The Cobbler (Beinn Artair), Argyll and Bute

[NN 260 058]

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Introduction

The Cobbler is a distinctive triple peak in the Arrochar Alps, in the South-west Highlands of Scotland. It is the most striking case in Britain of a mountain shaped by rock slope failure. Although limited failure has been recorded here its full extent and topographical impact has only recently been recognized (Jarman, 2004b). The main slope failure extends over the whole upper south flank of the mountain, and its source arête includes the Summit 'tor' and the spectacular horn of the South Peak. The North Peak is deeply fissured and overhanging, with indications of previous failure below. The well-known profile of three peaks closely grouped around a small corrie is therefore attributable to pervasive paraglacial rock slope failure (Figure 2.46).

The Cobbler is at the heart of the largest rock slope failure cluster in the Scottish Highlands (Figure 2.13) and (Figure 2.15). Several different modes of failure are evident on The Cobbler, ranging from in-situ fracturing through coherent translational slides with varying degrees of arrestment to a fully disintegrated rockslide. These kinds of rock slope failure are widely distributed in the 'old hard rock' uplands of Britain, and those on The Cobbler are particularly characteristic of the massive schists of the Arrochar Alps–Cowal area (Clough, 1897).

Description

There are four distinct zones of rock slope failure on The Cobbler, affecting 0.84 km^2 or 10% of the area of the mountain (22% of the area above 500 m OD), a remarkable intensity (Figure 2.47).

The main rock slope failure on the south face of The Cobbler is one of the 50 largest in the Scottish Highlands at 0.62 km^2, and is a translational slide complex in various stages of disintegration and arrestment. The 1901 geological map marks 'landslip' across the slope, but the current inset map only indicates two small slips. Holmes (1984) identified only the west part (0.20 km^2) from aerial photographs. The slide has four components or 'panels' over its 1200 m width, which emerge onto a broad midslope bench or 'alp' at 450–600 m OD (Figure 2.48) and (Figure 2.49).

Panel 1 (westmost) has the appearance of a chaotic pile of blocks several metres across. Its flank rampart is 5–15 m high, while its exceptionally steep (40°) toe rampart — which barely reaches the 'alp' — is at least 30 m high, suggesting the order of depth of the failed debris. However, the extent of disintegration is deceptive: the upper half is semi-intact, with only local fissuring, blocky dislocation, and short antiscarps in a grassy sheepwalk. The steeper lower half is extensively disrupted, but the aerial photograph shows organization into quasi-antiscarps, which are up to 6 m high and 150 m long. The anti-scarps are much broken up, and appear to have emerged by forward rotation of contour-parallel rock slices on a convex slope. This indicates a considerable degree of coherence, given that the failed mass has spread fanwise from an 8 m-wide and 8 m-deep tension trench along the ridge west of the summit.

Panel 2 is separated from Panel 1 by an open gully on the general alignment of the NNE–SSW faults common in this area. The failed mass has descended appreciably further, despite appearing less disrupted, apart from some very large masses that protrude irregularly. One fractured slice on the west side is 25 m long and 8 m deep, and projects by 6–10 m. To the east, these protrusions resemble intact bedrock, but occasional deep fissures and basal springs confirm that most if not all are failed. Unlike Panel 1, a high but irregular headscarp is present, reaching 28 m west of the summit, and 12 m at the arête south-east of the summit above a tract of impenetrably jumbled megablocks, while the South Peak presents a 60 m rockface to the least distressed part of this panel. A stack of four triangular wedges steps down the upper junction between Panels 1 and 2, so that the upper part of the dry gully acts as a flank scarp to Panel 2, reaching 14 m in height. Panel 2 has also travelled farther out onto the 'alp' than Panel 1, with slopes around 30° and a toe only 6 m high, suggesting greater fragmentation and fluidity. A series of powerful springs along the toes of Panels 1 and 2 confirms the pervasiveness and interconnectivity of deep fracturing.

Panel 3 by contrast is grassy and fully consolidated, with a probably thinner failed mass only betrayed by decimetre-scale furrow swarms and a small array of < 1 m antiscarps. It has a weak headscarp 8–10 m high rather below the summit ridge, and a presumed degraded toe rampart 8 m high. The debris of Panel 2 appears to have encroached onto it, although there is some continuity in the pattern of small antiscarps.

Panel 4 (eastmost) is a distinct cavity between contour-orthogonal flank scarps up to 12 m high. In effect a section of Panel 3 has slipped out, leaving a higher but still degraded 15 m head-scarp, and with a subdued debris-tongue draping over the edge of the 'alp'.

The boundaries of the main rock slope failure are clearly defined, by comparison with many that have diffuse margins. The head and east flank scarps are almost continuous, and there is no spray fan below the toe ramparts. There is no west flank scarp, unusually, since the outer end of the summit ridge has collapsed laterally. It is impossible to give an accurate volume for this rock slope failure, in view of its short travel and unknown failure surface, but applying conservative estimates for average depths of 20/15/5/10 m to the four panels yields an order of magnitude of 8–10 x $10^6 m^3$.

Farther along the south-east ridge, the An t-Sron rock slope failure (Figure 2.47) is a rather subdued 'armchair' translational slide, similar to Panels 3–4 (Figure 2.48) and (Figure 2.49). It has distinct approximately 6 m-high source and flank scarps and minor holes and ruckles, with one open trench above indicating incipience.

