Burbage Brook

[SK 260 815]

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Introduction

The site at Burbage Brook, contains an assemblage of sediments and landforms that are significant for studies of rock weathering, periglacial processes and landscape evolution in the Pennines. The Pennine tors are at the heart of a long-standing controversy concerning the nature of deep weathering and tor formation in the British Isles. There currently are two main theories that can account for tor formation. The first entails a two-stage model of weathering and stripping (Linton, 1955, 1964) and the second requires only a single cycle of denudation under periglacial conditions (Palmer and Radley, 1961; Palmer and Nielson, 1962). Much of this debate has focused on the tors of the Pennines, which are developed in Millstone Grit. One of the characteristics of the Pennine tors is that commonly they are developed on the edge of escarpments. Palmer and Radley (1961) termed these features 'edge tors', although they are also widely known in the literature as 'scarp-edge tors' (Cunningham, 1964, 1965). This site is noted for its particularly well-developed scarp-edge tors.

The landform–sediment assemblage at Burbage Brook includes a variety of escarpments, tors, structural benches, solifluction deposits, weathering features, blockfields, blockslopes and a Devensian Late-glacial soil. The site has been used by Linton (1964) to illustrate his theory of tor formation and by Cunningham (1965), who identified and described in detail eight tors on Mother Cap Moor as part of his discussion of the south Pennine tors. A detailed description of the geomorphology of the Burbage basin is given by Said (1969). This area of the Pennines was also used in the pioneering work on slope form and slope evolution (Young, 1961; Carson and Petley, 1970) and in attempts to establish a denudation chronology for the British uplands (Johnson and Rice, 1961; McArthur, 1970, 1971, 1977, 1981).

Description

Burbage Brook occupies an area of *c.* 3.5 km^2 of Hathersage Moor, some 10 km to the west of Sheffield. These moorland slopes form a broad valley containing the Burbage Brook. Geologically, rocks of Namurian (Upper Carboniferous) age dominate the area (the 'Millstone Grit' of Eden *et al.,* 1957). At Burbage Brook these are primarily massive sandstones, siltstones and mudstones of the Chatsworth Grit and the Middle Grit Group. A number of prominent cliff faces and scars, including those at Millstone Edge and Burbage Edge, define the upper slopes of the Burbage valley. In places, these cliffs reach heights of up to 30 m and immediately below them are accumulations of detached blocks. Large boulder fields extend for a considerable distance below the edges. On the eastern side of Burbage Brook are a series of continuous scarps and slopes. The area to the west of Burbage Brook is generally more broken up and consists of a number of tors, including those at Higger Tor, Carl Wark, Winyards Nick and Over Owler Tor (Figure 7.11). These tors generally consist of large, isolated hills that are capped by deeply fissured and often disturbed Chatsworth Grit. Disturbance of the sandstone cap can be seen at its margins, where collapse and downslope movement is evident. Extensive blockfields are developed below the tors, especially on the slopes below Higger Tor and Earl Wark.

The tors of the Burbage area can be subdivided into two main types (Linton, 1964). These are the higher tors and the lower tors. The higher tors are located on the top of free faces, on the back slope of cuestas and on ridge summits. They exhibit evidence of deep weathering along joints and bedding planes. Large weathering pits are common on their summits. There are no free faces of corresponding height in the immediate vicinity. The lower tors are those immediately in front of free faces. They show little evidence of deep weathering along joints and bedding planes. Weathering pits are less common on their summits, but where these do occur they are shallow and widely spaced. Well-developed weathering pits have convex lips, an inner wall and floor. Some pits are crossed by open joints and cracks, possibly of periglacial origin. A second type of weathering is evident in the form of honeycomb weathering on the sloping surfaces of free faces, tor plinths and blocks. Overall, the honeycomb weathering appears to be less common than the weathering pits.

