

GEOLOGICAL SOCIETY OF GLASGOW

ROCK SLOPE FAILURES OF THE ARROCHAR HILLS

- A ROAD TOUR

Rock Slope Failures (**RSFs**) comprise large landslips, rockslides, and slope deformations. They can affect square kilometres of hillsides and penetrate 100 metres deep. They mostly happened around or soon after deglaciation, and are thus 'paraglacial' phenomena.

RSFs are of

- *geological* interest as offering some of the best and freshest exposures of rock fabric and structures (mostly in 'schists');
- *geomorphological* interest as major contributors to the shaping, enlargement, and destruction of mountain ridges, cirques, and valleys; and as clues to glaciation history;
- *biodiversity* interest in providing sheltered and nutrient-rich habitats (often the last refuges of natural woodland); and
- *archaeo/historical* interest as affording oases of dry fertile ground, good for deer and cattle, with shieling sites and springs - not forgetting the caves and crannies enjoyed by early humans, outlaws, fleeing princes, illicit whisky distillers, and Glaswegian rock-climbers.

With nearly 1000 RSFs in the Highlands, the greatest concentration (around 150) is here in the Arrochar hills, between Loch Lomond and Loch Fyne (see Fig A, back page). They are almost unknown, yet are fascinating to explore - and sometimes hazardously fissured. While many RSF locations can be glimpsed from the roads, most need serious hillwalking to appreciate - or a fly-by on GoogleEarth.

*This Guide has been produced for a **Geological Society of Glasgow** Day Excursion (27April 2013) but is designed as a self-guided tour. The thumbnail illustrations can be expanded if you ask for the e-version !*

LUSS HILLS

Coming north up the A82, the action starts beyond the Helensburgh roundabout at the Highland Boundary Fault - the very first little side valley, **Glen Finlas**, has a cracking great hole in its NE flank leaving a 40m-high headscarp in Creachan Hill. This can be glimpsed from the A82, if sun angle or snow traces are just right. [The private road is a pleasant stroll, and from the dam the failed trough-head invading Balcnock can be seen.]



- 1 - Creachan Hill RSF - from the headscarp onto the slipmass bulging towards Glen Finlas reservoir
- 2 - Beinn Dubh (Luss) RSF - across the slipped wedge which lowers the ridge above Luss by 5-10m
- 3 - Ben Lomond across the Loch, with (4) the RSF scar sharpening its north end and debris lobe

Glen Luss has the highest density of RSF in Britain, with 50% of the north side affected by a dozen sites. Their absence on the south side is unusual, as RSF often occurs on both valley sides. It may be due to a structural dip favouring sliding to the SW, also to greater freeze-thaw cycling on south slopes. From the A82, the first RSF can just be seen - with a triple wedge cavity on Beinn Dubh, the deepest apex being an astonishing 180m behind the crest. [This is one of the easier RSFs to walk up to - a grassy ascent of 2000' on a well-worn path; watch for the abrupt scarps up to 7m high cutting across the ridge - pic 2]

Look across the Loch through gaps in the trees for the summit of Ben Lomond (974m) - the distinctive cocking-a-snook north end is an RSF scar, with a quite prominent blocky

debris lobe. It suggests how RSF, over many glacial-paraglacial cycles, has sharpened mountain peaks - sometimes destroying them.

Just beyond *INVERBEG INN*, turn up *Glen Douglas* on a narrow road which goes through to Loch Long.

GLEN DOUGLAS RSFs

STOP 1 - *glen entrance* (top of steep climb), passing places: on the right, a broad, grassy landslip toe descends almost to the road - but its source cavities some 20m deep can't be seen [a 1000' ascent, aided at first by a bulldozed track, then up steep grass, gets you to the fissured brow of Stob Gobhlach, a spur of Beinn Bhreac and a fine viewpoint]. In fact, this landslip is just the south end of a vast RSF complex which extends above Loch Lomond to the Rubha Mòr promontory. Unseen from the road are bold '*antiscarps*' or uphill-facing scarplets, one over 5m high impounding Lochan Uaine.



