
12 Ben Alder

[NN 477 722]–[NN 483 722] and [NN 495 733]–[NN 499 708]

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12.1 Introduction

The Ben Alder GCR site comprises the whole of the eastern flank of the mountain (Figure 5.33), (Figure 5.34), from Garbh Coire [NN 498 715] to Coire na Lethchois [NN 502 734], together with the western corrie of Coire Labhair [NN 483 722]. Its national importance arises from the architecture of large-scale polyphase folding of a varied Grampian Group metasedimentary succession, adjacent to the Geal-charn–Ossian Steep Belt that is exposed in the *Aonach Beag and Geal-charn* GCR site.

The summit of Ben Alder stands at 1148 m in the midst of an extensive plateau with much ground above 970 m, some 10 km from the nearest 4-wheel-drive track and 15 km from the nearest road. The cliffs on the north-western flank and in the imposing eastern corries are over 200 m high. The remote and mountainous nature of the terrain has no doubt led to the paucity of geological investigations. The area was originally surveyed by the Geological Survey, who identified a number of ‘sharp folds’ whose ‘true nature and value are unknown’, deforming ‘quartz-biotite-granulites of the Moine Series’. It was concluded that it was ‘impossible to decipher the structure of the Ben Alder plateau’ (Carruthers in Hinxman *et al.*, 1923). Thomas (1979) provided the first detailed account of the country between Loch Ericht and Loch Treig, which includes the great corries on the north-east face of Geal-charn (the *Aonach Beag and Geal-charn* GCR site) and those of Ben Alder. Much of the structure relevant to the Ben Alder area is represented on the BGS 1:50 000 Sheet 63E (Dalwhinnie, 2002), although this GCR site lies along strike to the south-west, entirely within the adjacent Sheet 54E (Loch Rannoch).

Thomas (1979, 1980) recognized major changes in facing across early recumbent structures affecting a ‘Moine’ succession in the Ben Alder area to the south-east of the Geal-charn–Ossian Steep Belt. He regarded the area as critical to any understanding of potential stratigraphical and structural linkages between the NW-facing nappes that had by then been recognized in the Loch Leven district (Treagus, 1974; Roberts, 1976) and the SE-facing nappes of Glen Orchy (Thomas and Treagus, 1968), Strathummel (Thomas, 1980) and the Southern Highlands (Harris *et al.*, 1976; Bradbury *et al.*, 1979). The model proposed by Thomas (1979) had major nappes diverging to the north-west and south-east from either side of the upward-facing Geal-charn–Ossian Steep Belt, which in effect acted as a fundamental root-zone (see Stephenson *et al.*, 2013a, fig. 10a). In the Ben Alder area, the early SE-facing nappe structures were refolded by two further phases of folding.

Robertson and Smith (1999) examined many of the critical sections across the Geal-charn–Ossian Steep Belt in Coire Cheap and Coire Sgòir. That work essentially confirmed the presence of Appin Group lithostratigraphy in the core of the upward-facing Kinlochlaggan Syncline (F1) and the importance of ductile slide structures in Coire Cheap, Coire Sgòir and on Aonach Beag. Three main penetrative deformation phases were recognized; the resultant structures and fabrics equate broadly with those described by Thomas (1979), while recognizing that the strict timing of deformation might be diachronous in structural domains across the region. The facing and vergence of small- and medium-scale structures is such that the structural pattern must have developed to a large extent during the first main deformation, there being few significant changes in secondary-phase fold vergence across the steep belt. Robertson and Smith (1999) thus regarded the steep belt as a zone of primary major upright folds with associated slides developed on severely attenuated fold limbs, as originally stated by Thomas (1979).

12.2 Description

The following description is drawn largely from the maps and comments within publications by Thomas (1979, 1980), supplemented where appropriate by more-recent work by the British Geological Survey, mainly on the adjacent 1:50 000 Sheet 63W (Dalwhinnie, 2002) (Robertson and Smith, 1999). The most-recent BGS work (2005–2006) extended that re-assessment southwards onto the Ben Alder massif itself and will rationalize the regional stratigraphical relationships within current understanding of the Grampian Group (c.f. Banks, 2005). The structural chronology referred to here is that of Thomas (1979).