Said (1969) completed the most comprehensive study of the geomorphology of the area (Figure 7.12) in an attempt to produce a regional chronology of events. Evidence used to determine Quaternary environmental change includes sedimentary descriptions, the analysis of pollen and organic remains, slope profiles and the evolution of the edges, tor morphology, weathering pits and other weathering phenomenon, such as honeycomb weathering (Said, 1969).

Soil and vegetation currently cover most of the Burbage Brook catchment. Beneath this cover, the sedimentary evidence is exposed mainly in stream-cut sections along the course of the Burbage Brook. These show evidence for several phases of river aggradation and incision (Table 7.3). The principal facies are indicative of alternating fluvial and periglacial deposition. Solifluction deposits (head) are widespread across the area. Above the fluvial and periglacial units are sediments indicating temperate fluvial activity and chemical weathering. Said (1969) examined nine sections along the length of Burbage Brook and in one recovered organic remains sufficiently intact to be identified.

Said (1969) also described slope profiles across the shale–grit and shale–sandstone lithologies. Convex slopes occur on highly jointed grit or sandstone lithologies. Free faces (edges) are restricted to the more massive grit outcrops, particularly near summit crests. Bedding planes and joints on the edges commonly are weathered, particularly on the flaggy sandstones. Slope profiles commonly are covered by head material, although this is deeper and better developed on concave slopes than on convex slopes. The size, location and morphology of boulder accumulations are also controlled to a certain extent by lithology. The blocks are not rounded corestones but show considerable variation in degree of roundness. They are more angular on interfluves and at the foot of free faces, but relatively more rounded at a distance. Large differences in the roundness of sandstone and grit fragments are apparent. Sandstone fragments tend to be more angular whereas the grit fragments are relatively more rounded. All shapes of grit blocks can be found, including oblate, equant, bladed and prolate. Glacial erratics are also noted in the area, but these generally are rare.

Interpretation

Said (1969) explained the different sedimentary units of the area as a function of fluctuating climate in the Late-glacial (Table 7.3). He also related changes in the activity of the Burbage Brook in terms of climate-driven changes in slope stability, vegetation cover, hydrological regime and sediment supply. The slopes of the area show widespread evidence of periglacial modification, including the deposition of head sequences, and are only very slowly modified under present-day climate. Most of the periglacial deposits therefore are regarded as relict rather than having formed under present-day conditions.

Detailed study of the different types of edges (free faces) and their morphology led Said (1969) to suggest that these were formed in the cold phase preceding the antepenultimate glaciation. There was also a phase of face development during the penultimate glaciation. Some of the free faces probably survived the last interglacial. The development of free faces was renewed in the last glacial episode and it is likely that periglacial processes shaped much of their present form at that time. The active evolution of free faces ceased with the cessation of cold conditions at the end of the Late-glacial. McArthur (1981), working in the upper Derwent basin, came to similar conclusions regarding the timing of these episodes of periglacial activity. He described 'periglacial slope planations' and argued that these valley-side benches formed through retreat of sandstone and gritstone scarps and associated removal of rock waste by solifluction. McArthur (1981) invoked river incision of 40–50 m following the initiation of scarp retreat to leave the benches in their current position. The upper Derwent basin, however, lies within the limits of the maximum glaciation and it has been suggested that this is a significant factor in their formation (Ballantyne and Harris, 1994). There appears to be strong structural control on the development of the 'periglacial slope planations' described by McArthur (1981), with the lip of each bench underlain by resistant sandstone and the treads cut across shales. It therefore is equally, if not more, plausible to interpret these benches as the products of differential glacial erosion of strata of variable resistance (Ballantyne and Harris, 1994). The role of cryoplanation therefore may be limited in this area simply to scarp retreat and solifluction of regolith over the surfaces of glacially eroded benches.