5 - Stob Gobhlach - GoogleEarth image shows its slicing by 'faults' paralleling the L Lomond trough
6 - Sith Mòr - splendid antiscarp array seen from Mid Hill opposite and (7) from Glen Douglas
8 - Tullich Hill E RSF - staircase debris lobes emerging from a false 'corrie'

STOP 2 - *Doune Farm entrance* : look up the side valley opposite, which is an extraordinary dogleg glacial breach going through to Glen Luss (Fig B). The skyline at its apparent head is Beinn Eich (703m): the col is invaded by a large RSF in Glen Luss-head, paving the way for a future breach which will progressively isolate the hill.

On the immediate right brow, above the farm, notice several 'cocked hat' breakouts. This is Sith Mòr (big hill of the fairies - but think 'trolls'). It is the corner of an extensive RSF zone all along that valley-side. Glacial erosion through the breach has generated *rebound stresses* in the lower slopes, which can 'pop out' as 1-10m high antiscarps.

Looking on up Glen Douglas, there is a bold 'corrie' on Tullich Hill East - but glacial cirques don't usually face south ! Its floor has failed (bold antiscarp along the lip), with vast debris lobes almost to the road. The corrie crags look more 'natural' but are probably the gullied, weathered scar of an earlier RSF. On the skyline nose, there looks like a huge erratic, but it is a midway collapse crag marking the adjacent RSF just beyond (Tullich Hill West).

However, at the roadside just beyond this stop there is a genuine *mega-erratic*, its angularity suggesting short travel on the glacier surface, probably from Tullich Hill.

STOP 3 - *a mile beyond Invergroin* - passing place beyond MoD No Entry track: we are now beneath the vast landslips of Tullich Hill East. They are quite wet, and crossed by streams at odd angles (technical term '*deranged drainage*' !), implying they are quite old and fully consolidated: could they predate the Loch Lomond Readvance glacier here ?

On the opposite (south) side, the steep face of Doune Hill North rising above the MoD compound has lineaments slanting across it: this is a fine suite of antiscarps attaining 4m high and 600m long, with some vicious open fissures up to 8m deep.

The extensive RSF on both sides here suggests that Glen Douglas-head has undergone considerable glacial enlargement.

STOP 4 - *MoD main entrance* - parking easily found along roadside for a very short, or slightly longer, hike north along the good landrover track which starts at a gate just before the railway bridge.

Here we are at the Glen Douglas col, with a plunge west into the Loch Long fjord trough; this extreme asymmetry could suggest:

either Glen Douglas-head is a glacial breach,
or Loch Long has been glacially incised down a Caledonide fault, beheading a proto-Glen Douglas which rose in Ardgoil - as inferred by HM Cadell in 1886 (see Fig B).

LOCH LONG RSFs

VERY SHORT HIKE - The track (signposted path) leads in 2-300m to an excellent viewpoint across Loch Long. Each of the craggy bluffs opposite displays extensive RSF:

a. Garbh (shoulder of Cnoc Coinnich) - the overhanging crag is clearly a 'fresh' RSF scar, with megablocks below. The legendary Geological Survey member CT Clough was the first to recognise and systematically map RSFs, in the 1890s. On Garbh, without aid of air photos or satellite imagery, he miraculously identified the subtle breaks and scarplets delimiting a 1.75 km² slope deformation, one of the ten largest in the Highlands, its source daylighting at least 550m behind the crags, a British record indicating the potential scale of RSF contribution to trough widening.

b. The Brack - the shoulder above Ardgartan (and inaccessible forestry) is failed; beyond it, binoculars reveal a shrinking summit, invaded by a fractured wedge which has dropped by some 20m without quite disintegrating.

c. The Cobbler - again, RSF scars along the shoulder; but why the remarkable summit fangs ??

d. Beinn Narnain - binoculars reveal another shrinking summit plateau, this time invaded by a fractured wedge which creates the Spearhead Arête (itself so perforated you can crawl through it).