In the corrie floor the 1901 geological map marks another 'landslip', unrecorded on the current map or by Holmes (1984). Two modest degraded blocky debris-lobes have probably descended as rockslides from the North and/or South Peaks. The North Peak itself is deeply fractured, with several climbing routes penetrating its caves. It might be classed as a limiting case of rock slope failure in *situ.*

On the north-east ridge a quite different type of rock slope failure is extant (Jarman, 2004b). Its source is a wedge scar biting into the crest just behind the North Peak, and the debris has run out almost to the slope foot as a sub-cataclasmic failure (see 'Introduction', this chapter). Debris from similar earlier slides may core the bouldery morainic hummocks in Coire a' Bhalachain.

The geology is typical blocky schistose arenite, semipelite and pelite of the Beinn Bheula Schist Formation within the Dalradian Supergroup (late Precambrian–early Cambrian). This unit is laterally equivalent to the Ben Ledi Grit Formation but has a greater proportion of petite and semipelite, and was metamorphosed under upper greenschist facies conditions. The regional bedding and foliation vary from sub-horizontal to moderately north-west dipping (J. Mendum, British Geological Survey, pers. comm.).

Interpretation

The prevalent mode of rock slope failure in the Dalradian schists of the Southern Highlands is the short-travel arrested translational slide (Jarman, 2003a). On The Cobbler, the main and An t-Sron failures fall within this category. A geotechnical analysis of The Cobbler is not available, but Watters (1972) and Holmes (1984) back-analysed 14 rock slope failures in the Beinn Bheula Schist Formation in this area. They found peak friction angles ranging from 34°–50° and residual friction angles around 24°, increased by i values typically of 1°–5°, depending on coarseness of asperities and orientation of microfolds. This renders somewhat conjectural attempts to interpret the failure mechanics of large complex rock slope failures such as these, where actual sliding surfaces are not revealed, are of unknown depth and state of weathering, and may not even follow preexisting joint planes.

Translational sliding in the metamorphic lithologies, which predominate in the Highlands, is facilitated by the multiplicity of discontinuities, both in joint-sets and especially in the foliation or schistosity surface (Figure 2.4). On The Cobbler, the schistosity surface generally dips at 25°–40° to the north-west. Since the failures are orientated from SSE through to

WSW, this surface can have only contributed marginally to sliding, notably in the spreading of the north-west end. The joint-sets in this vicinity identified by Holmes (1984) and Watters (1972) are all above 50° and too steep for controlled sliding. They generally provide detachment planes, as seen here in the head and east flank scarps. Sliding may therefore have occurred along a staircase of joints, as modelled by Watters (1972) at Beinn an Lochain West [NN 215 076], or possibly by inventing a suitable plane where none pre-existed, as a series of small shear facets (Jarman, 2003c).

Holmes (1984) and Watters (1972) concluded that the translational slides in this area probably required a small additional force augmenting gravity in order to trigger shearing failure. Watters identified a toppling component (de Freitas and Watters, 1973), and both invoked elevated cleft water pressures; chemical weathering of abundant chlorite and muscovite may also have played a role in lubricating slide surfaces. Separation of large rock units by low-angle block gliding is common in this area, notably at Ben Donich [NN 22 05], Carnach Mor [NS 13 99], Hell's Glen [NN 18 05], and The Steeple [NN 20 00], and may account for the tensional spreading seen at The Cobbler (Panels 1–2, (Figure 2.48) and (Figure 2.49). However, the source area is almost certainly above the Loch Lomond Stadial limit which Holmes (1984) identified as the likely locale of abundant meltwater to pressurise clefts, the Arrochar peaks having formed nunataks at this stage (cf. 'Introduction', this chapter).

The north-east rock slope failure is sub-cataclasmic in having fully disintegrated but not travelled bodily to the slope foot or beyond. It has no contained toe, and an extensive 'spray fan', indicating relatively rapid travel. Such failures are rare in the Highlands. The sub-cataclasmic rock slope failure on Beinn an Lochain North (Watters, 1972; (Figure 2.9)) approaches it in character, but is fully contained by a stickier matrix; it was interpreted as a rock glacier (Ballantyne and Harris, 1994) but is now seen as a conventional rockslide. The extensive near-vertical fissuring around North Peak might suggest that this north-east failure was simply a very large rockfall, but the wedge-shaped cavity and a retained cubic mass that has slipped 2–3 m from the rim could indicate initial release as a high-angle slide of more alpine character, as at Beinn Alligin.

A possible seismic trigger for rock slope failure has often been invoked but has yet to be established (see 'Introduction', this chapter). Against this, The Cobbler is 10 km from the nearest major basement fault and its rock slope failure components are unlikely to be of the same age, but it does lie on a current zone of seismic attenuation (Carlisle to Kyle of Lochalsh). The coherence and containment of its translational slides are suggestive of progressive creep. However, an unusually large fissure 75 m long and 10 m deep just beyond the toe of Panel 1 [NN 255 056] has affinities with tear or impact fractures beside large failures in Scandinavia (cf. Dawson *et al.,* 1986; Jarman, 2002).

No dates are available for The Cobbler rock slope failures. It is most probable that the translational failures here developed soon after final deglaciation, but since they extend to the summit, they owe their inception to the much greater stresses induced by the Late Devensian glaciation. In the main rock slope failure, Panels 3 and 4 are subdued, with degraded source and toe areas, and may be earlier than Panels 1 and 2; they may even be the rump of similar events since removed by glaciers, and here resemble the two-tier rock slope failure at Beinn an Lochain West (Watters, 1972; cf. Beinn Each (Glen Ample)). Erratic boulders are strewn over the upper parts of Panels 3 and 4 and across much of the upper south-east ridge (Figure 2.47) and may be ice transported following earlier rock slope failure episodes, as they occur up to 600 m OD, rather above the toe of

Panels 1 and 2 (Figure 2.49). Boulder trains from probable failure sources are surprisingly uncommon: Carn Ghluasaid [NH 140 119] offers an unusually clear case.