Said (1969) considered the development of tors to be an integral part of the development of free faces. Whether a tor is produced in any part of a free face is a function of its lithology and structure. For example, he noted that in the Burbage area lenses of massive grit in the free faces are often left as isolated stacks or small tors. Said argued that because this area was ice covered during the antepenultimate glaciation all tors would be destroyed and that the tors in this area therefore cannot be Tertiary in origin. According to Said (1969), therefore, the active evolution of tors ceased at the end of the Late-glacial. This does not of course allow for the possibility that the tors survived beneath cold-based portions of the ice sheet, as demonstrated elsewhere for other tor landscapes (Fitzpatrick, 1963; Sugden, 1968, 1989; Hall, 1985, 1991; Hall and Sugden, 1987; Hall and Mellor, 1988; Hall *et al.,* 1989; Ballantyne, 1994; Kleman, 1994). In contrast, both Linton (1955) and Cunningham (1965) advocated Tertiary deep weathering and argued that the tors were weathered long before the surrounding blocks were exposed.

The roundness of detached blocks was probably acquired subsequent to their detachment from the free faces and other bedrock outcrops. The difference in roundness between sandstone and grit boulders probably is lithological and holds no genetic significance. The blockfields probably formed during the penultimate and last glacial phases, but some may be much older. There is stratigraphical evidence to show that the blockfields were formed in both the Older Dryas and Younger Dryas and that their active evolution ceased at the end of the Late-glacial.

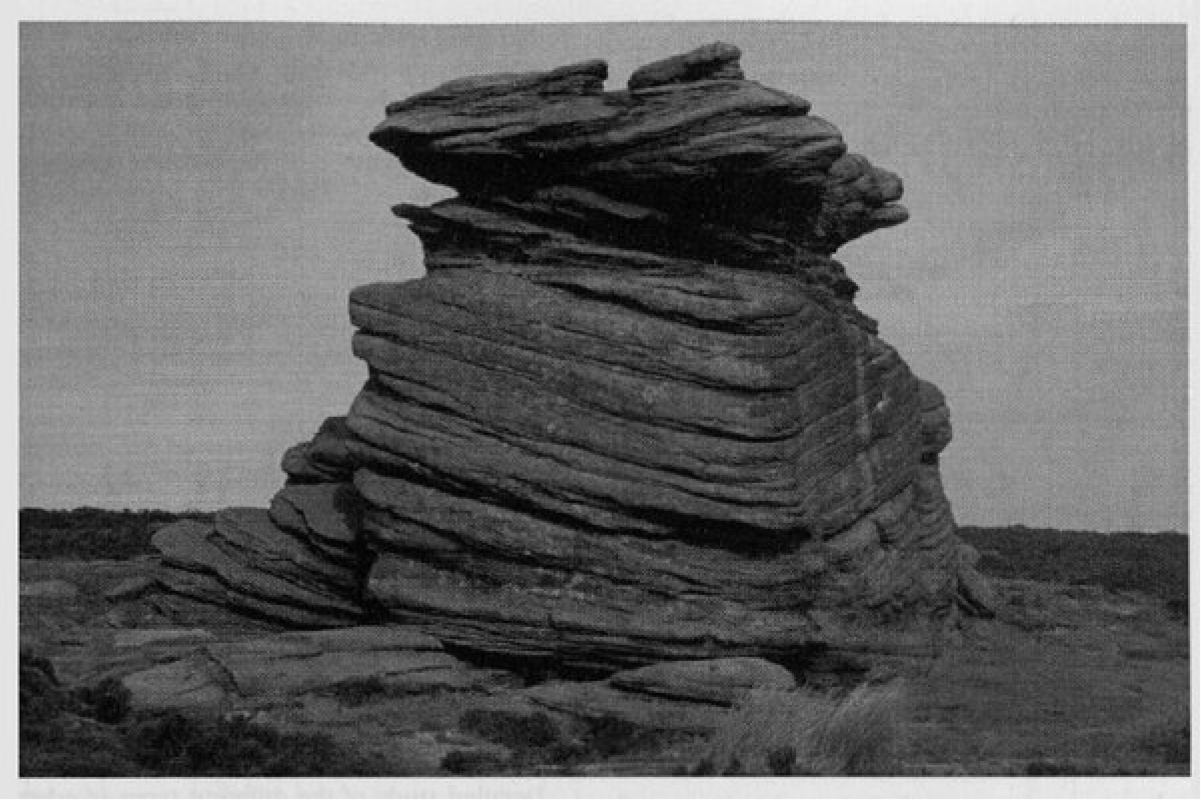
Weathering pits are currently developing on the surface of blocks, but those on the sides of blocks are relict. Pits are initiated on the surface of blocks where large quartz pebbles are removed, and develop through enlargement as a result of wetting–drying cycles, freeze–thaw and organic growth and decay. They cannot be used as evidence of Tertiary weathering because they can develop in a variety of climatic settings. Pit initiation probably began in the last interglacial but was interrupted by the onset of cold conditions during the last glacial. Their development has resumed in the Holocene. The honeycomb weathering on the sloping surfaces of free faces, tor plinths and blocks is interpreted by Said (1969) as weathering of an iron-deficient zone beneath iron crusts. Wherever the crust is punctured, for example by the removal of a quartz pebble, the inner, decomposed, iron-deficient zone is exposed and the pattern develops. The pits are probably of little palaeoclimatic significance.

