Wasdale Screes

[NY 150 044]–[NY 170 060]

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Introduction

Wasdale Screes are a famous example of scree development (Andrews, 1961; Boardman, 1996). The screes are formed below a 180 m-high rock face below Illgill Head and extend for 2.6 km along the southern shore of Wastwater (Figure 7.39). They also are important for their rich montane flora, which includes several nationally rare species (Ratcliffe, 1960; Halliday, 1997).

Description

Wasdale Screes are formed by rockfall events from rock cliff faces on the glacially eroded, precipitous and oversteepened north face of Illgill Head. They are described as 'gully screes' because they are sourced largely from rock gullies in the cliffs. The resistant, acidic, Borrowdale Volcanic andesite rocks are weathered and transported to form overlapping, fan-shaped debris accumulations from the base of gullies to below the lake level. The gullies are the result of faulting, which has resulted in shatter belts and fault breccias through the Borrowdale Volcanics, making them less resistant to weathering. Hence erosion along these lines of weakness has given rise to the major supply routes for scree. The largest boulders, up to 2 m across, occur chiefly at the base of the scree fans and there is a general fining of the grain size upslope (Figure 7.40). The average slope angle for the scree fans is *c.* 35°. This is less than the natural angle of slope for materials of this size, which is between 39 and 42°. The lower angle probably reflects the current, relatively low, rockfall input.

Measurements of slope angles reveal three main slope facets (Andrews, 1961). A relatively steep upper slope of between 35–37° decreases to 31–34° in the lower part to form a concave profile characteristic of many scree slopes (Statham, 1976). This basal concavity is not fully developed but is truncated typically 5–15 m above the lakeshore by a relatively steep basal slope of 39°, and locally up to 41–46°, where large boulder gravels accumulate. Between the main active scree fans, older, inactive scree slopes are vegetated. Slope angles on these vegetated screes are lower, at about 27°, but they too steepen at the lakeshore to 35°, and locally to 42–43°. There are considerably more fine-grained particles present between the larger gravels, and these vegetated screes possess a poorly developed soil. The vegetation of these areas and the rocky slopes above consists of patchy *Festuca–Agrostis* grassland and heather moorland (with both *Calluna vulgaris* and *Erica cinerea*). Other species present include wood sage, foxglove and goldenrod (*Solidago virgaurea*) and there are scattered trees present close to the lake and on cliff ledges, including oak, ash, holly, hawthorn and yew (Figure 7.41). In places there are former rotational slump scars that are now vegetated. In (Figure 7.41) debris-flow lobes are visible where some of the finer-weathered fraction has become remobilized during periods of heavy rainfall.

Interpretation

Screes are formed from the cumulative effects of rockfall. This is a process of small-scale failures in rock entirely along planes of weakness. Rock particles released by failure then fall and roll down the scree slope under gravity in discrete events. The planes of weakness, particularly joints, are thought to be opened up by freeze–thaw processes, and in Norway when the rockfalls are plotted against time of year their greatest frequency is at times when there are continual changes of temperature about the freezing point, that is in April and October. However, Douglas (1980) found that in Antrim over 60% of all rockfall events were independent of freezing conditions. Events over 0.21 kg in size occurred seasonally, as a result of freeze–thaw, but events under 0.21 kg were observed throughout the year. Furthermore, Eichler (1981), in Ellesmere Island in the Canadian Arctic, measured rock surface temperatures as high as 39.7°C and these high temperatures, plus observations of preferential weathering on south-facing slopes, suggested that insolation weathering – and not frost shattering – was the main agent of rock breakdown.

In the case of the Wasdale screes it is unlikely that insolation weathering plays a major role in rock breakdown; water freezing in cracks in the winter is the more likely preparer of rock for subsequent rockfall. Boardman (1996), however, suggests a more radical proposal that these screes have little to do with frost action and are the result of the removal of loading by ice during deglaciation. This rapid unloading would allow expansion of the rocks, the formation of joints as pressure is released and inevitably rockfall. However, it is difficult to assess such an idea in the absence of monitoring of both rockfalls and climate, especially as the screes must have been much more active in the past. The importance of rockwall instability in accelerating rockwall collapse during and immediately after deglaciation has been demonstrated by Andre (1985, 1986), however, who found that the most rapid rates of rockwall retreat in Spitsbergen resulted from pressure release following glacier surges.