Thomas (1979) referred to a 'Moine succession' rich in strongly striped and banded schistose semipelite and psammite, interleaved with much thicker units of schistose pelite and gneissose psammite. A few pods and lenses of calcsilicate rock occur throughout. These lithologies are likely to be assigned eventually to the sequence of Grampian Group formations recognized within Sheet 63E (Dalwhinnie, 2002) immediately to the north and by Banks (2005); namely the Coire nan Laogh Semipelite Formation, Creag Dhubh Psammite Formation, Pitmain Semipelite Formation and the Gaick Psammite Formation.

Thomas (1979, 1980) considered that the upright pattern of folds in the Geal-charn-Ossian Steep Belt is transformed to the south-east, over 2–3 km across strike, into broadly recumbent nappe structures, which have been refolded by second and third generation upright structures (Figure 5.35) that he termed the 'Ben Alder folds'. Details of the distribution and suggested way up of this sequence are reproduced in (Figure 5.34); (Figure 5.36) is a structural profile extending south-eastwards from the Geal-charn-Ossian Steep Belt through Ben Alder (both after Thomas, 1979).

The Sgòir Slide lies along the south-east margin of the steep belt. This slide lies on the north-western limb of the F1 Coire Sgòir Anticline and is marked by tight folding, migmatization, and loss of good bedding features. The slide juxtaposes Inverlair Psammite Formation rocks to the north-west against folded, strained and mobilized Creag Dhubh Psammite Formation in the south-east (referred to as the Creag Meagaidh Psammite on BGS Sheet 63E). Earlier slide structures are affected by refolding locally and, at a larger scale, the Coire Sgòir Anticline and the structurally lower level F1 Coire Labhair Syncline are re-orientated across the trace of the F3 Lancet Edge Antiform, so that the upright axial surfaces of both folds adjacent to the steep belt become NW-dipping to the south-east, across the trace of the F3 fold.

In the upright core of the Coire Labhair Syncline, where it crosses Lancet Edge [NN 495 745], are pelites, banded semipelites and psammites, which have been assigned to the Clachaig Semipelite and Psammite Formation by Robertson and Smith (1999) (see also BGS Sheet 63E). Thomas (1979) mapped these schistose semipelites and pelites from Lancet Edge along the trace of the Coire Labhair Syncline, south across the Bealach Dubh and then south-westwards through the crags to Coire Labhair, where the syncline closure is very well exposed in the south face of the corrie [NN 481 722]. At this point, schistose psammites are revealed in the core of the fold; semipelite and pelite on the lower limb extend eastwards across much of the summit plateau of Ben Alder and the cliffs and crags farther to the east around Garbh Coire [NN 500 715].

The closure of the complementary F1 Ben Alder Anticline is less clear and is dependent upon assessment of lithological repetition eastwards towards Coire na Lethchois and Garbh-choire Beag (Figure 5.34). Thomas (1979) placed the closure on the cliffs just south of Garbh-choire Beag [NN 501 724], within a unit of schistose psammite. From there, a repetition of the semipelite and pelite formations mapped at the Bealach Dubh is shown northwards from the closure towards Coire na Lethchois [NN 503 734]. From Garbh-choire Beag the Ben Alder Anticline was traced west and then north across the northern flank of the summit massif of Ben Alder to the crags at [NN 497 734]; here too the closure is within schistose psammite with schistose semipelite and pelite to the west and east on opposite limbs.

According to Thomas (1979), the major change in trend of the F1 Ben Alder Anticline occurs across the trace of the NE-trending F2 Ben Alder Antiform; the latter structure was identified in cross-section in the cliffs in Garbh-choire Beag [NN 503 726]. The complementary F2 Ben Alder Synform is less clear, being 'barely exposed' in a section around [NN 509 730], above the hanging valley of the Bealach Beithe.

Rather symmetrical open F3 folds, which deform both the D1 and D2 structures, are present as a fold-pair in Coire na Lethchois [NN 501 734] (the Coire na Lethchois Antiform and Synform) and as more-asymmetrical folds stepping down to the north-west on the southern edge of the Bealach Dubh [NN 498 737] (the Bealach Dubh Synform) and on Lancet

Edge [NN 496 745] (the Lancet Edge Antiform). These are open to tight folds with a crenulation cleavage developed locally, especially in the hinge areas.