Note also the large delta at Ardgartan, rare in a Highland sea loch, and suggesting copious debris inputs from Glen Croe - which is lined with RSFs.



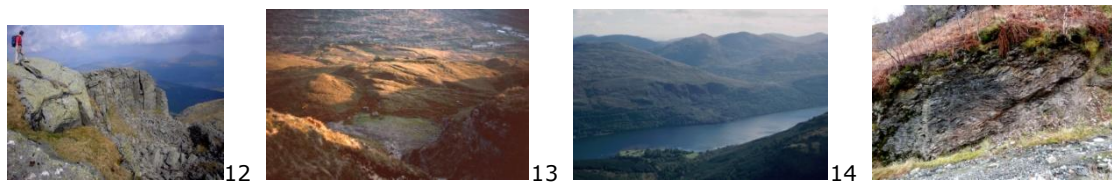
9-11 - pictures from viewpoints along track from Glen Douglas-head (10 as if with binoculars !)

9 - Garbh - conspicuous crag collapse (dark), RSF extends full width of picture and back to the dots

10 - The Brack - a secretive but massive RSF has invaded the summit rim (extent coloured)

11 - The Cobbler and Beinn Narnain across L Long - RSFs coloured - and Ardgartan delta

Up the steps to the derelict control room for a commanding view back down Glen Douglas: Tulich Hill West is seen in side profile, with vast debris lobes staircasing down from unseen (but elegant) source cavities serrating the brow; the Doune Hill anticarp array is seen in context. From here, the evolution of Glen Douglas vis-à-vis Loch Long can be further debated; but Loch Long has probably long been a tributary of the interloper Firth of Clyde, which interrupts an original Scottish main watershed from Cowal to Renfrewshire.



15

12 - Beinn Narnain - disintegrating wedge slip biting into plateau summit, isolating Spearhead Arête

13 - Tulich Hill W RSF - from the apex down onto the sliced upper slipmass and bulging lower one

14 - Morelaggan RSF from The Cobbler, with beheaded Glen Douglas and Luss Hills beyond

15 - Morelaggan RSF - the exposure at the south end, showing how massive creep might occur

SLIGHTLY LONGER HIKE - Morelaggan RSF - continue 1 km along the track. Where it descends abruptly, you are crossing the south end of the Morelaggan landslide, which extends to a 'hinge' at the next headland 1 km beyond. A trackside exposure in massive but friable, finely contorted schist has a possible slanting slip surface with soft gouge. This end of the RSF is demonstrated to be still actively subsiding by the West Highland Railway just below, which has had to be built up on a ballast embankment now several metres high. Above the railway and also above the track there are some large rockfalls from the RSF headscarp crags, probably 'ancient'. The RSF may extend into the loch, attested by unevenness of the shore road. If so, it is one of only a handful in the Highlands to do so, or to affect infrastructure (another being near Strome Ferry, Loch Carron).

A good viewpoint across this RSF is from a glaciated knoll just beside where the track descends; in winter the problem stretch of railway can be glimpsed through the trees.

Continue down to A814 and on to ARROCHAR. From the waterfront (before A83 junction), admire the classic tourist view of The Cobbler: its intriguing puzzle - why those dramatic fangs? - is now solved (pic 19). Two bluffs to the right, just above the forest, binoculars reveal the ruptured brow of Creag an t-Searraich. This array of anticarps includes deep fissures which claimed an experienced hillwalker's life in snow some years ago.

*Continue along A83 up to **REST AND BE THANKFUL (R&BT)***

This pass at 260m is one of very few on a main road in the Highlands of any 'alpine' abruptness (only Glencoe compares). It even required hairpins to get out of Glen Croe, before the ill-advised 1930s 'new road' now causing so much trouble. This trouble incidentally is not due to RSF - despite the steepness of the trough wall, the slopes this side are largely unaffected by it - but to a thick plastering of glacial till onto slabby bedrock, with numerous gullies prone to flash-flooding and bringing down a few skiploads of debris each time, which happens everywhere and would go unnoticed here if a road hadn't been built right across the firing line.