Screes generally are accumulation slopes, which means that the amount of sediment increases through time (although it could be argued that there will be some erosion of basal scree by lakeshore erosion, particularly during storms) and that therefore the screes should show characteristics of transit slopes, which would be a straight scree slope at the angle of repose for the debris falling. If such a slope is undercut then mass avalanching can occur, where all the particles on the scree move as a unit. The characteristics described above for the Wasdale Screes, however, suggest that although this may occur occasionally, the screes could better be described as low-rockfall input, and no, or very little output, screes. This type of scree does not possess characteristics compatible with the angle of repose model, but it does have a basal concavity, a straight slope under the angle of repose and a coarse downslope sorting. These characteristics describe the Wasdale Screes, where there is a poorly developed basal concavity, but with some undercutting.

The angle of slope is 4–11° less than the angle of repose and must be stable with respect to mass avalanching. The reason for this profile shape is because the screes are formed by one-at-a-time gravel inputs by rockfall. When these gravels hit the scree surface they have some input energy (their mass times the distance through which they have fallen). Some of this energy is transferred into downslope movement. In contrast, the angle of repose is related to the coming to rest of a sliding mass of particles, which has a velocity much less than the down-slope velocity of a falling particle. Therefore the particle moves itself and others by impact downslope and keeps the slope angle lower than the repose slope. The concavity at the base of the slope is caused by faster particles running out as a tail on to the accumulation surface, although this cannot be easily seen at Wasdale because of the lake and some undercutting.

The coarse downslope sorting results from the sieve-like nature of the scree surface, which is irregular. Starting with a random or uniform size distribution on a surface, the small particles are trapped more easily by interlocking and do not move as far as the larger particles, which travel to the base of the slope by overriding the surface irregularities. Ballantyne (1985) found that fall sorting is dependent not only on the particles being trapped amongst interstices but also reflects the greater success of larger particles in overcoming frictional losses as they travel downslope. As accumulation continues, as the area of feeding rock face diminishes and the range of fall velocities becomes less, the scree slope becomes nearer the repose angle because there is less input energy to move debris downslope. The Wasdale Screes are still far from this situation and there remains a large, vertical, free face to supply further rockfall. However, the result of weathering and rockfall is a parallel stripping of rock along the rock face, which can be seen from the crags below the summit of Illgill Head.

Colder climates than today – and particularly the Loch Lomond Stadial climate and/or the Little Ice Age climate – would be a much more favourable climatic regime to provide the greater temperature range and the higher frequency of temperature oscillations that are required to cause frost shattering of the bedrock. Andrews (1961) suggested that the Wasdale Screes last received a significant debris input in the Little Ice Age of the seventeenth and eighteenth centuries. Although this possibly is correct, he did not provide any evidence to support this suggestion. However, the fact that many of the slopes in Wasdale have the characteristics of fossil, vegetated screes and even the classic, more active screes themselves can be seen to be showing the initial stages of colonization by vegetation, suggests that these screes are not as active in today's climatic regime as they have been in the past. The landforms are probably almost relict landforms that are not in equilibrium with today's processes, or as Andrews (1961) described them they are in 'a retarded state of development'.

Ballantyne and Kirkbride (1987a) suggest too that the Loch Lomond Stadial climate was particularly conducive to rockfall by frost wedging. Conditions for freeze–thaw probably were favoured by a combination of strong insolation during the spring, summer and autumn months, and much cooler air temperatures than at present. Hence, although there is the possibility that the relict Late-glacial screes might be interpreted as paraglacial landforms resulting from the rapid break-up of glacially oversteepend rock walls immediately after deglaciation, rather than periglacial landforms produced by enhanced frost action operating on the free faces during the Loch Lomond Stadial, this seems unlikely as the main cause of the screes. The relative immaturity of most Flandrian screes below steep rock walls that were occupied by glacier ice during the Loch Lomond Stadial suggests that paraglacial effects generally have been of secondary importance, and that the primary impetus for the development of screes such as the Wasdale examples during the Late-glacial was climatic (Ballantyne and Harris, 1994).