South of the Garbh Coire Fault [NN 497 715], Thomas (1979) recorded that several F1 isoclinal folds become truly recumbent over the broad symmetrical hinge of the F3 Coire na h'Iolaire Antiform [NN 513 705], so that in general terms the attitude of the earliest isoclinal folds is upright in the steep belt to the north-west and recumbent on the Ben Alder massif and to the south-east.

12.3 Interpretation

Thomas (1979, 1980) described local successions of what is now termed the Grampian Group from both the Ben Alder area and farther to the south-east across Strath Tummel. Tentative correlations, in the area of Sheet 63E (Dalwhinnie), of the psammite and semipelite successions immediately south-east of the steep belt with the Corrieyairack Subgroup succession of the Loch Laggan–Glen Roy area (Robertson and Smith, 1999) have been further rationalized by Banks (2005).

Thomas' succession for the Ben Alder area comprised three psammite-dominated, and two semipelite-and-pelite-dominated units. Whilst Robertson and Smith (1999) recorded a strikingly similar sequence for their Grampian Group lithostratigraphy in the steep belt, detailed correlation is an ongoing concern. Adopting the most-recent analysis of Grampian Group lithostratigraphy (Banks, 2005) will mean, for example, that the pelite, banded semipelite and psammite in the core of the Coire Labhair Syncline should be correlated with the Pitmain Semipelite Formation, and the younger schistose psammites should be correlated with the Gaick Psammite. Banded and graded schistose psammites that enclose these two formations are correlated with the Creag Dhubh Psammite Formation.

Establishing the lithostratigraphical succession on Ben Alder, and hence the structural architecture, was apparently more problematical than it was in the steep belt (Thomas, 1979). This was largely due to the apparent lack of sedimentary structures and evidence of younging, compounded by the superimposition of polyphase folding on a major scale. More-recent work farther to the north and north-west, notably on Loch Laggan side and in Glen Roy has recognized sedimentary rocks of the Corrieyairack Subgroup that were deposited in deep water, largely by turbidity currents (see the *Rubha na Magach* GCR site report). These are overlain in turn by the Glen Spean Subgroup, which represents a basin-shoaling succession from shallow marine to estuarine (Glover and Winchester, 1989; Glover *et al.*, 1995; Glover and McKie, 1996). Such documentation of the stratigraphy and sedimentary history has transformed understanding of the Grampian Group depositional record. The lithostratigraphy of the Ben Alder massif is now known to straddle the boundary between the Corrieyairack and Glen Spean subgroups of the Grampian Group, with the Pitmain Semipelite Formation deposited on the flooding surface that defines the base of the Glen Spean Subgroup.

The Ben Alder GCR site is centred upon the northern part of the Ben Alder massif where Thomas (1979) recorded his evidence for D2 and D3 refolding of the primary nappe structure on the south-east flank of the steep belt. The earliest folds were considered to change from an upward-facing, upright form in the steep belt to more-recumbent SE-facing structures, (ultimately downwards-facing to the south-east) as they were traced south-eastwards away from the steep belt, across the Drumochter Dome and into the Atholl Nappe-complex in the footwall of the Boundary Slide in the Blair Atholl district (see 1.4.1 in *Introduction*). The NW-facing structures in the Appin and Lochaber districts were represented as a 'mirror-image' emerging from the steep belt to the north-west. Thus the Geal-charn-Ossian Steep Belt was envisaged as a root-zone to both the SE-facing and the NW-facing nappes of the Central Grampian Highlands.