Panels 1 and 2 appear considerably 'fresher', and to encroach onto Panel 3, but no conclusions can be drawn as to their relative ages. Although Panel 2 has descended further than Panel 1 (Figure 2.50), they may have originated at the same time, with the eastern component able to travel farther owing to the slant of the basal 'alp' and suitably orientated release planes. The arrestment of Panel 1 at a high angle approaching 40° is a common feature of Scottish rock slope failure. Why such failed masses do not disintegrate cataclasmically on such steep and unconfined slopes has yet to be addressed, but possible explanations include dewatering, locking-up of large component slices, and lack of available relief by comparison with alpine ranges.

Landscape evolution

The main rock slope failure source area along the summit ridge has resulted in one of the most striking mountain landscapes in Britain, and has only recently been recognized as the product of paraglacial failure intersecting a corrie headwall (Jarman, 2004b). Prior to failure, the corrie rim would have cut into a level or gently south-west dipping smooth ridge, as it still does between the Summit and North Peak. This can be demonstrated if the flatter elements of the upper rock slope failure are re-instated to their source scarps. The exceptional rock tower of the South Peak may have been exaggerated by a small wedge slide yielding a blocky debris-pile a short way to the south-east. The North Peak may also have been reduced to a fractured stump by failure of a former north-east arm to the corrie during earlier interglacials: the prominent schistosity surfaces dip back into the corrie at angles (20°– 30°) highly conducive to sliding and toppling.

The shaping of mountain summits by rock slope failure into arêtes and horns is also seen in this area at Ben Lomond and Beinn an Lochain (Figure 2.9). It is attributable to failure planes daylighting behind the crest, leaving a sharp edge that has not suffered rounding by glacial over-riding or periglacial weathering, as have most summit ridges in the schists.

If the west summit ridge of The Cobbler is reassembled to pre-rock slope failure condition, a small fragment (approximately 0.05 km^2) of preglacial upland surface can be identified. Behind the main headscarp and ridge-splitting trench, a small (< 2 m) dogleg depression and fissures indicate incipient extension of the rock slope failure by up to 25 m into the residual pre-glacial surface. The remarkable summit 'tor' may be a corestone left from stripping of a deep-weathering regolith (cf. Hall, 1991). The next peak to the east, Beinn Narnain, has a more extensive plateau surface of approximately 0.5 km^2 (Figure 2.47) and (Figure 2.50), and likewise has lost a quadrant of it to failure, leaving a projecting fractured arête. Other surrounding peaks show similar traces of an undulating pre-glacial upland surface, and encroaching rock slope failures.

In the core mountain area of 87 km^2 around The Cobbler, 7% of the total land surface is affected by rock slope failure, one of the highest densities so far identified in Scotland (Table 2.2); the figure could in fact be higher with many small failures. This rises to 10% for The Cobbler itself, to its bounding waters. This concentration lies within the largest cluster of rock slope failures in Scotland, with over 100 significant (> 0.02 km^2) cases in 500 km^2 west of Loch Lomond. No reasons were advanced for the existence of this cluster by Holmes (1984), nor following its publication by Ballantyne (1986a). Explanations related to Loch Lomond Stadial limits or high-magnitude seismic shocks are inadequate, although suitably inclined foliation and bedding, and the style of metamorphic grade, increase the incidence of rock slope failure (see 'Introduction', this chapter).

The tentative association between rock slope failure incidence and glacial breaches of possibly recent origin or active enlargement can be investigated here (Jarman, 2003a), if less straightforwardly than in the Kintail cluster (see Sgurr na Ciste Duibhe). The Arrochar Alps and surrounding hills are intensely dissected to such a degree that most are isolated, and few high-level linking ridges survive (Haynes, 1977a). This reflects their location at the junction of the catchments of the Clyde estuary, Loch Fyne, and the River Forth prior to its beheading by the cutting of Loch Lomond (Linton and Moisley, 1960) (Figure 2.13). These pre-glacial radiating valley systems have been over-run by ice centred at various times to the west, east, and particularly north of the triple watersheds, although probably not from as far as the Rannoch Moor ice centre, as suggested by Linton (1957) and Boulton *et al.* (1991). As a result, almost all of the peaks in this area are separated by glacially breached cols, some relatively narrow or deep.

