Cross Fell

[NY 687 344]

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Introduction

The northern Pennines upland landscape of high, open and exposed plateau is, arguably, England's last wilderness. At 893 m OD, Cross Fell [NY 687 344] is the highest point of the Pennines and the coldest place in England (Manley, 1936). The site covers approximately 4 km^2 of the plateau and includes not just Cross Fell but the adjacent summits of Great Dun Fell (847 m OD) and Little Dun Fell (841 m OD) (Figure 7.35). It is bounded by a steep scarp along its western edge to the Vale of Eden, but, in contrast, the eastern slopes are more gentle and include the headwaters of the River South Tyne and River Tees. The climate generally is cool with a high number of cloudy and usually wet days, with winters characterized by negative mean monthly temperatures (Smithson, 1985). This climatic regime is similar to that of southern Iceland and allows for the present-day operation of small-scale periglacial processes (Tufnell, 1969, 1971, 1972, 1985).

Cross Fell is part of the geological unit termed the 'Alston Block' (Johnson and Dunham, 1963; Johnson and Hickling, 1970; Taylor *et al.,* 1971; Burgess and Wadge, 1974; Dunham, 1990). It is bounded to the north by the Stublick Fault and the Tyne Gap and to the south by the Lunedale Fault and the Stainmore Trough. To the west is the Pennine Fault, which has produced a major displacement and an impressive, although degraded, fault-line scarp with an estimated displacement of 600 m near Cross Fell ((Figure 7.36)a). The area is underlain at depth by the Weardale Granite batholith, which has caused regional deformation and the gentle easterly dip of the Alston Block (Bott, 1967). The exposed solid geology is of Carboniferous rocks, primarily sandstones, limestones and mudstones ((Figure 7.36)b). These lithologies alternate within definable cycles and have a direct influence on the development and style of topography and periglacial forms.

Description

Although there is little direct evidence of glaciation within the summit area of Cross Fell, a series of giant erratics, known as the Tullman Hills' [NY 705 375], occur 2 km to the north east. These erratics are 100–200 m in diameter, 12–15 m high and are composed of a sequence of Great Limestone strata rafted from an outcrop about 2 km to the south, indicating ice transport northwards into the Black Burn catchment (Lunn, 1995, 1996). Drumlins also have been identified, extending down-valley from Moor House [NY 756 327] towards Cow Green and Harwood Beck.

A number of large-scale periglacial features, such as blockfields, blocky scree slopes and frost-riven cliffs, large-scale stone stripes, polygons and nivation terraces can be found in the summit area. These features are thought to be relict and associated with the severe climatic conditions of the Late-glacial period (Lowe and Walker, 1997a, b). However, the smaller scale landforms, such as gelifluction terraces, polygons, stripes, erected stones, ploughing blocks and thufur, continue to be active under present climatic conditions, because the climate is cold enough to generate frost processes (Tufnell, 1985). In places, contemporary gelifluction terraces are superimposed over large-scale 'fossil' stone stripes.

Weathering forms

The summit plateau of Cross Fell (Figure 7.37)a is characterized by large areas of mountain-top detritus formed by in-situ weathering (macrogelivation) of the underlying bedrock creating blockfields (Ballantyne and Harris, 1994). This open framework of angular boulders with no interstitial material occupies the level, or very gently sloping, ground, over an area of about 0.5 km^2 to the north of the summit of Cross Fell ((Figure 7.37)b), in association with an outcrop of coarse-grained sandstones. Smaller areas of blockfield also can be observed on the other two summit areas and excavations on the top of Great Dun Fell revealed a thick zone of in-situ weathered, Dun Fell Sandstone (Johnson and

Dunham, 1963; Tufnell, 1985). Many of the surface boulders have been split by intense frost action indicating a severe climate and deep frost penetration. Block streams composed of large angular blocks of sandstone, which appear to flow from blockfields, have been reported from Knock Fell (Tufnell, 1969).