Other workers have confirmed the overall conclusion of Said (1969) that the landscape of the southern Pennines owes much to relict periglacial processes. In his study of the neighbouring upper Derwent basin, for example, McArthur (1981) concluded that solifluction sheets are essentially immobile under the present-day climatic regime. Similarly, landscape elements such as benches, escarpments and regolith are periglacial in origin, but the dominant landscape-forming processes in the southern Pennines under present climatic conditions are fluvial.

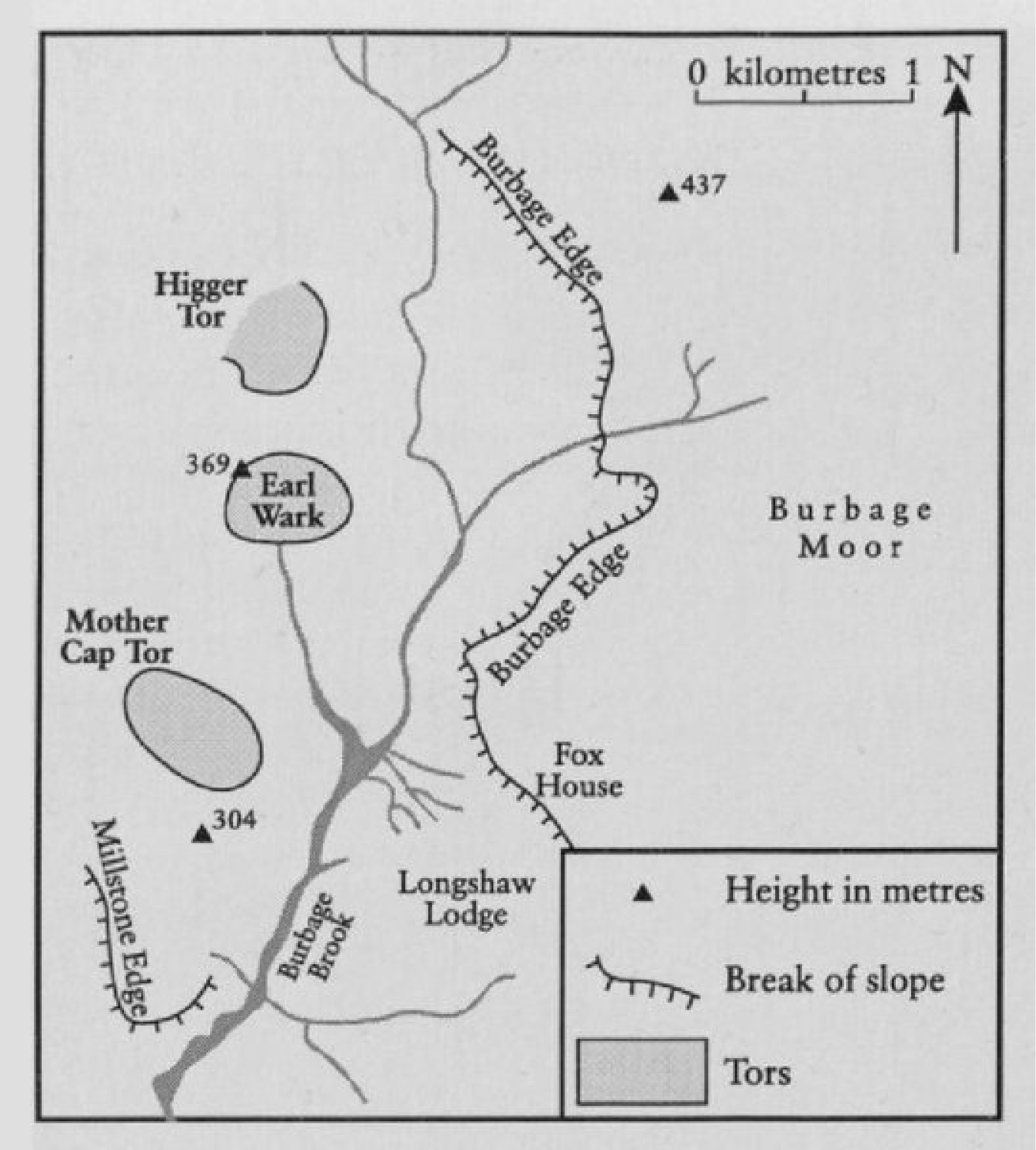
Conclusions

Burbage Brook contains an assemblage of landforms and sediments typical of upland areas in the southern Pennines. It is an important site for the study of tors, edges, and the processes of rock weathering and slope formation. An important element of this site is that it has been used to construct a chronology and regional picture of events during Late-glacial and Holocene times. The evidence from Burbage Brook indicates periods of intense weathering under periglacial climates during the Older and Younger Dryas, followed by a return to fluvially dominated, landscape modification under present climatic conditions.