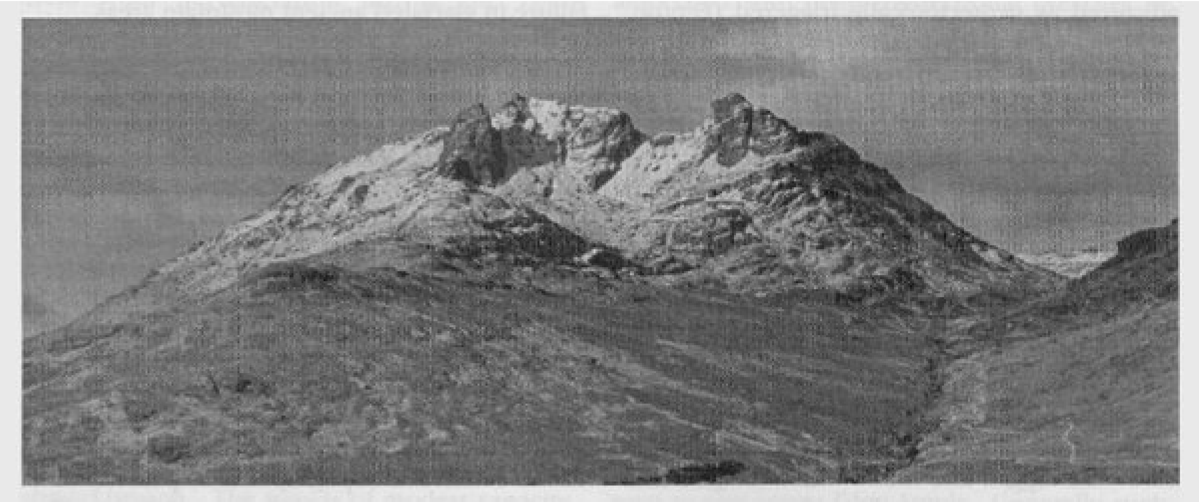
The Cobbler is isolated by high-level breaches at 630 m OD and by the deep trough of Glen Croe, which descends from the Rest-and-be-thankful Pass (260 m OD) to sea level at Loch Long (Figure 2.15) and (Figure 2.47). Linton and Moisley (1960) show Glen Croe as a probable breach of the main pre-glacial Clyde–Forth watershed; it has certainly been incised in response to over-deepening of the Loch Long fjord. However, while the sub-cataclasmic northeast rock slope failure is directly above the breach into Coire a' Bhalachain, the main and An t-Sron failures are separated from the Glen Croe trough by an 'alp'. If recent breaching through the Rest-and-be-thankful Pass from the north has created high, local, slope stresses, then the rock slope failure incidence might suggest this has been more by widening at upper levels than by trough deepening. A similar incidence at higher levels is found on Ben Donich and The Brack opposite (Figure 2.47); this is not always the case, as rock slope failure is concentrated at lower levels along Loch Long and in Glen Kinglas, and extends from crest to foot of the deep Loch Sloy breach (Figure 2.15).

Conclusions

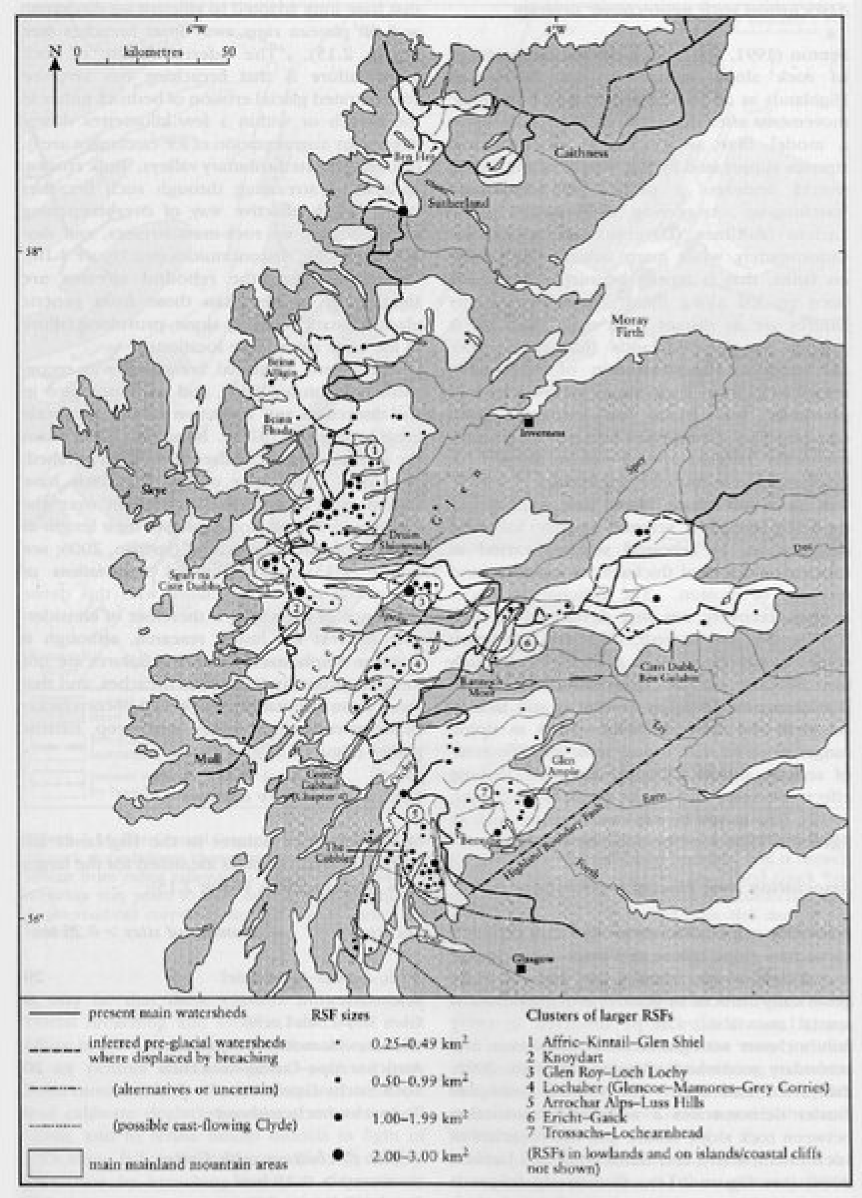
The Cobbler clearly demonstrates the effects of large-scale rock slope failure in creating mountain landforms such as arêtes and horns. The contribution of paraglacial slope failure to bulk erosion, valley widening, dissection of mountain massifs, and progressive elimination of ridges and summit areas has been given little consideration, but in susceptible areas its cumulative impact over the Quaternary Period is likely to be very considerable. The Cobbler and the surrounding Arrochar Alps and Cowal hills provide an important opportunity to understand this process, and to seek to quantify and date it. Containing the densest large cluster of rock slope failures in Scotland, they provide an exceptional locus for research into its causes and its possible significance as an indicator of shifting ice centres and dispersal patterns. Relicts of the pre-glacial land surface on The Cobbler and its neighbours provide scope for landscape reconstruction, in one of the upland areas of Britain most intensely dissected by glacial breaching.