R&BT is a classic glacial breach, adorned by handsome Loch Restil. The breach cuts the preglacial main watershed, which linked the nodal peaks of Ben Lui—Beinn Ime—Beinn Mhor Cowal (see Fig C). However the ice movement here is N→S into the Firth of Clyde, rather than the E→W typical further north, and may be a late or secondary development, hence the incompleteness of the breach and the steep roads up to the pass. Even so the breaching ice has cut a slot possibly 400m into the bedrock, and gone on to gouge out Glen Croe, with a branch down Gleann Mòr to Loch Goil. It is this *concentrated erosion of bedrock* which seems to provoke RSF clusters.



16 - Ben Donich N ridge seen across Glen Croe - the RSF slump has almost reached the forest
17 - Ben Donich N ridge seen from Beinn an Lochain - headscarp dotted (image courtesy Bert Barnett)
18 - tension fractures on Ben Donich upper north ridge - the fissures become hazardous if overgrown
19 - The Cobbler from The Brack - the short and longer-travelled RSF elements have left 3 fang peaks behind; red envelope suggests original summit plateau, as at Beinn Narnain (rear right)

From the R&BT car park there is a classic view down the 'icefall' through the breach into Glen Croe. But a better viewpoint is a short way along the B828 (first long passing places over the col):

- ⇒ Ben Donich N ridge - this is extensively failed, the main source being a distinct groove which doglegs across the ridge at 550-650m (not quite seen from the road. Although this looks like a typical uphill-facing anticarp (dotted on pic 17), it is confusingly the headscarp, here daylighting 100m behind (right of/west of) the crest (compare pic 2 Beinn Dubh Luss); this section of the ridge has dropped 8m at the low end. This is one of the easier RSFs to reach, with a climb of 1200'.
- ⇒ Beinn an Lochain - although the visible flanks are RSF-free (probably because the structure dips into the slopes), the skyline beyond Loch Restil is notched by rockslide cavities into Glen Kinglas (see pics 33-34); the summit is shrinking from these and encroachments on the west - it used to be a Munro !
- ⇒ Beinn Luibhean - extensive landslipping almost down to the road at Loch Restil foot, mostly hidden by the shoulder but summit source visible (see pic 35).

The Cobbler - its unique triple fangs are now seen in perspective. A vast landslip has split the summit ridge, seen end-on from here, leaving behind the central and south peaks. The near half has travelled only a few metres, opening yawning chasms which can be walked through in the upper parts but become impassable lower down. The far half has descended 100m into Glen Croe. Both parts have held together remarkably, so that you can walk easily below the teetering toe rampart, from beneath which copious springs emerge. The north peak is the

D - braided valley pattern arising from glacial breaching of most cols (indicative only)

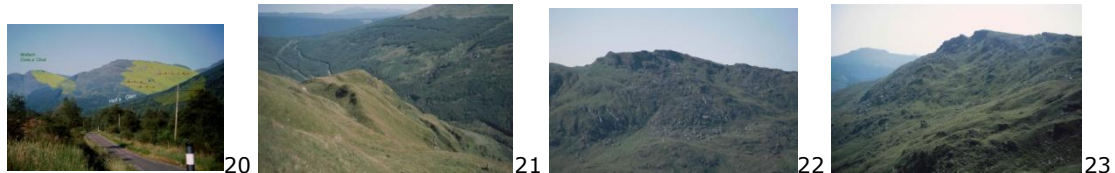
⇒ fractured rump of a separate collapse (climbers can cave up through it), while the broad notch in the skyline is probably the scar of an earlier one. Thus contrary to popular imaginings, the fangs don't owe much to the little corrie, within which there are only modest debris heaps. All this is better seen with binoculars - or from The Brack opposite (pic 19).