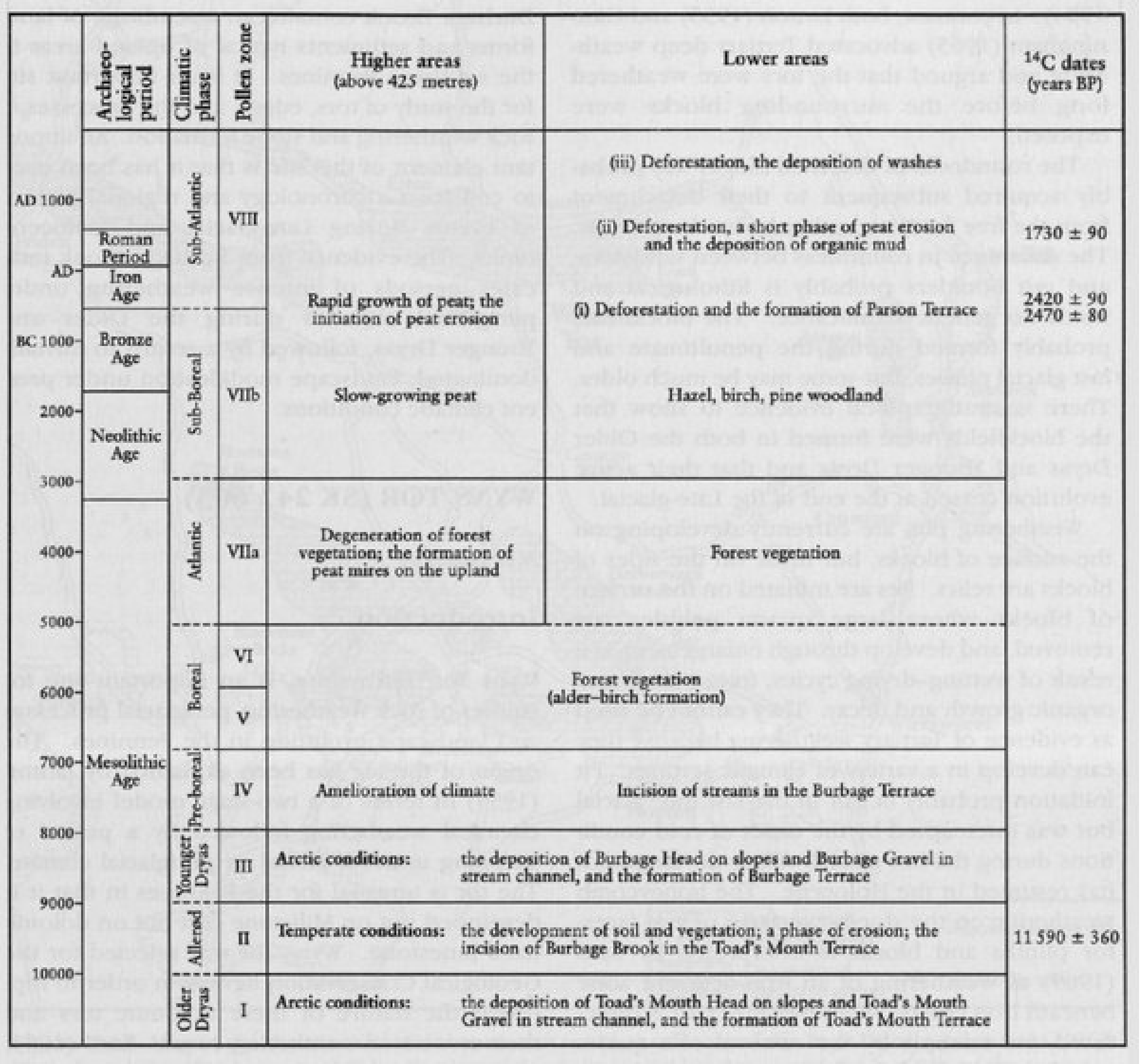
References



(Figure 7.11) A typical tor above Burbage Brook. (Photo: N.F. Glasser.)



(Figure 7.12) Morphological map of the Upper Burbage Basin (after Said, 1969).



	Archaeological period	Climatic phase	Pollen zone	Higher areas (above 425 metres)	Lower areas	^{14}C dates (years BP)
AD 1000 AD	Roman Period Iron Age	Sub-Atlantic	VIII	Rapid growth of peat; the initiation of peat erosion	(iii) Deforestation, the deposition of washes (ii) Deforestation, a short phase of peat erosion and the deposition of organic mud (i) Deforestation and the formation of Parson Terrace	1730 ± 90 2420 ± 90 2470 ± 80
BC 1000 2000 3000	Bronze Age Neolithic Age	Sub-Boreal	VIIb	Slow-growing peat	Hazel, birch, pine woodland	
4000 5000	Mesolithic Age	Atlantic	VIIa	Degeneration of forest vegetation; the formation of peat mires on the upland	Forest vegetation	
6000		Boreal	VI	Forest vegetation (alder–birch formation)		
			V			
7000 8000		Pre-boreal	IV	Amelioration of climate	Incision of streams in the Burbage Terrace	
		Younger Dryas	III	Arctic conditions:	the deposition of Burbage Head on slopes and Burbage Gravel in stream channel, and the formation of Burbage Terrace	
9000		Allerød	II	Temperate conditions:	the development of soil and vegetation; a phase of erosion; the incision of Burbage Brook in the Toad's Mouth Terrace	11 590 ± 360
10000		Older Dryas	I	Arctic conditions:	the deposition of Toad's Mouth Head on slopes and Toad's Mouth Gravel in stream channel, and the formation of Toad's Mouth Terrace	

(Table 7.3) Chronology of the Late-glacial and Holocene events in the Burbage area (after Said, 1969).