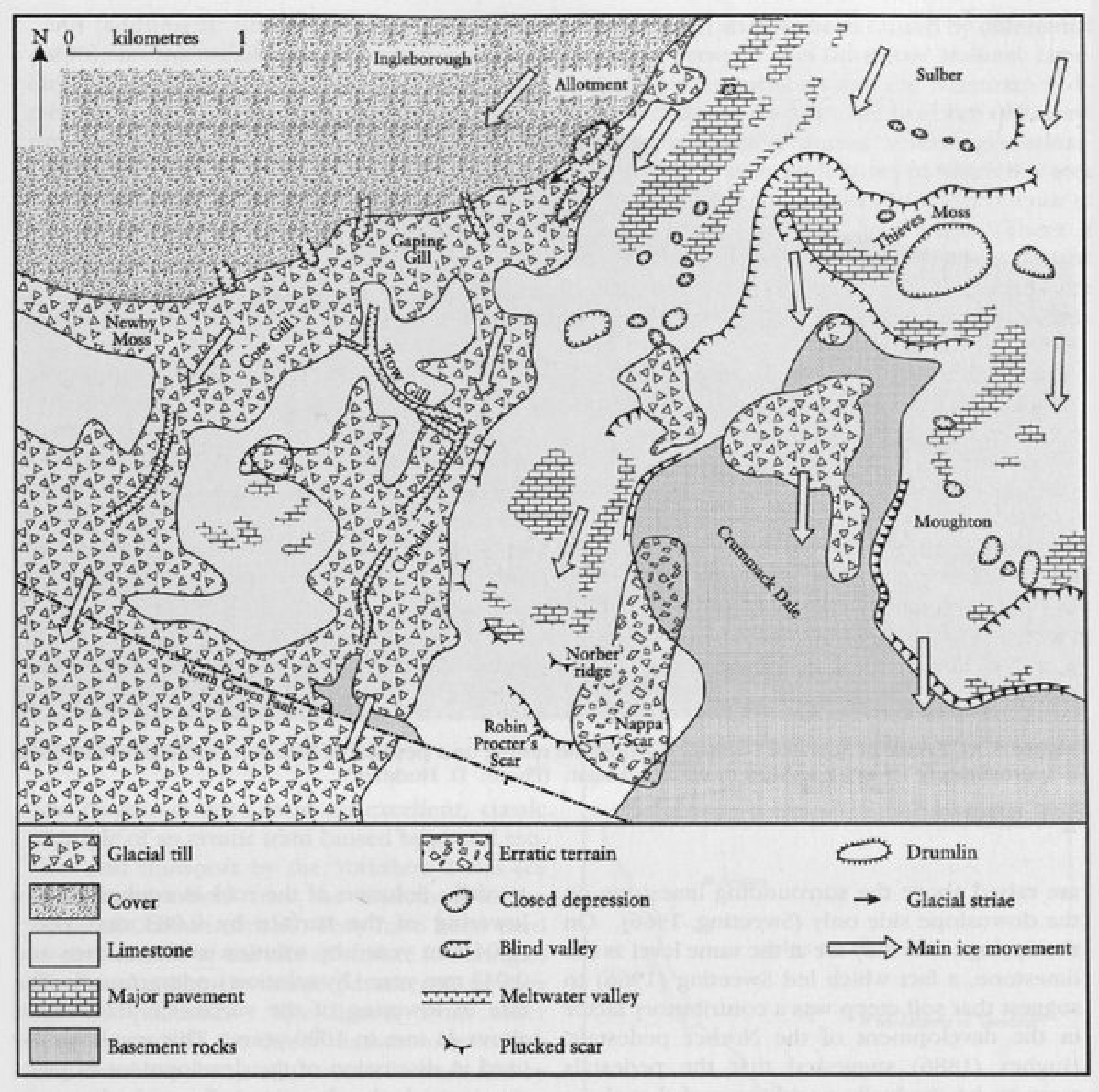
An additional observation by Goodchild (1890), on the weathering of limestones, is of direct interest here. He used the weathering rate on local monuments and gravestones to estimate the rate of weathering of the northern England limestones at about 48 mm in 1000 years. On this basis the weathering of the limestone since the last glacial would be about 60 cm, a figure not too dissimilar to that already quoted. Goodchild regarded his figure as a lowest estimate and thought that 80 mm in 1000 years might be nearer the truth. Nevertheless, Sweeting (1966) suggested that Goodchild's findings remained in reasonable accordance with the Corbel formula.