The Cobbler itself has a variety of types of rock slope failure representative of the Dalradian rocks of the South-west Highlands. As one of the best-known and most idiosyncratically shaped mountains in Britain, in a conspicuous and accessible location in the Loch Lomond and The Trossachs National Park, The Cobbler is also well suited for research into geomorphological education, for geotourism, and for widening public awareness of landscape origins.

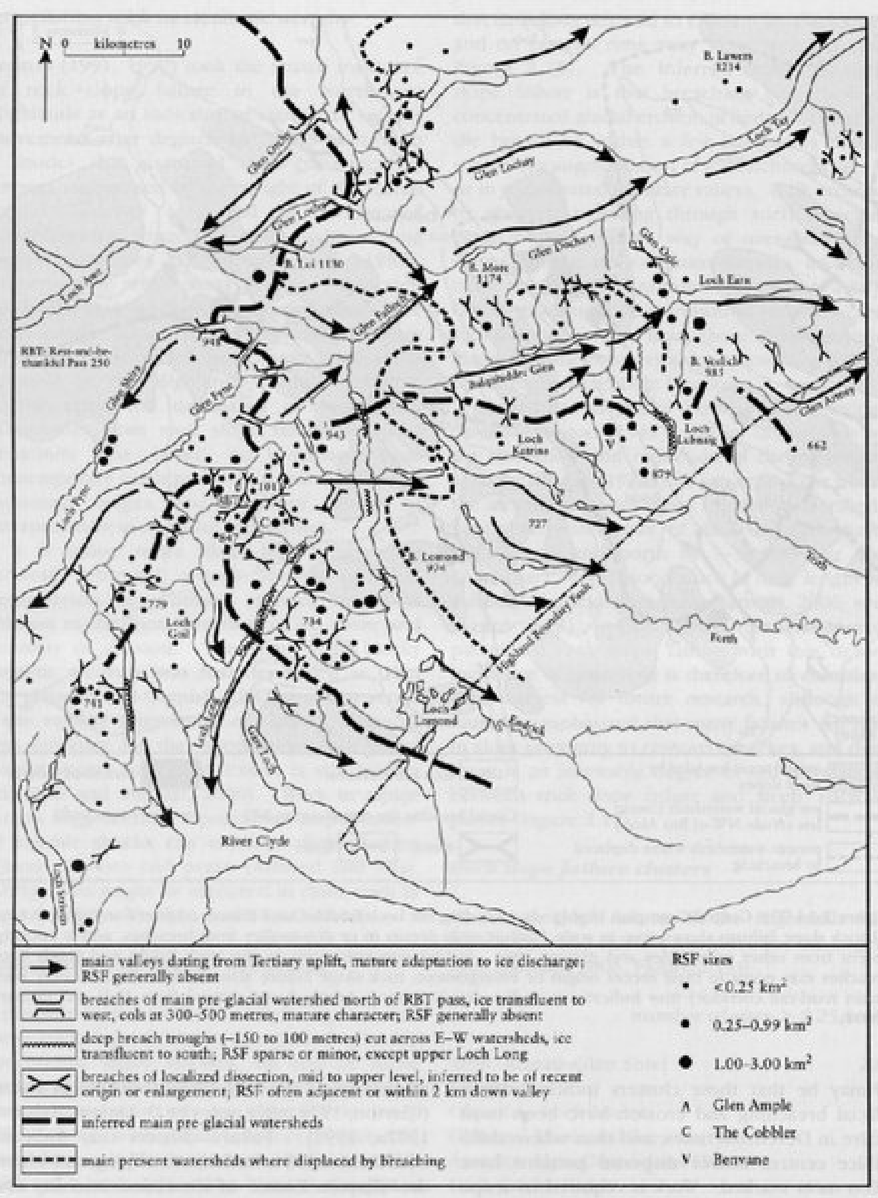
References



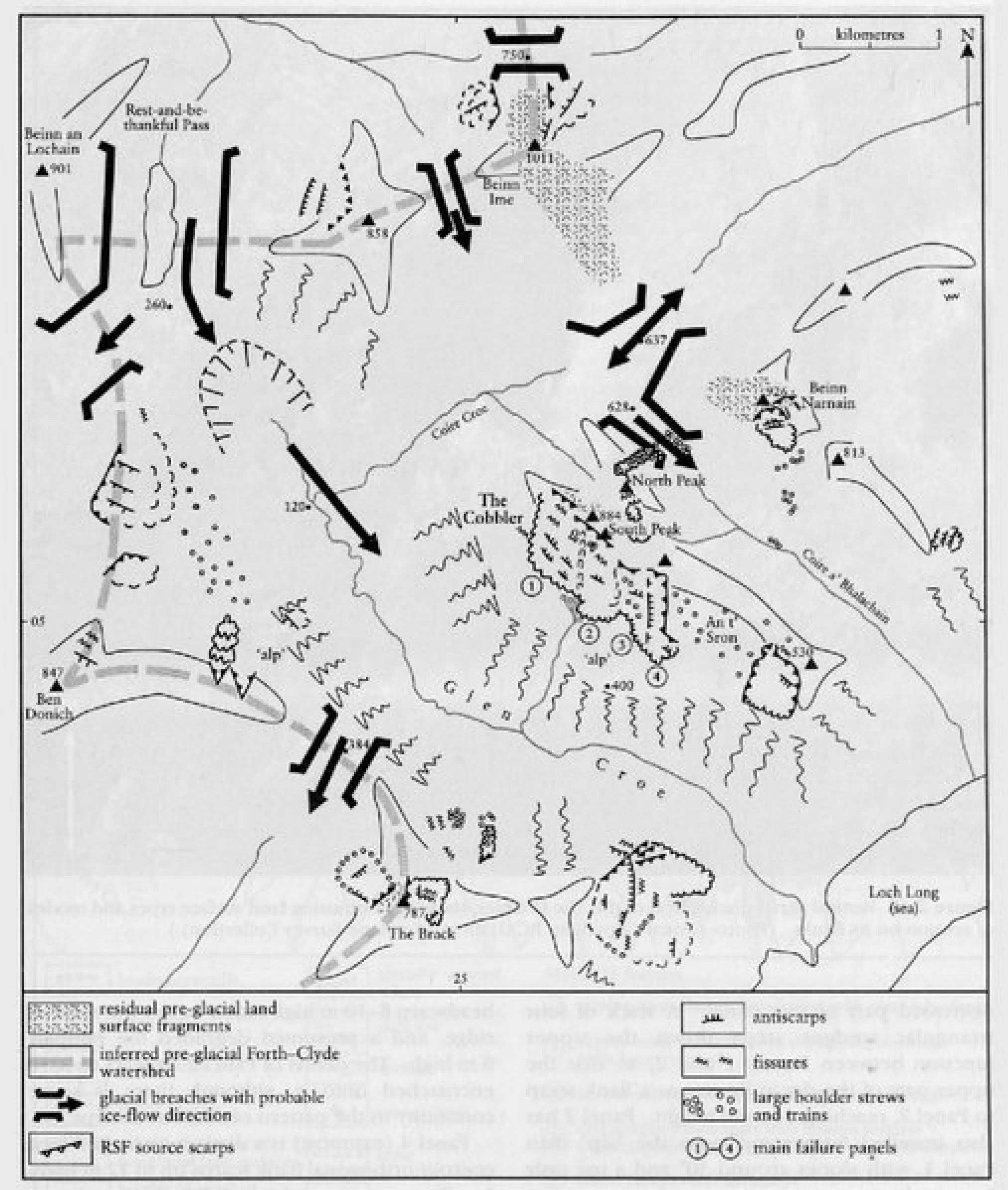
(Figure 2.46) The distinctive profile of The Cobbler from the ESE, with the main rock slope failure on its left flank and a small rockslide into the breach col on the right. Both North Peak and South Peak may be the remnants of former corrie arms truncated by rock slope failure. The wide skyline nick may also result from a headwall collapse, but only small debris-lobes remain in the corrie. (Photo: D. Jarman.)



(Figure 2.13) Spatial distribution and size of 140 larger rock slope failures (RSFs) (> 0.25 km^2) in the mainland Scottish Highlands (distribution of all rock slope failures is similar). Rock slope failure is clustered on main watersheds that have been breached and displaced during Pleistocene times. It is scarce in ranges away from the watersheds, in the far north where ice cover was thinner, and in the eastern Grampians where glacial dissection is less intense. Sites reported in this chapter are shown. After Jarman (2006).