Continue down B828 Gleann Mòr

Looking up into the corrie on the left, the north face of Ben Donich summit is a large rockfall scar (pic 17 top right). The top of the NE ridge is deeply notched by an RSF moving slightly SE into Glen Croe. Dangerous fissures abound (pic 18).

Further right, a shovel-shaped sub-corrie is mapped by BGS as an RSF, although the evidence is mainly at the head. This sub-corrie may be an RSF cavity, illustrating an idea first published by CT Clough in the 1892 Cowal Memoir.

Lower down Gleann Mòr, you can look across the foot of Hell's Glen to a spectacular landslip complex. It extends from the summit of Stob Liath to the valley floor, with an exceptional 15m deep trench-parapet slanting across its waist, and one of the largest known detached blocks - 60m high - attesting to the robustness of the Dalradian grits. A blockpile here has been dated to 4000 years ago.



20 - Hell's Glen and Mullach Coire a' Chuir RSFs from the road down Gleann Mòr
 21 - Hell's Glen RSF - the main antiscarp trench, with lesser antiscarps down the failed shoulder
 23-24 - Mullach Coire a' Chuir RSF

The next side valley south, on the right, is flanked by the sharp crest of Mullach Coire a' Chuir - sharp, rather than the usual irregular whalebacks of upper Cowal, because yet again a vast RSF complex a kilometre long has shorn away from it.

Collectively these large RSFs suggest active glacial breaching in several directions - from Loch Fyne SSE into Loch Goil, from R&BT SW, and from Lochgoilhead west through to Loch Eck - itself a through valley breaching from Loch Fyne. This maze of interconnecting valleys is like a braided river or delta, frequently shifting channels and even outflow directions, as the icesheet centres fluctuated (Figs C-D).

At LOCHGOILHEAD fork right just before the village past Drimsynie Hotel and continue to the road end at CARRICK CASTLE

Just beyond the hotel another pass goes through to Loch Eck by Curra Lochain (325m), an easy 3 km walk up a forest path. On its right directly above the col - exactly where bed-rock erosion would have been most concentrated - a striking RSF bites into Beinn Lochain, with a finely sliced slipmass. On its left the shoulder of Beinn Bheula is parting company.



24-25 - Beinn Lochain RSF looking east from the summit, Lochgoilhead off top left
 26 - Beinn Bheula NW RSF, a deeply fissured shoulder with local collapse lobes
 27 - The Steeple RSF has a 25m headscarp crag and 35m deep tension fissures

Across the head of Loch Goil The Steeple has a necklace of huge landslip blocks, well seen from the 378m summit for a fairly modest climb of 1250' in a mile or so.

CARRICK GLEN RSFs

At the entrance to Carrick Castle village (room for one car in the passing place end) find a private track leading between houses uphill into Carrick Glen. A mostly steady ascent of 130m (450') brings you in 1.5 km to the track end at an easy ford.

Straight ahead is a broken crag some 150m high - Creag na Saobhaidhe - with a conspicuous mansion-sized block below it, supporting an elegant birch tree. This block is large enough to be depicted on the 1:25000 map as a 20x30m 'edifice', and is 15m high. Nothing more of the RSF can be seen from here, though a walk up to the block is amusing.

A climb to the crag top is not recommended save for experienced hill explorers, as it is steep and pathless. It reaches a broad shelf where subtle scarps and fissures reveal that a slice of the valley headwall some 500m long and 1-200m deep has failed, and is beginning to part company, in places lowered a few metres. Subtle except at the point marked 'caves' on the 1:25000 sheet: this turns out on very close inspection (indeed only located on my third visit) to be a yawning chasm some 10-15m deep (50 feet sounds more dramatic). Curiously, it is at right angles to the main crag, and slants north into the more stable zone. It is thus the northern flank detachment scarp to the incipient slipmass. The matching southern flank scarp also has lesser clefts.