In this scenario, Thomas regarded the Drumochter Dome as an F2 structure (Thomas, 1979, figure 6). However, Lindsay *et al.* (1989) demonstrated that S2 axial planes and cleavages are folded across the dome, which is consequently now generally accepted as a later structure, possibly F3 as originally proposed by Roberts and Treagus (1977c, 1979) for the related domes of Glen Orchy and Glen Lyon or F4 of other authors. Thomas (1980, 1988) regarded the Meall Reamhar Synform of the Blair Atholl district as the F1 closure of the SE-facing Atholl Nappe but in the light of work by Treagus (1987, 2000) this fold is now regarded as an F2 structure. The most-recent structural interpretations of the Grampian Highlands emphasize the importance of the D2 deformation (rather than D1) in relation to the generation of the major nappes (Krabbendam *et al.*, 1997; Treagus, 1987, 2000) and it seems likely that a similar modification of the structural

chronology of the polyphase folding displayed on the Ben Alder massif will be appropriate, with the major recumbent folds essentially D2 in age rather than D1. However, the presence of F1 folds of significant magnitude cannot be discounted at this stage.

Robertson and Smith (1999) broadly agreed with Thomas (1979) on the structural architecture within the steep belt but dismissed the idea of a root-zone for emergent nappes. Instead they argued that the steep belt forms the boundary between contrasting structural domains, with primary upright structures to the north and west and recumbent folding to the south and east (Figure 5.31). In this model, the steep belt itself is believed to have formed at the eastern margin of a major Grampian Group basin with partitioned (and possibly diachronous) deformation patterns interpreted to be the result of buttressing of the sedimentary rocks of the basin against a rigid upstanding block of 'basement' to the east composed of the Glen Banchor Subgroup (see the *Aonach Beag and Geal-charn* GCR site report). In this respect, the steep belt would have a similar origin to the upright Stob Ban-Craig a'Chail Synform, which reflects deformation of the western edge of both the deep water Corrieyairack Subgroup basin and Appin Group half grabens (Glover *et al.*, 1995). Current syntheses of the structure of the Central Grampian Highlands do not therefore invoke the D1/D2 'fountain of nappes' emanating in opposing directions from a root-zone as was envisaged (Thomas, 1979) in earlier structural models (see discussion in 1.4 in *Introduction*).

12.4 Conclusions

The area around Ben Alder has been central to debates concerning the existence or otherwise of a root-zone for the regional nappe-complexes of the Central Grampian Highlands. It was believed that the nappes were 'squeezed out' on both sides of a zone of steeply dipping rocks, now called the Geal-charn–Ossian Steep Belt, which is well exposed in the adjacent *Aonach Beag and Geal-charn* GCR site. This in effect created a mushroom-shaped 'fountain' of nappes in which individual nappes were separated by ductile dislocations termed slides. Away from the steep belt to the south-east the primary F1 nappes became highly inclined, SE-facing, and all of the structures were subsequently refolded by more-upright folds of at least two generations (F2 and F3), resulting in the observed pattern of recumbent structures.