Certain of the limestone units also have been fragmented into large clasts near their outcrop. These, however, tend not to form the plateau surface but tend to form cliffs, with the underlying mudstones obscured by talus slopes of limestone clasts. Talus slopes also have developed below outcrops along the northern and western flanks of Cross Fell, terminating at a break of slope at 750 m, particularly below a massive sandstone known as the 'Six Fathom Hazel' (Pounder, 1989). Lobate forms of boulders downslope of the talus slopes on the southwestern side of Cross Fell indicate the operation of debris-flow processes on these slopes ((Figure 7.37)c).

Patterned ground

To the south and south-east of Cross Fell summit there is discernible patterned ground, particularly sorted stone polygons (Figure 7.37)d and stripes. Large-scale blocky stone stripes occur on the western slopes of Little Dun Fell (Figure 7.37)f and small active forms have been reported from the south-facing slopes and summit of Great Dun Fell (Figure 7.37)e. Clasts with a vertical long axis, termed 'erect stones' by Tufnell (1969), are widespread over much of the higher ground, often in association with relict patterned ground.

A particular type of patterned ground is the vegetation covered hummocks or thufur found on many west-facing slopes at altitudes over 800 m OD (Tufnell, 1966). On Great Dun Fell they occur on slopes with a gradient of 14–17°. In upper Knock Ore Gill, between 680 and 750 m OD, thufur are found in association with wet flushes on the eastern side on a 6–9° slope (Figure 7.37)g. The dimensions of these landforms from a measured population of 254 indicate an average maximum height of 17.3 cm and an average maximum diameter of 36.0 cm. They are hemispherical in shape, although some are elongated as a result of slope processes and they show arching of thin vegetation layers that enclose a core of fine-grained sediment. These landforms are probably still forming today, as Tufnell (1969) measured 3–5 cm of stake movement as a result of frost heave since the late 1940s to early 1950s. They are found in association with gelifluction terraces and ploughing blocks that are moving downslope at detectable rates (Tufnell, 1972). Such hummocky microrelief may be polygenetic in origin (Tufnell, 1966; Ballantyne and Harris, 1994) and many of these forms in this part of northern England may reflect non-periglacial processes.

Solifluction

A widespread feature of upland slopes in Britain is the downslope movement of material by seasonal freezing and thawing of the upper soil layers. This may also be termed 'gelifluction', where slow saturated flow of an ice-rich soil occurs during thaw consolidation (Ballantyne and Harris, 1994) and is termed 'congelifluction' by Tufnell (1969). The presence of mudstones in the area has provided large amounts of fine-grained material to be broken down by microgelivation. Mechanical fracturing of the interbedded sandstones and limestone has provided a number of angular clasts that mix with the mud to form a widespread diamicton that generally is regarded to be the result of periglacial processes. This clay-rich diamicton has been subjected to flow and deformation under gelifluction processes, which have resulted in a number of different surface forms. Tufnell (1969, 1985) identified five different types of 'gelifluction terrace', which he divided according to whether they are convex in plan down-slope (lobe) or parallel to slope (terrace), whether they are vegetated or expose sediment on the riser. Lobes are reported from Great and Little Dun Fell whereas terraces are exemplified above 730 m OD in Knock Ore Gill (Tufnell, 1985).

'Ploughing blocks' are the most widely distributed of the currently developing periglacial phenomena and have been observed down to an altitude of 450 m OD (Johnson and Dunham, 1963; Tufnell, 1969). 'Ploughing block' is a term used by Tufnell (1966) to describe large blocks on slopes that travel faster than the finer soil material. Such large clasts are able to move downslope under gravity, particularly when the soil is soft owing to high moisture content, and form distinctive mounds of ploughed material in advance of the block and a notable track or depression upslope behind the block. They indicate differential slope movement with mean annual rates of 1–5 cm a^{-1}, with a maximum movement in the spring when frozen soil is melting (Tufnell, 1969, 1972, 1985). In plan, the depressions can be niche-shaped, or elongate, depending on the differences in speed of block movement relative to that of the surrounding ground. Blocks travelling faster than adjacent parts of the slope will create an elongate depression, whereas a niche-shaped depression will form where movement just exceeds that of the surrounding slope. These landforms usually occur on grassy slopes where there is sufficient moisture; they are rarely found in areas that lack vegetation. The possible causes of ploughing block movement are summarized in (Figure 7.38).