28 - across Carrick Glen head - Creag na Saobhaidhe RSF tinted yellow, Carnach RSF green; white line across broad failed shelf marks 'caves'; arrow points to megablock at foot

29 - Creag na Saobhaidhe shelf - caves across north end extend well below visible slip-scarp

30 - treacherous cleft just behind slip-scarp (with March 2013 long-winter ice curtains)

31 - Carnach RSF collapse brow slice anchored by rowan roots - stag skull above my right hand

At the track end, if you look up right you will see a small wooded area taking advantage of tumbled blocks (my theory is that the trees have flourished not because they are inaccessible to deer, but because deer have a folk memory going back generations to when these broken-up RSFs were ideal wolf lairs). This RSF - Carnach - is small but intriguing. The collapse brow visible from the track is only halfway up the landslip, which fades gently almost up to the crest.

At the collapse brow a vertical slice of rock 10m long and 5m high is anchored to the 'mainland' by several thick tree roots from the rowan which clings to the outer face (the roots are thus above the deer-nibbled treetop !). They span a gap 1-2m wide which cannot have opened much since the roots grew, as they would snap not stretch. It is likely that the gap was created by collapse of fractured material, as tufts of vegetation clinging to the roots confirm. And my brother Rob, a born delver into nooks and crannies, descended at some peril into the pit, to emerge with a fine set of antlers still adhering to the skull of the luckless foraging stag which went through the root-mesh.

This pair of RSFs is not attributable to glacial breaching, but rather to vigorous enlargement of the glacial trough-head, which itself is cutting down to the Loch Goil fjord. Glacial erosion provokes RSF which feeds further glacial erosion in a cyclical process.

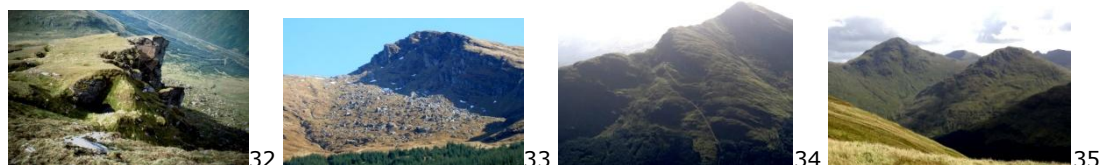
These RSFs together with neighbours in adjacent glens are on or close to a fairly major Caledonide Fault trending NNE-SSW. While a theory that high-magnitude seismic events account for RSF clusters in the Highlands has been generally discarded, the ruptured character of these fairly small RSFs in rather low relief might point to a local earthquake at the time of deglaciation, when rapid isostatic rebound could have reactivated old faults.

OPTIONAL RETURN DETOUR

Follow the B839 up Hell's Glen (close view of RSF) and over to the A815 Loch Fyne road, turn right, and pause near the A83 junction (safe pull-ins available). Here you can see at

unusually close quarters a neat, narrow but bold RSF on the south side of the valley, its toe almost reaching the road (Carn a' Mhuilín on 1:25000 map).

Midway up Glen Kinglas, about 2.5 km east of this junction, pull in to admire the two striking RSFs opposite, on the north face of Beinn an Lochain. The conspicuous one, on the right (west), is one of the finest fully-disintegrated rockslides in Britain - dated to 11600 years ago, which if accurate suggests it fell onto a cirque glacier, thus accounting for its travel distance and regular shape. Its source bites into the summit ridge, where deep fissures indicate future episodes awaiting the next glacial cycle (pics 32-33).



32 - Beinn an Lochain N RSF from the summit, with a precarious next slice, and (33) from the A83
34 - Beinn an Lochain NE RSF from opposite - scalpel-sharp antiscarps; N RSF source top right
35 - Beinn Ime and Beinn Luibhean above Butterbridge - spot the four RSFs...