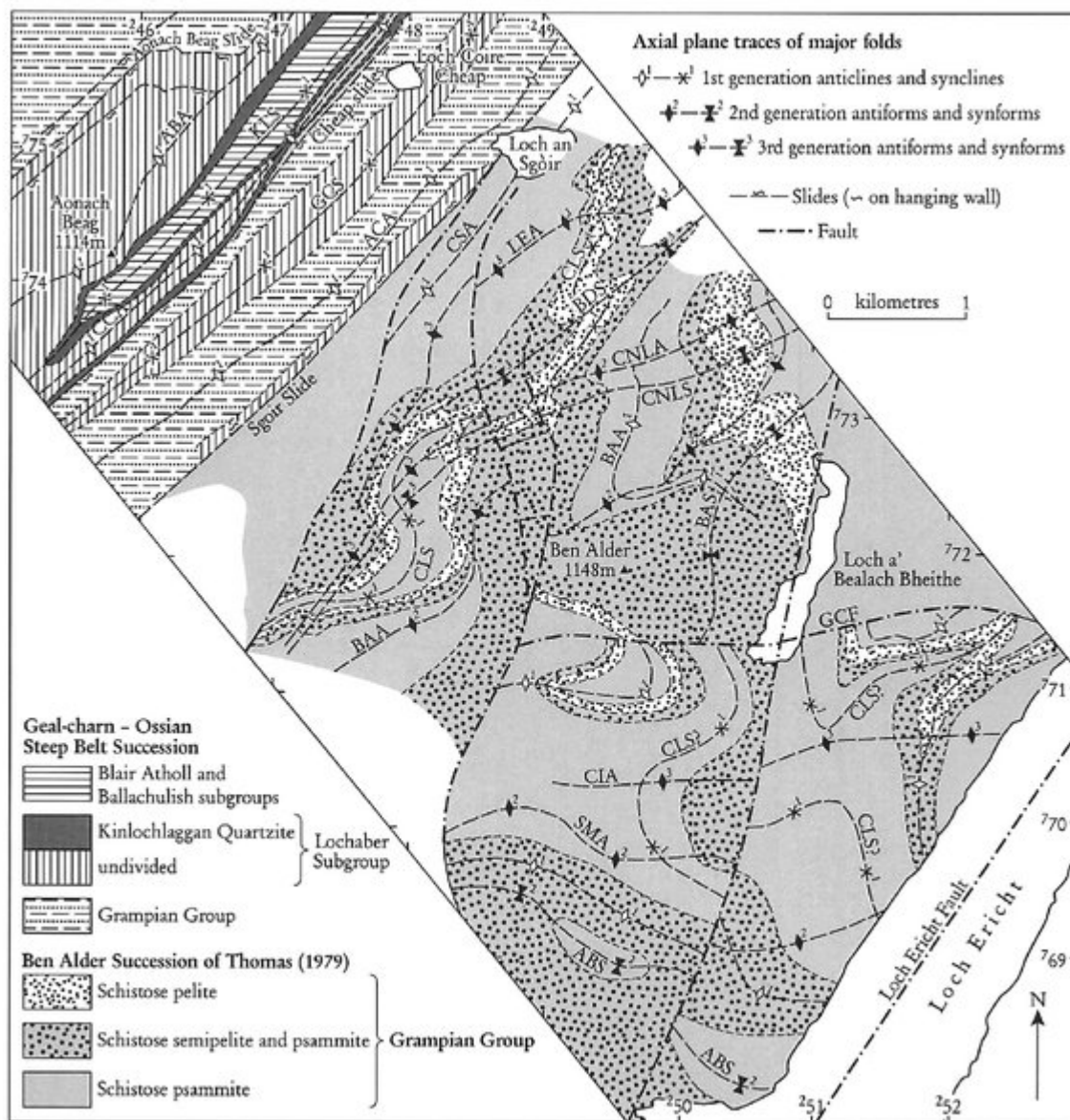
The Ben Alder GCR site is situated on the south-east side of the steep belt and has been crucial to any interpretation of the steep belt and of the nappes between there and the Boundary Slide at Blair Atholl. This in turn is fundamental to theories for the origin and evolution of the Grampian nappe-complexes in general.

The most recent published work has emphasized the influence of the original depositional framework of the Grampian Group sediments, and in particular the basin geometry, on the subsequent structural architecture. Hence the Geal-charn–Ossian Steep Belt is no longer regarded as a root-zone to the major nappes and has been attributed to compression of the sediments against a basement 'high' that forms the basin margin, with the SE-facing nappes attributable largely to the D2 deformation phase. The ongoing debate will continue to draw heavily upon evidence from the Ben Alder area, emphasizing still further the national importance of the *Aonach Beag to Geal-charn* and *Ben Alder* GCR sites.

[References](#)