Nivation landforms

The Cross Fell area is well known for its late-lying snowdrifts and snow patches associated with distinct bedrock benches on the upper slopes of the mountains (Tufnell, 1971) and in some cases the snow is associated with semicircular hollows. They compare well with cryoplanation terraces and nivation hollows in present periglacial environments (Ballantyne and Harris, 1994) and have the following features in common:

1. they occur on the upper slopes of relatively undissected mountains that have a generally rounded form;
2. the treads of the terraces are up to 12° in slope — whereas the steeper risers can vary between 20 and 35°;
3. other frost landforms are associated with them and bare ground is found on the steeper parts of the terraces, which facilitates – and is a result of – their erosion.

Some of the best terraces in the Dun Fell area are situated on the north-western slopes of the Upper Knock Ore Gill on ground that repeatedly experiences snow-patch formation ((Figure 7.37)h). This provides moisture that facilitates freeze–thaw break-up of the ground ice and needle ice, as well as the downslope movement of unconsolidated debris, water erosion and removal of the fine sediments at the base of the snow patch (Huddart, 1981d). The major controls on this nivation process are climate and topography, but rock structure with well-developed joints can promote the parallel development of frost-riven scarps. This may well be the case in the Cross Fell area, where the cyclical sequence of sedimentary rocks means that the limestone and sandstones act as cliff formers, with the shales being more easily eroded and covered by talus. It is therefore very possible that they are lithologically controlled with little periglacial modification.

Interpretation

During the last glaciation, Cross Fell acted as an area of local ice accumulation that was surrounded by ice from Scotland and the Lake District (Dwerryhouse, 1902; Raistrick, 1931b; Beaumont, 1968; Vincent, 1969; Lunn, 1996). This local ice was not thought to be very important in these original reconstructions. A similar situation in the western Pennines, however, has shown that the local ice was not just a summit ice cap but a linear ice divide, which extended along the mountains to the south of the Vale of Eden where it joined an ice divide over the Lake District (Mitchell, 1991c, 1994).

The presence of ice flow off the summit area is confirmed by drumlins to the east of the summit area in the headwaters of the River Tees, which indicate a flow direction generally southeastwards off the summit into the Tees valley (WA. Mitchell, unpublished data). A local origin for this ice is confirmed by the erratic content in till exposures near Moor House [NY 758 328]. However, this mapping also indicates ice flow southwards from the ground around Tynehead [NY 754 360] and suggests that it was not an ice dome but a linear ice divide that extended from Cross Fell towards Burnhope Seat [NY 788 376]. This interpretation would also explain the large erratic blocks of the Bullman Hills that indicate ice flow northwards off Cross Fell (Lunn, 1996). It therefore appears that during this phase the upland plateau areas were covered by local ice and not available for periglacial modification, although there is an alternative explanation.

Recent papers on other areas of the British Isles, particularly north-west Scotland (Ballantyne, 1997, 1998; Ballantyne *et al.,* 1997, 1998) and the Lake District (Lamb and Ballantyne, 1998) have identified a series of periglacial trimlines. This is defined by an upper limit on slopes of features attributable to glacial action, with the summit areas ice free and characterized by frost-shattered regolith, such as blockfields. Periglacial trimlines allow the delimitation of areas that existed as nunataks above the surface of the last ice sheet and have been shown to occur between 800 and 870 m in the Lake District (Lamb and Ballantyne, 1998). This may well have been the case with the Cross Fell summits, although it also is possible that these plateau areas were buried under cold-based ice, which allowed the preservation of the periglacial forms (cf. Rea *et al.,* 1998). The height at which glacial features become apparent is therefore a reflection of a change to temperate, basal ice.