Less obvious but even more striking is a pair of 3m-high 'antiscarps' slanting steeply up from the forest edge (pic 34). Antiscarps this sharp are uncommon in the Arrochar hills (well seen on this tour only on the south side of Glen Douglas) but typical of Lochaber and Affric-Glenshiel. It is hard to imagine how they could have emerged with such scalpel-cut elegance in this rough terrain: they neatly express the extreme stresses within the eroded mountain wall.

Finally, looking straight ahead and slightly right at Butterbridge before the A83 loops up to R&BT, you will now readily spot the signatures of RSFs on Beinn Chorranaich and on Beinn Ime itself. This highest peak of the Arrochar Alps has a smooth dome profile, a survival of the ancient upland surface before its intense dissection by glaciers, and rising well above its neighbours as befits a nodal peak on the old main watershed - but this summit is being shrunk almost to an arête by RSFs on this flank and in the corrie behind.

THE TALLY

You might now have seen 30 or more RSFs, a fifth of the Cowal-Arrochar-Luss cluster. This cluster affects 30 square kilometres, or 5% of the main mountain area (Fig A), an impressive density which rises to over 9% in the Luss Hills. Clearly RSFs have a major overall effect on the evolution of the mountain landscape, and some have directly created distinctive the individual mountain shapes we so love to recognise. You have seen quite a wide variety, but even larger and more dramatic RSFs occur both in the higher mountains further north and, surprisingly, in quite modest hill country such as Perthshire and Angus. Few are so visible from main roads as here, although Glen Shiel has some prominent ones.

Good hunting - and you are a pioneer, as these remarkable features are found in no textbooks or school or college courses or National Park displays.

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you can read more about some of the Arrochar RSFs in my publications on :

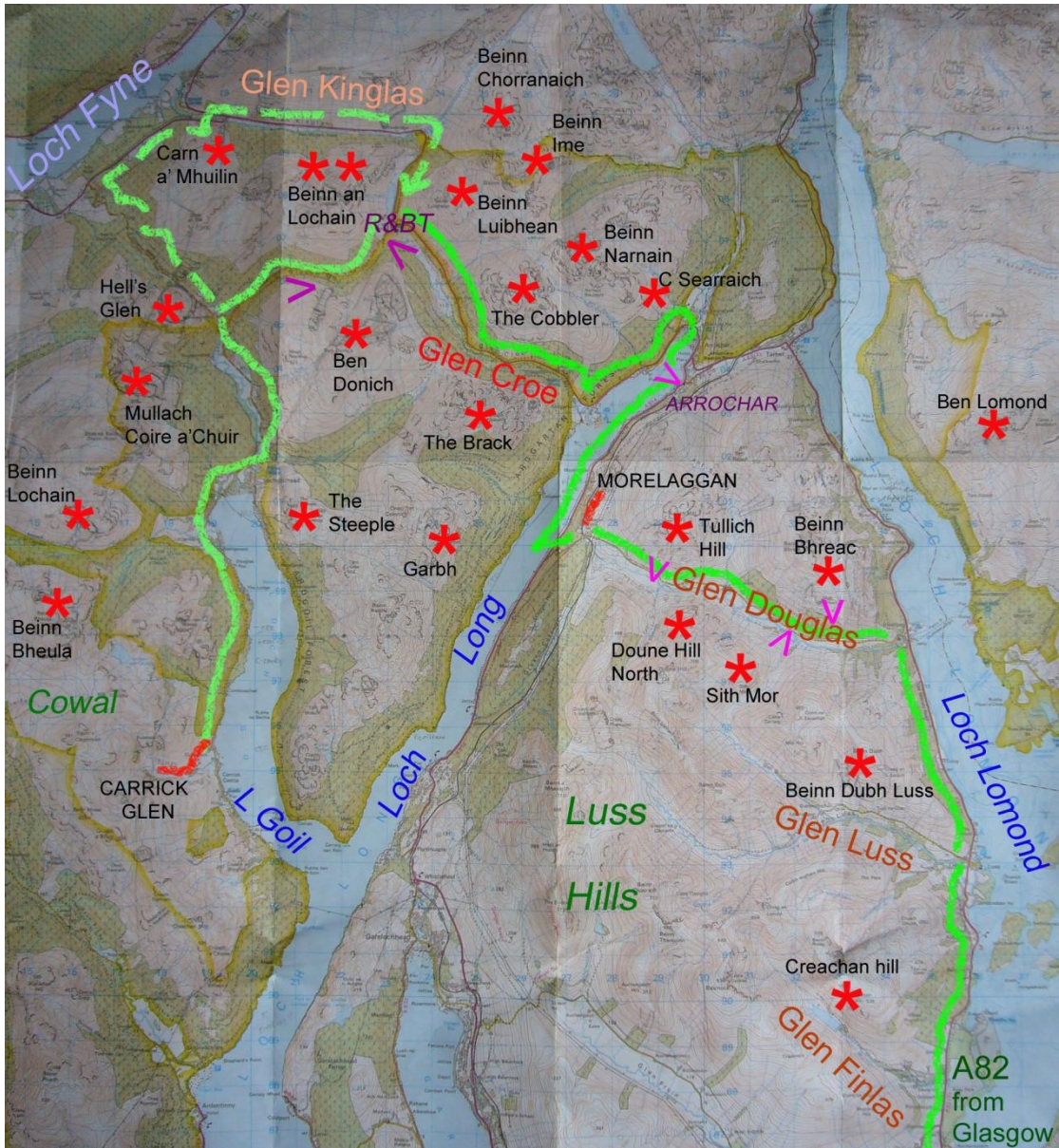
The Cobbler - Scottish Geographical Journal 120, pp. 227-240 (2004)