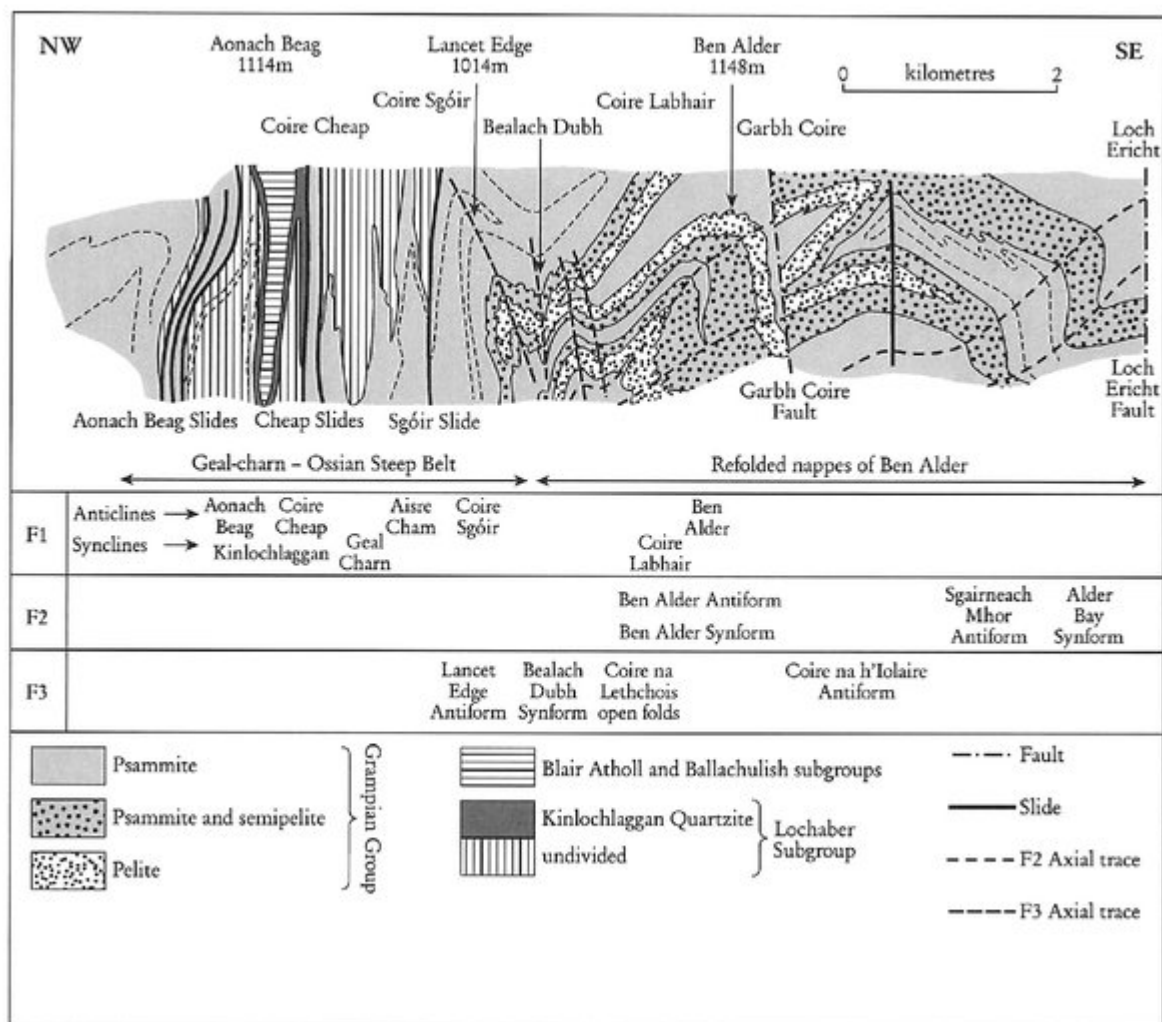
(Figure 5.33) Looking south-west from the Allt a'Chaoil-reidhe by Culra Bothy [NN 5230 7600] to Ben Alder, Sgor lutharn and Geal-charn. The prominent gap between Ben Alder and Sgor lutharn is the Bealach Dubh; the Ben Alder GCR site lies to the left of the bealach and the Aonach Beag and Geal-charn GCR site is to the right. (Photo: BGS No. P 001218, reproduced with the permission of the Director, British Geological Survey, © NERC.)