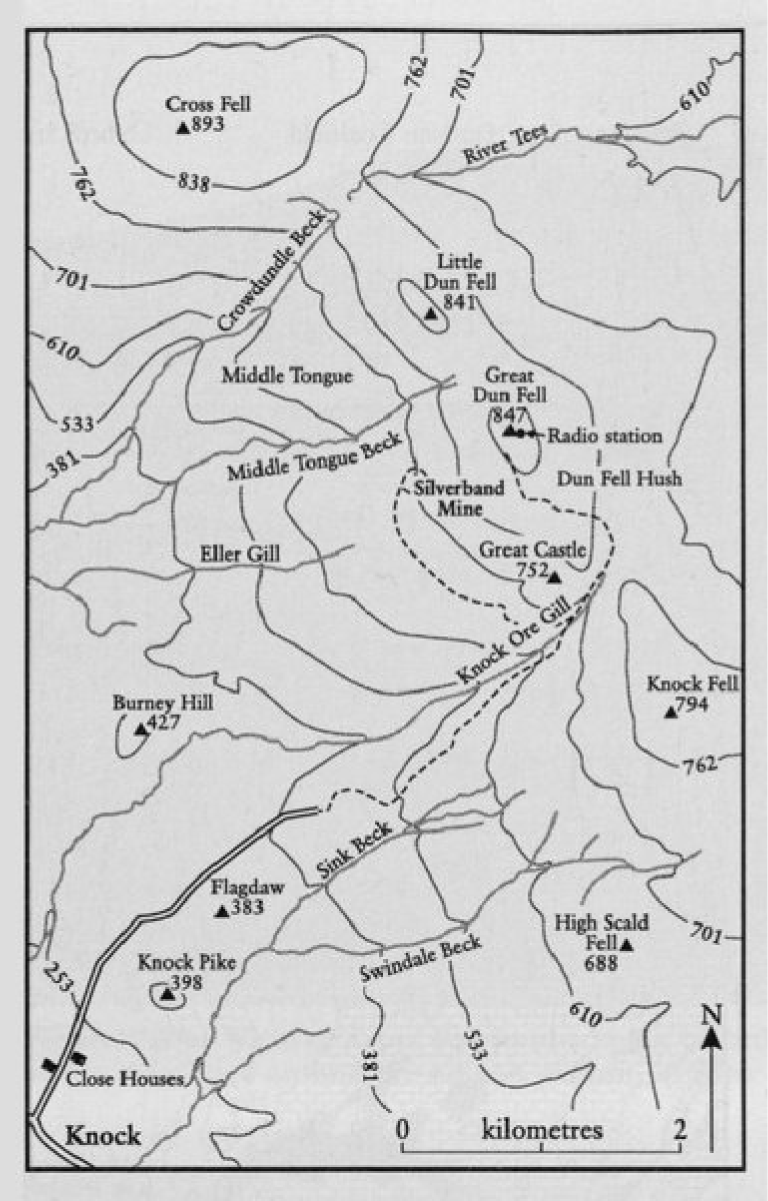
Earlier workers were convinced that Cross Fell had remained unglaciated during the last glaciation and had been used to explain the presence of a number of species of alpine plants in Upper Teesdale. The idea was taken up by Raistrick (1931b), who produced a map showing the distribution of nunataks, such as Cross Fell, based on evidence such as the lack of evidence of till above *c.* 650 m and the extensive and abundant periglacial evidence described previously. However, this idea is now discounted and the arctic–alpine plants probably migrated to these areas during the cold phase of the Late-glacial. An early description of a supposed interglacial peat on the eastern slopes of Cross Fell by Lewis (1904) has since been re-examined and discredited (Godwin and Clapham, 1951). Turner (1984) in fact demonstrates from pollen analysis of peats that woodland was present to the summit of Cross Fell in the mid-Holocene. A.G. Lunn (pers. comm., 1999) favours a complete Late Devensian ice cover, based on evidence of an ice-scoured pavement in the midst of blockfields just north of Cross Fell and a meltwater channel, presumed to be subglacial, that cuts through the main divide north of Green Fell [NY 666 365]. This would imply an ice surface higher than 680 m OD. Vincent (1969) also concluded that it is difficult to account for the northeasterly ice flow in West Allendale [NY 788 500]–[NY 788 560] without a strong Cross Fell ice influence.