A scree surface might be thought of as an inhospitable place for plants to colonize, with free drainage, little humus and reworking of generally unstable, coarse debris slopes. Screes, however, do become slowly vegetated, as can be seen from the Wasdale examples, and the nearly ubiquitous presence of lichens on the gravels implies a low current geomorphological activity and the first stage in the colonization process. Soil development and colonization by vegeta tion is more rapid on finer particle sizes, but where this fine-grained sediment originates is not known. It is likely to be a combination of wind transport and the in-situ weathering of the coarser scree. As boulder gravel becomes embedded in the irregular scree surface there are quiet areas created in front of them. Bryophyte (*Rhacomitrium*) cushions colonize here, these hold water and then the parsley fern (*Cryptogramma crispa*) (Figure 7.42) comes in to provide water-holding humus (Leach, 1930). This is the most famous scree pioneer in the Lake District (Pearsall and Pennington, 1973). Other plants can then colonize from the surrounding hillsides, particularly the heath plants such as lady's bedstraw (*Galium verum*) and the grasses such as *Festuca, Agrostis* and *Deschampsia.* The vegetation colonizes downwards in vertical strips from the boulders and eventually becomes dominated by *Calluna* and has a typical heath composition. Similarly at the base of crags away from the gullies there are locations where debris accumulates at a very slow rate and therefore vegetation can gain a hold and spread down the scree as strips. The colonized areas of these screes usually occupy depressions, because there is a piling up of debris on either side of each colonized area and hence fan-shaped gravel accumulations hold back the growth of vegetation. Typical of all active screes is the destruction of vegetation by reactivation of rockfall and by burial and the complete colonization process takes a long time. The screes also are colonized from the marginal areas, which have become stabilized. The stable scree becomes colonized by plants such as bracken (*Pteridium aquilinum*), foxglove (*Digitalis purpurea*) and bilberry (*Vaccinium uglinosum*). Eventually the screes become completely 'fossilized', as can be seen in the middle right section of (Figure 7.39).

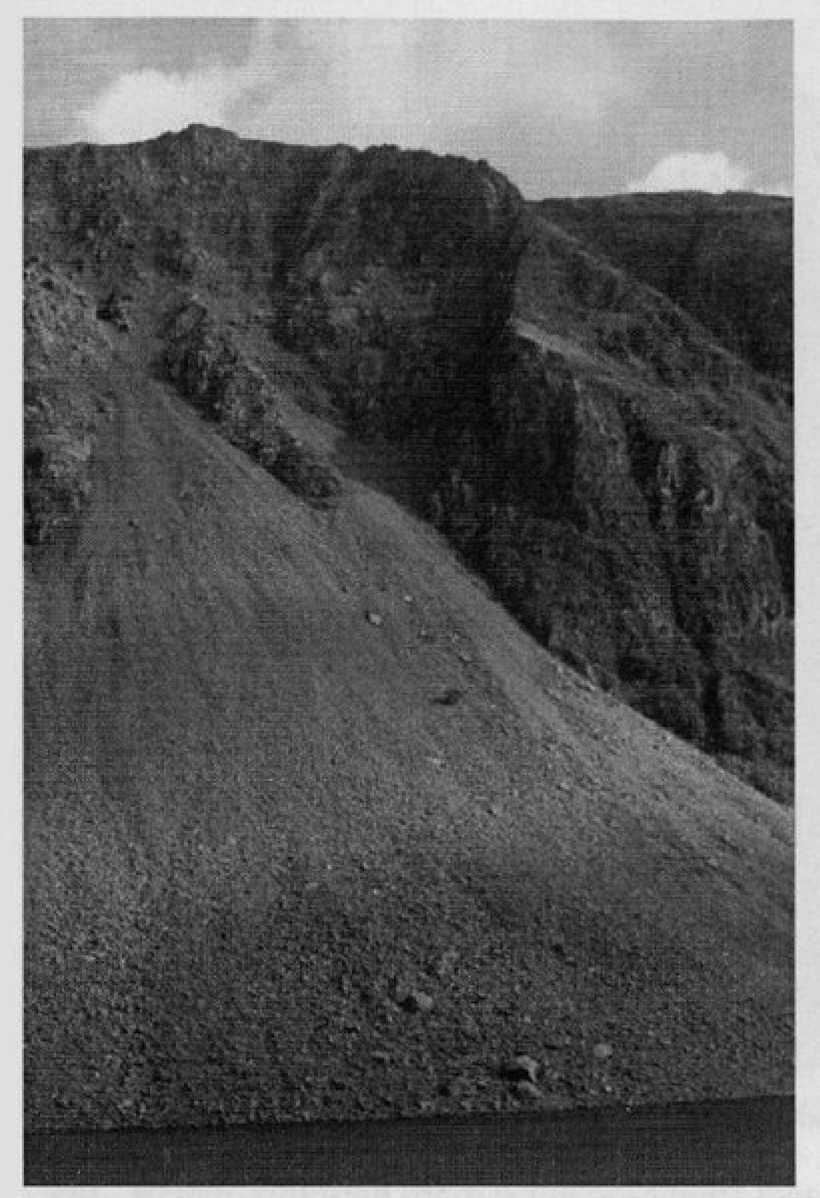
The steep and crumbling gullies, rich in calcite from the weathered iron-rich volcanic rock, provide habitats for the extremely rare shrubby cinquefoil (*Potentilla fruticosa*) on moist ledges and rock crevices. Other nationally important mountain plants include roseroot (*Sedum rosea*), mountain sorrel (*Oxyria digyna*), lesser meadow rue (*Thalictrum minus*), northern bedstraw (*Galium boreale*), stone bramble (*Rubus saxitilus*), *Alchemilla wichurae,* mossy saxifrage (*Saxifraga hypnoides*), eyebright (*Euphrasia rivularis*) and green spleenwort (*Asplenium viride*) (Ratcliffe, 1960; Pearsall and Pennington, 1973; Halliday; 1997). Several species reach their lowest elevation in Wasdale, where for example alpine lady's mantle (*Alchemilla alpina*), yellow mountain saxifrage (*Saxifraga aizoides*), alpine clubmoss (*Diphasiastrum alpinum*) and parsley fern (*Cryptogramma crispa*) reach the shore of the lake, and purple saxifrage (*Saxifraga oppositifolia*) descends to below 300 m on the slopes above.