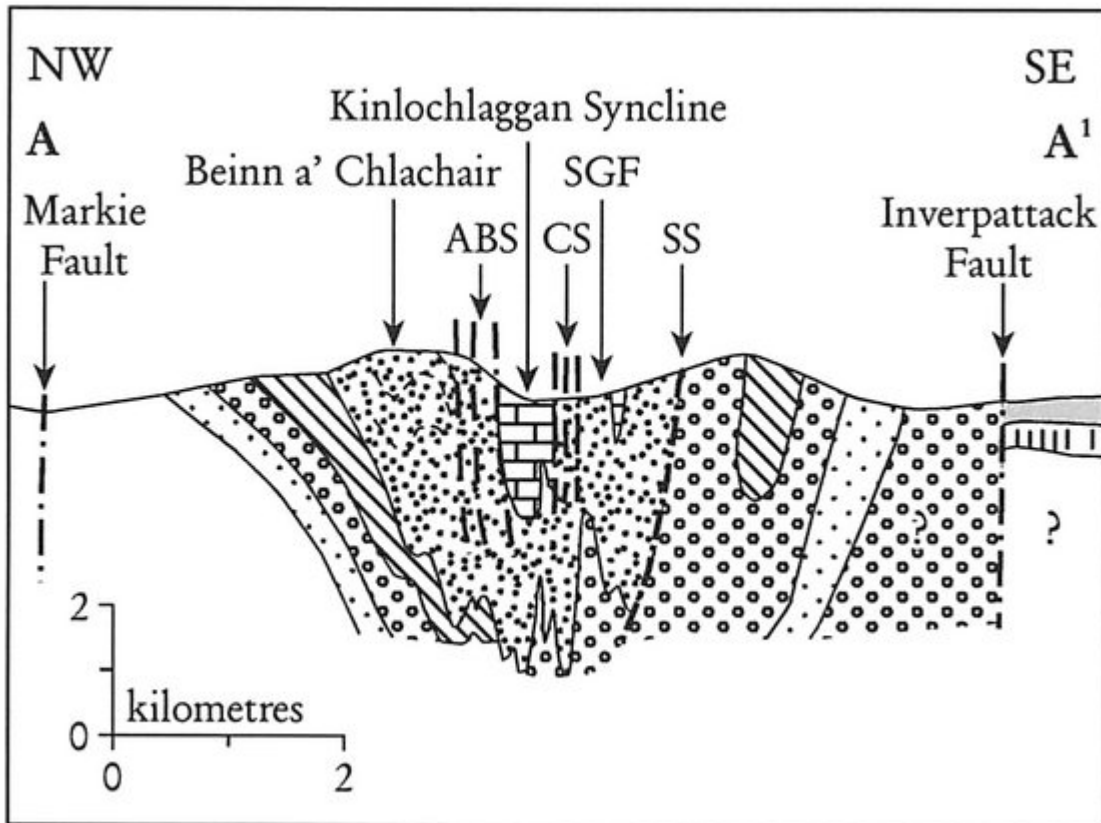
(Figure 5.34) Map of the area around the Aonach Beag and Geal-charn and Ben Alder GCR sites (after Thomas, 1979). ABA Aonach Beag Anticline (F1), ABS Alder Bay Synform (F2), ACA Aisre Cham Anticline (F1), BAA Ben Alder Antiform (F2), BAAAn Ben Alder Anticline (F1), BAS Ben Alder Synform (F2), BDS Bealach Dubh Synform (F3), CCA Coire Cheap Anticline (F1), CIA Coire na h' Iolaire Antiform (F3), CLS Coire Labhair Syncline (F1), CNLA Coire na Lethchois Antiform (F3), CNLS Coire na Lethchois Synform (F3), CSA Coire Sgoir Anticline (F1), GCF Garbh Coire Fault, GCS Geal Charn Syncline (F1), KLS Kinlochlaggan Syncline (F1), LEA Lancet Edge Antiform (F3), SMA Sgairneach Mhor Antiform (F2).



(Figure 5.35) Secondary upright folding superimposed on earlier tight to isoclinal folds in Grampian Group psammities. Structural architecture is typical of that developed within the 'Ben Alder folds' (*sensu* Thomas, 1979). South-east side of Bealach Dubh, [NN 5014 7120]. Hammer shaft is 35 cm long. (Photo: C.J. Banks, BGS No. P605207.)



(Figure 5.36) Schematic cross-section, approximately true-scale, across the Aonach Beag and Geal-charn and Ben Alder GCR sites (after Thomas, 1979).



(Figure 5.31) Schematic cross-section across the Geal-charn–Ossian Steep Belt along the line A–A' indicated on (Figure 5.30). ABS Aonach Beag Slide, CC Coire Cheap, CS Coire Sgoir, SGF Sron Garbh Fold-complex, SS Sgoir slides. After Robertson and Smith (1999). Ornaments as on (Figure 5.30).