During the Late-glacial period there was no ice in the Cross Fell area, although nearby small glaciers may have formed during the Loch Lomond Stadial, such as the glacier associated with the scarp at Cronkley Scar [NY 840 294] (Wilson and Clark, 1995). There also have been landforms on the western scarp, such as the southern side of Knock Ore gully, that have been interpreted both as moraines and landslide landforms. Pounder (1989) explained this landform as a protalus rampart associated with a snow bank, but it is more reasonable to explain it as one of a series of deep-seated rotational landslides that are common in all parts of the Pennines (Mitchell, 1991b, 1996). Despite the difficulties of interpretation, it is certain that this area had a severe periglacial climate, which allowed a whole range of periglacial modification by frost, slope and snow processes during the Late-glacial, particularly the Loch Lomond Stadial (cf. Boardman, 1985b, Ballantyne and Harris, 1994).

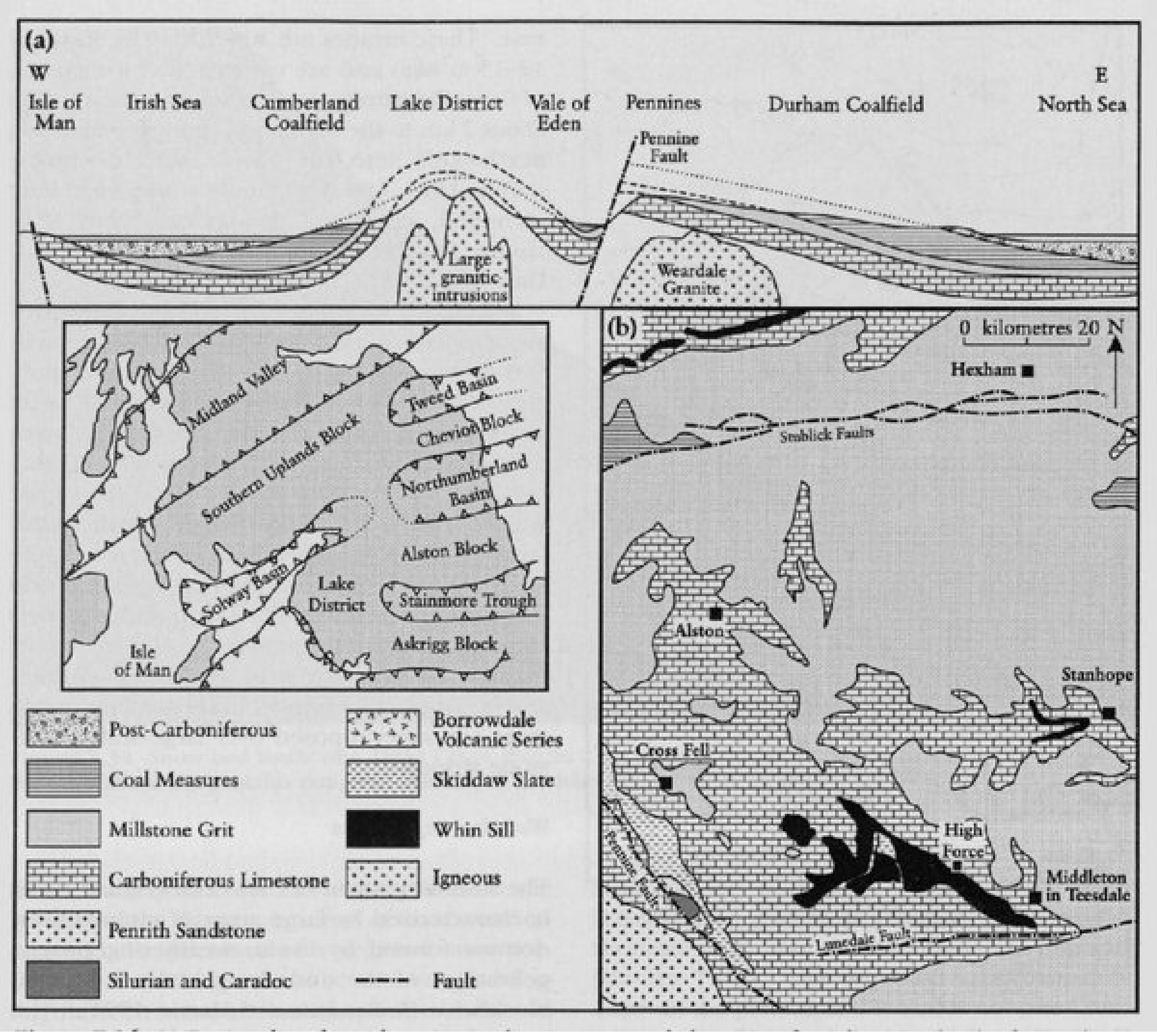
Conclusions

The significance of periglacial processes in shaping the environment of upland Britain is clearly demonstrated by the range of associated landforms found on the highest ground of the Pennines. The Cross Fell area is important because of the range of periglacial geomorphological landforms found within such a small area. It has been one of the most actively studied periglacial landscapes in northern England.