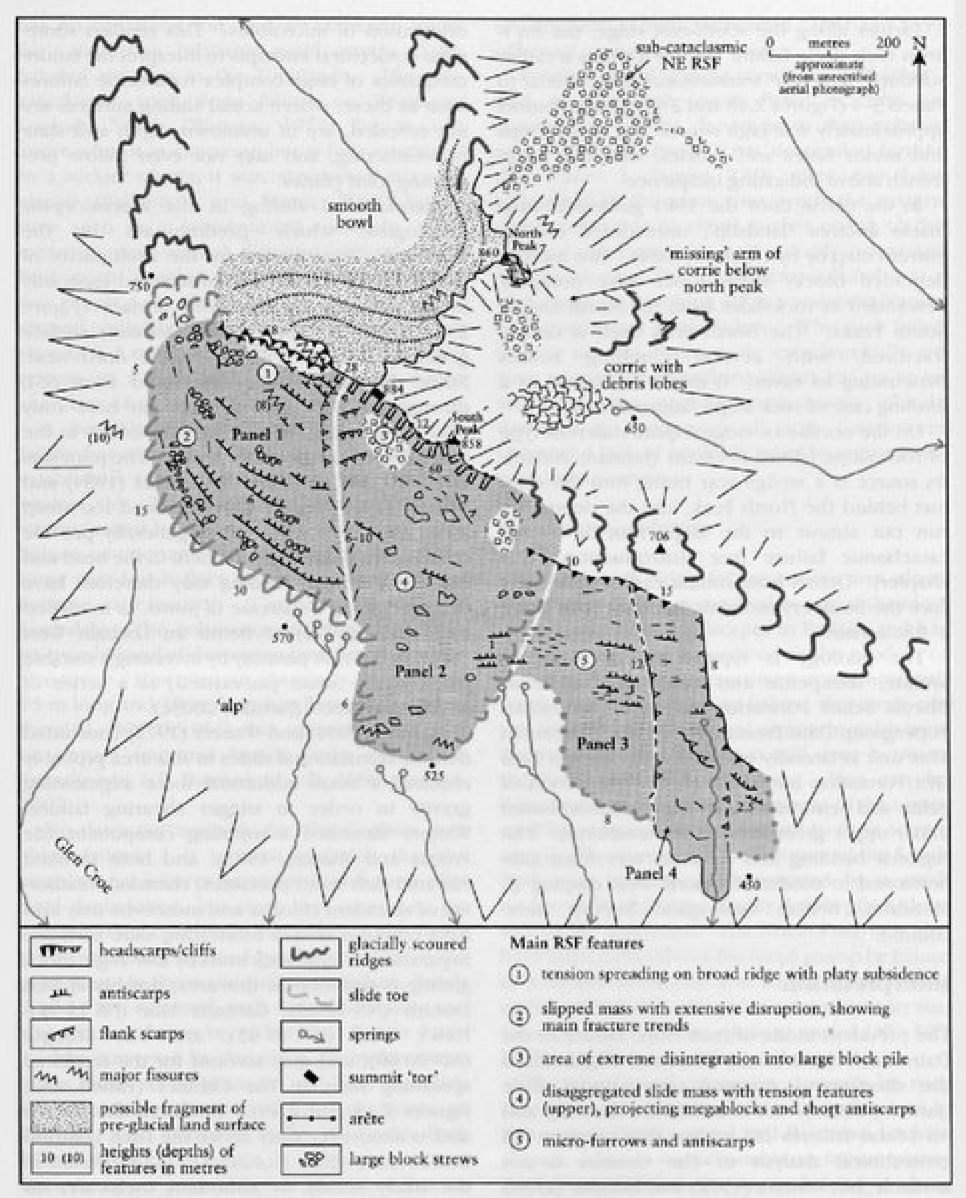


(Figure 2.15) The Southern Highlands, an area of intense rock slope failure (RSF) activity, including the Arrochar–Cowal–Luss and Trossachs–Lochearnhead clusters (clusters 5 and 7 in (Figure 2.13)). Failure is scarce or absent in main pre-glacial valleys and some breaches of the main watershed, despite their slopes and geology being susceptible to it. Its paucity along the deep breach trench of Loch Lomond is surprising. Note mini-clusters top-centre and top-right, where locally intense breaching occurs across main and secondary watersheds. The locations of three sites (Glen Ample, The Cobbler, Benvane) are shown. Adapted and revised from Jarman (2003a).

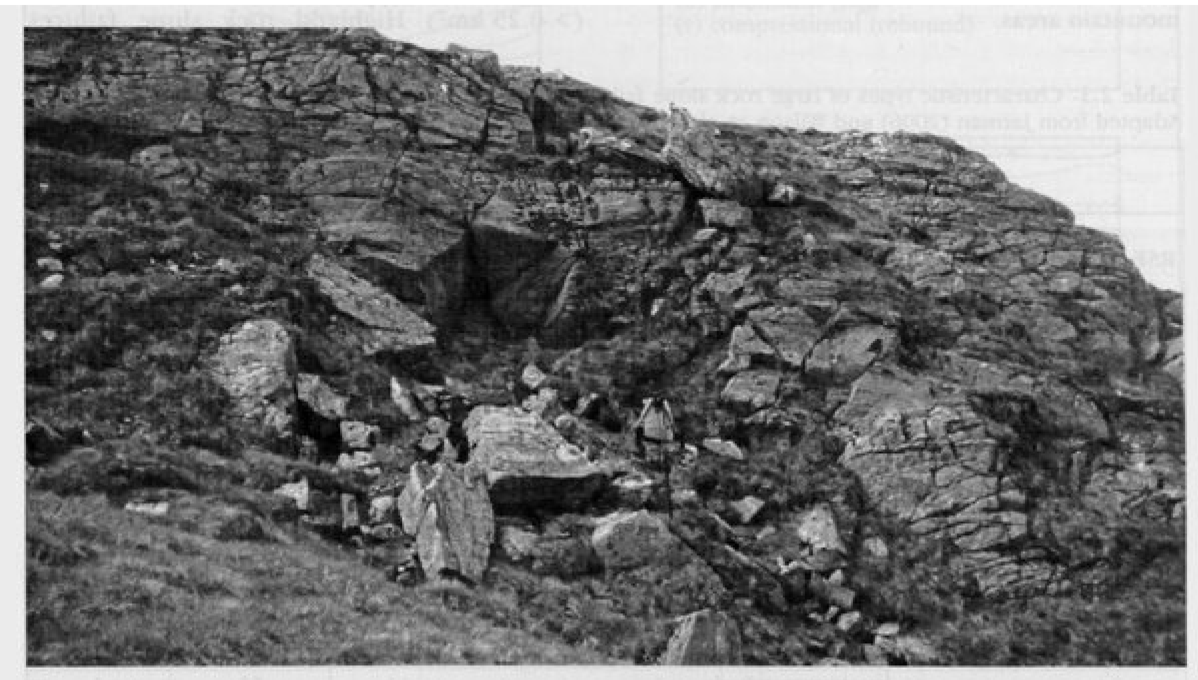


(Figure 2.47) The Cobbler and adjacent peaks, isolated by glacial breaching and incision, and with rock slope failure (RSF) encroaching into the pre-glacial land surface.