Conclusions

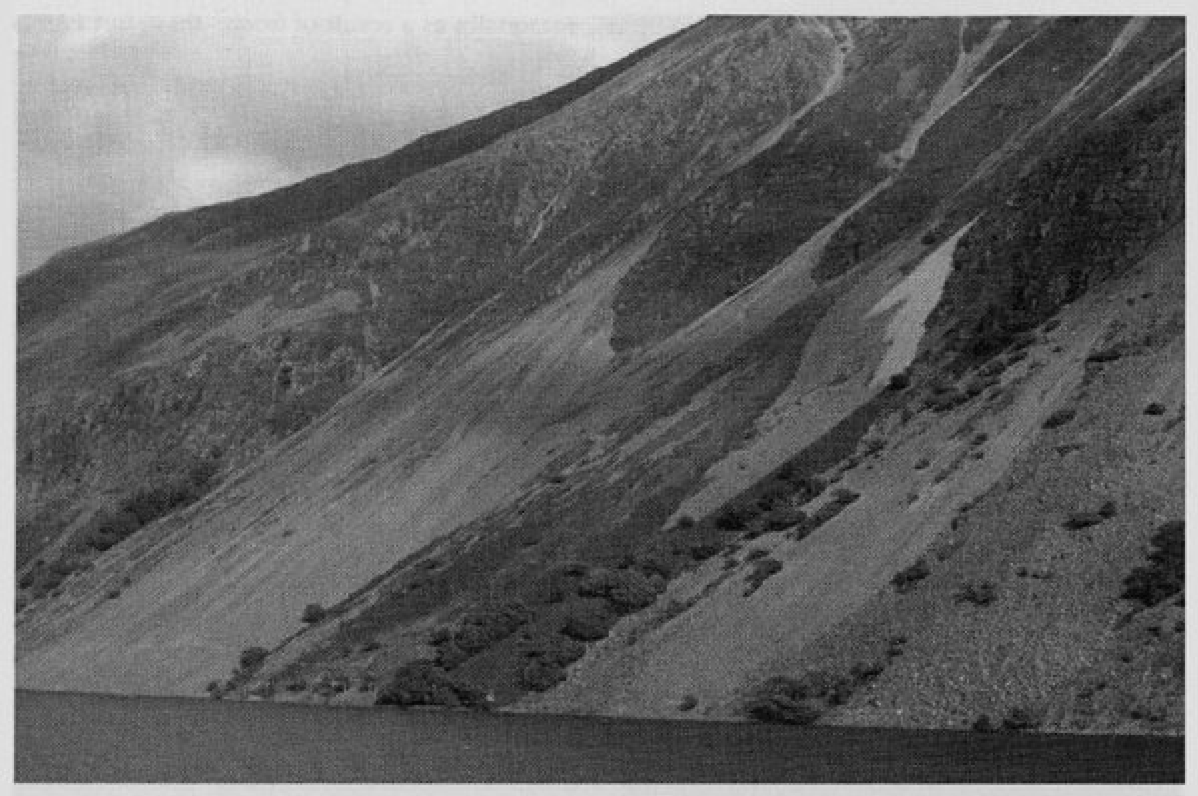
Wasdale Screes show all the classic morphological and sedimentological characteristics of low-input and little-output screes, which are fed by rockfall, largely from weathering in gullies on the free face above the screes. They are largely out of equilibrium with the present climatic conditions and formed mainly in the Loch Lomond Stadial and possibly through reactivation in the Little Ice Age when the climate of this part of northern England was considerably colder than today and there would have been many temperature oscillations around 0°C. This caused frost shattering of the bedrock. The screes show various stages of vegetation colonization and there are some nationally rare, montane species.