Direct measurements of the erosion rate of the limestone using micro-erosion measurements over three years by Nicholson (1990) on the pavement close to Alum Pot beck in Ribblesdale show an erosion rate of 0.33 m 1000^{-1} years. This agrees well with the rate of 0.4 m 1000 years^{-1} as an average since deglaciation estimated using the Norber erratics and pedestals by Sweeting (1966).

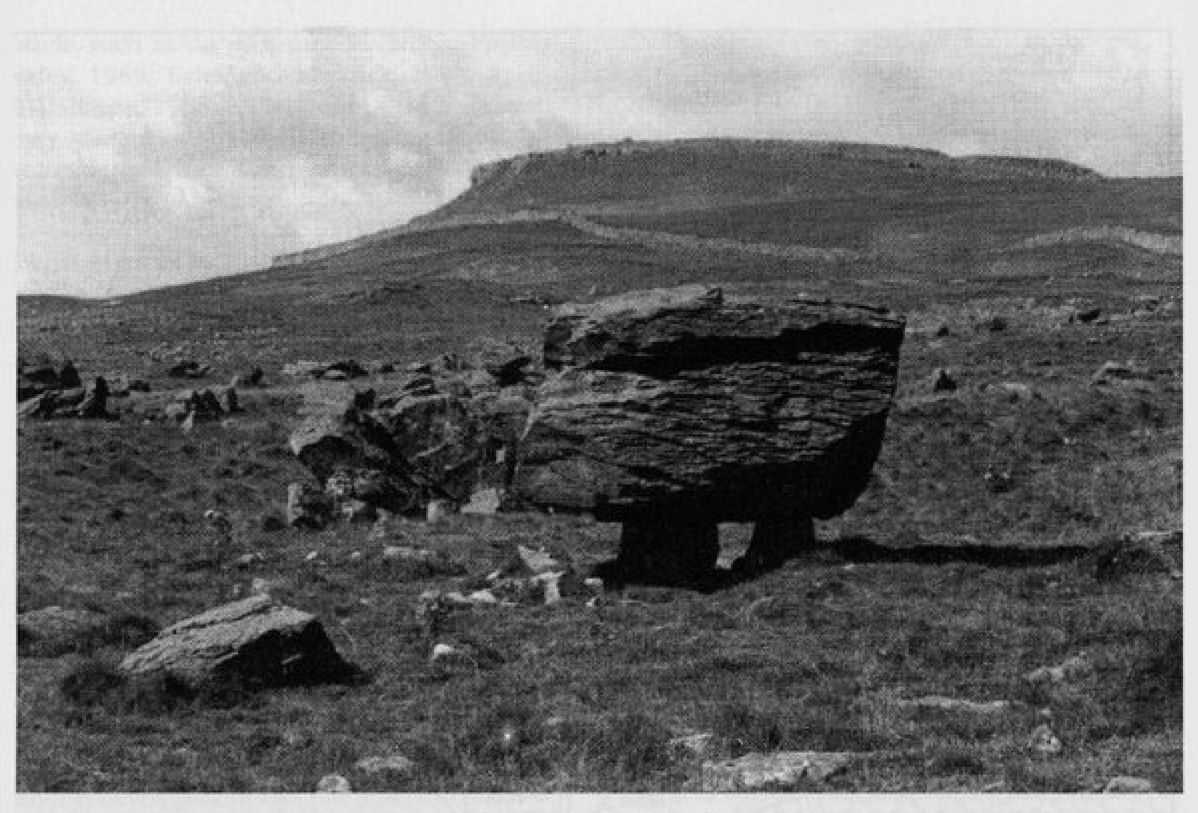
Conclusions

The Norber erratics show an excellent, classic example of an erratic train caused by glacial erosion and transport by the Yorkshire Dales ice sheet as it moved over the limestone to the north of Crummackdale. They have been used as an indicator of the rate of surface lowering of the surrounding limestone pavements, as they rest on pedestals. The figures from other sources, such as the direct measurement of the solutional loss, by using Corbel's formula and by a comparison of the weathering of limestone gravestones and monuments all suggest an approximate rate of surface lowering. However, some doubts remain as to the exact formation of the erratics and their pedestals and their real value in measuring the rate of surface limestone lowering.

References



(Figure 5.72) Geomorphological map of the southern sector of Ingleborough (after Waltham 1990).



(Figure 5.73) Erratic of Austwick Formation sandstone resting on a pedestal of limestone at Norber. The block is approximately 1.5 m high. View to the north-west. (Photo: D. Huddart.)