(Figure 2.48) Vertical aerial photograph of the The Cobbler, showing contrasting land surface types and modes of erosion on its flanks. (Photo: Crown Copyright: RCAHMS (All Scotland Survey Collection).)

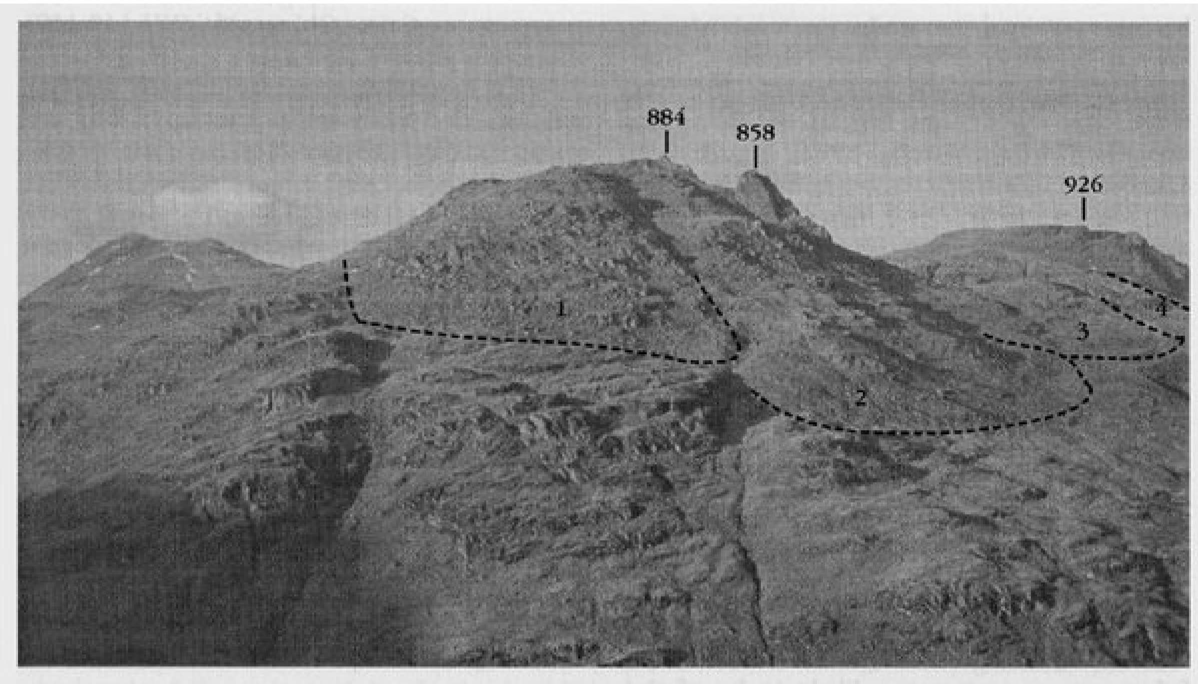


(Figure 2.49) Geomorphological map of The Cobbler, based on (Figure 2.48).



(Figure 2.4) A typical small crag in Moine psammites displays four distinct discontinuities (the foliation or schistosity surface and three joint-sets), which have released a miniature wedge failure. (Photo: D. Jarman.)

(Figure 2.9) Beinn an Lochain North rock slope failure, Arrochar Alps [NN 217 083]. A sub-cataclasmic rock-slide, partly fallen from the cliffs (behind which deep fissures indicate incipient increments), but with a sliding component that has sharpened the summit ridge (top left) to an arête. (Photo: D. Jarman.)



(Figure 2.50) The main rock slope failure complex seen from the south-west across Glen Croe, showing the panels mapped in (Figure 2.49). Panel 2 (on the right) has travelled further than Panel 1 to expose the arête culminating in the South Peak (Point 858). The level pre-glacial summit surface of Beinn Narnain (Point 926, right background) suggests the character of The Cobbler before it underwent more intense paraglacial rock slope failure. The summit tor (Point 884) stands out from the vestigial pre-glacial skyline. (Photo: D. Jarman.)

	Southern Highlands				S. Affric/Kintail/Glen Shiel
	1W	1E	2	Total	7N/8S
Number of RSFs	119	40	13	172	54
< 0.25 km^2	86	33	8	127	33
0.25–0.99 km^2	31	6	4	41	17
1.00–3.00 km^2	2	1	1	4	4
Extent of RSF (km^2)	27.9	7.0	5.2	40.1	18.6
average size (km^2)	0.23	0.17	0.40		0.35
% of densest core area affected by RSF	7.7	7.2	16.7		6.0
extent of core area (km^2)	112	40	26		41
RSF character (number of)					
arrested translational slides	48	20	11	79	25
sub-cataclasmic failures	35	21	6	62	6
slope deformations	6	10	5	21	23
incipient failures	28	10	5	43	5
not ascertained	26	8	1	35	–
Landshaping contribution					
glen and trough widening	89	17	9	115	38
corrie enlargement	13	13	1	27	11
corrie initiation	11	2	1	14	–
spur truncation	39	11	6	56	9
crest sharpening, arêtes and horns	39	16	7	62	19
ridge reduction	8	5	0	13	23
potential watershed breaching/ dissection	3	2	2	7	6
elimination of mountain blocks	12	4	1	17	2
Association with evolving glacial breaches					
at a 'recent' or enlarging breach	20	5	5	30	27
near a breach (< 2 km downflow)	24	15	4	43	
in a side trough rejuvenated by a breach below					11

(Table 2.2) Rock slope failure (RSF) incidence, character, landshaping effect, and association with breaching in the Southern Highlands and Kintail area