References

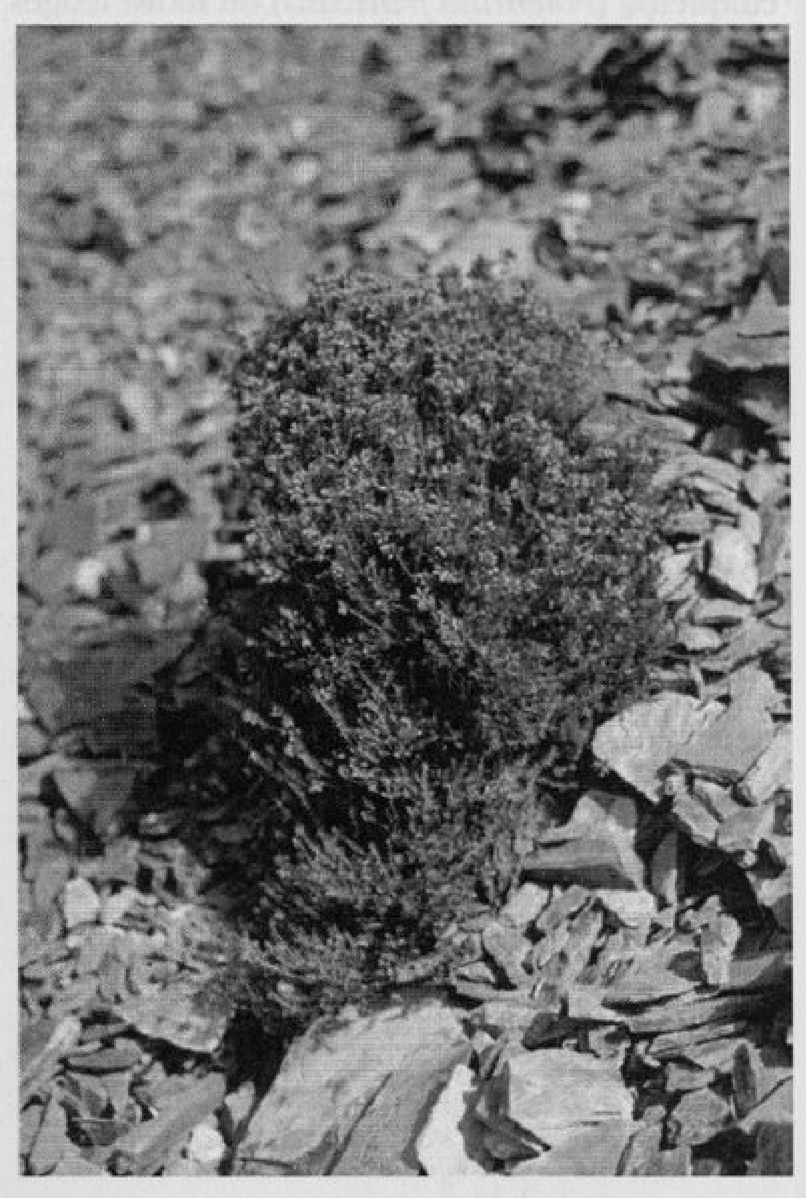
(Figure 7.39) Wasdale Screes and Illgill Head from the north side of Wastwater. Note the gullies that feed debris to the screes, and the partially vegetated screes. (Photo: D. Huddart.)



(Figure 7.40) Coarse down-scree sorting on Wasdale Screes and gullies. (Photo: D. Huddart.)



(Figure 7.41) Debris-flow lobes on Wasdale Screes and vegetational colonization of the screes. (Photo: D. Huddart.)



(Figure 7.42) The pioneer species on Wasdale Screes, the parsley fern (Cryptogramma crispa). (Photo: D. Huddart.)