References

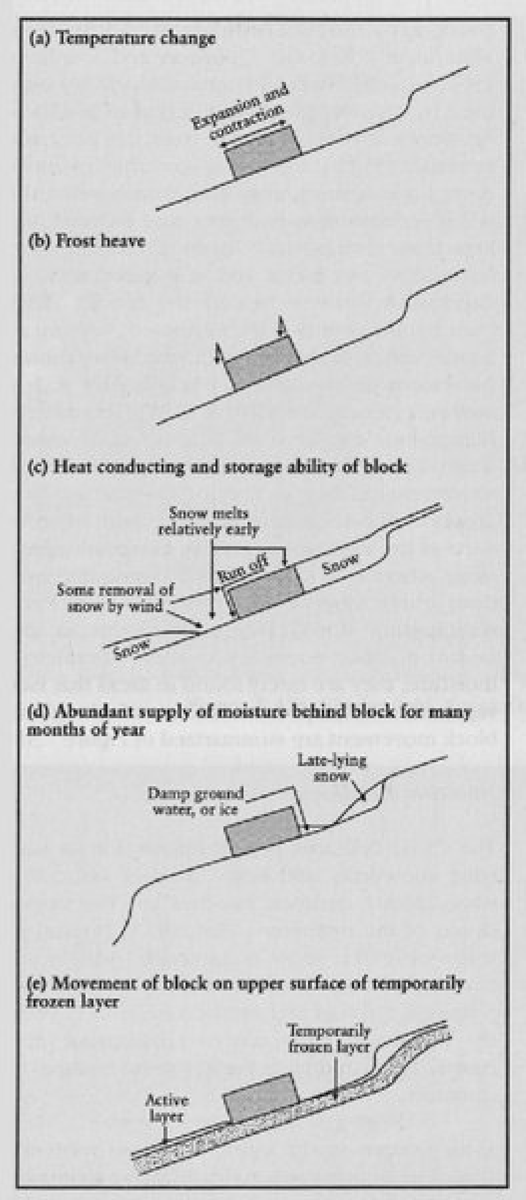


(Figure 7.35) General map of the Cross Fell area.



(Figure 7.36) (a) Regional geological section and main structural elements of northern England (after Taylor et al., 1971). (b) Geological map of the central north Pennines (after Johnson and Hickling, 1970).

(Figure 7.37)a. View of Cross Fell from summit of Little Dun Fell showing the general topography and talus slopes developed around the summit plateau. (Photo: W.A. Mitchell.) b. Blockfield on the summit plateau of Cross Fell. (Photo: W.A. Mitchell.) c. Talus slopes on the south-east flank of Cross Fell showing the lobate nature of the basal part of the talus, suggesting flow and deformation of the talus. View looking southwards towards the radio station on Great Dun Fell. (Photo: W.A. Mitchell.) d. 'Fossil' polygonal patterned ground on the summit area of Cross Fell looking southwards towards Great Dun Fell. (Photo: W.A. Mitchell.) e. Active, small-scale sorted circles, Great Dun Fell summit. (Photo: D. Huddart.) f. 'Fossil' large-scale blocky stone stripes, western slopes of Little Dun Fell. (Photo: D. Huddart.) g. Thufur field, Knock Ore Gill valley. (Photo: D. Huddart.) h. 'Fossil' altiplanation terrace, western slopes of Great Dun Fell. Note the vegetation contrast where late-lying snow banks still occur today. (Photo: D. Huddart.)



(Figure 7.38) Possible causes of ploughing block movement (after Tufnell, 1966).