Garbh - in Knight and Harrison: Periglacial and paraglacial processes and environments. Geological Society of London Special Publication 320, pp. 103-131 (2009)

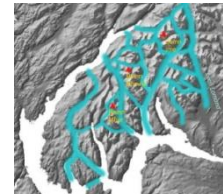
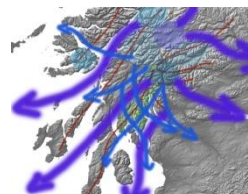
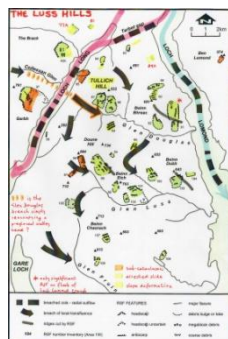
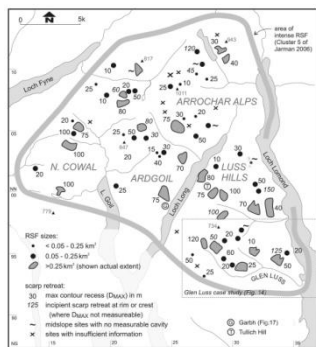
Tullich Hill - The Quaternary of the Western Highland Boundary - Field Guide. Quaternary Research Association, London, pp. 200-208 (2003)

[this Field Guide also has an article on RSF across the whole SW Highlands at pp. 50-68]
Geological Conservation Review 33 - Mass Movements (R Cooper, Ed.) 2007 has my chapter on RSF in the Highlands, together with case studies and general references

The RSF dates are from Colin Ballantyne & John Stone - "Timing and periodicity of paraglacial rock-slope failures in the Scottish Highlands" in 'Geomorphology' 2013



TOUR ROUTE with RSFs, Viewpoints, and Short Hikes mentioned in Guide



- A - main RSFs in the Cowal-Arrochar-Luss cluster (numbers indicate severity of landscape impact; some additional sites have since been identified)
- B - sketch map of Luss Hills with pattern of glacial breaches and associated RSFs
- C - dissection of SW Highlands by glaciers crossing former main watersheds, with cross-cutting patterns as ice centres shift
- D - braided valley pattern arising from glacial breaching of most cols (indicative only)