
Beinn a' Chapuill

[NG 815 147]–[NG 847 154]

A.J. Barber

Introduction

At the Beinn a' Chapuill GCR site a c. 2 km-wide, sickle-shaped outcrop of Moine psammites, enclosed by Lewisianoid rocks of the Eastern Unit of the Glenelg–Attadale Inlier defines a kilometre-scale fold interference pattern (Figure 7.26). The Moine outcrop lies north-west of the Strathconon Fault and extends west and north almost to Gleann Beag. It can be demonstrated that the Moine and Lewisianoid rocks were first interlayered on a fine scale, and then refolded by two subsequent phases of folding. This site provides one of the dearest and best-documented examples of a large-scale refolded fold in the British Isles. Together with structures at Loch Monar (see Loch Monar GCR site report, this chapter), it formed a model for the recognition and interpretation of similar structures in fold mountain belts throughout the world (e.g. Ramsay and Huber, 1987).

C.T. Clough first mapped the Beinn a' Chapuill area as part of the primary geological survey of the Glenelg (Sheet 71) (Geological Survey of Scotland, 1909), and an account of the geology was included in the accompanying memoir (Peach *et al.*, 1910). J.G. Ramsay subsequently remapped the area in detail with particular attention to the minor structures and the structural relationships between Moine and Lewisianoid rocks. Ramsay (1957b) proposed a complex sequence of structural events to account for the structural features and the outcrop pattern in the area.

Description

Beinn a' Chapuill (742 m) is a castellate mountain surrounded by steep cliffs that rise to a rocky plateau at a height of 600–700 m. It lies to the south of Gleann Beag and 4.4 km SSE from Glenelg. The GCR site covers an area of about 4 km². Moine rocks are very well exposed in the steep cliffs, and on the plateau where they form ice-smoothed rock outcrops. Lewisianoid rocks occupy the lower ground where they are relatively poorly exposed; the best exposures occur in burn sections but lithological units may be traced along strike between small outcrops on the grass and heather-covered slopes.

The Lewisianoid rocks in the Beinn a' Chapuill area belong to the Eastern Unit of the Glenelg–Attadale Inlier. The dominant lithologies are hornblende and biotitic felsic gneisses that underlie the lower slopes of the mountain and the hilly ground to the west, rising to Meall Buidhe (Figure 7.26). A range of other lithologies form narrow strips interlayered with the gneisses, orientated roughly parallel to the Lewisianoid–Moine boundary. They include forsterite 'marble', quartzofeldspathic gneiss, gneissose pelite and serpentinite. Mafic rocks, including amphibolite, garnet-amphibolite and eclogite, form two major bodies on the western side of the Lewisianoid outcrop and abundant small lenses in the felsic gneisses (Figure 7.26). The Lewisianoid gneisses in the western part of the outcrop, adjacent to the narrow strip of Moine that separates the Eastern and Western units, have been intensely deformed and recrystallized into blastomylonites.

The Moine rocks constitute the bulk of Beinn a' Chapuill itself and are predominantly grey, uniform psammites, with their original bedding now modified to pale centimetre-scale siliceous and feldspathic layers alternating with millimetre-scale dark-grey micaceous layers. Micas are commonly aligned in the foliation, generally sub-parallel to the transposed bedding. Locally, there are pebbly layers, with vein quartz and quartz-feldspar clasts, typically 1–2 cm in size, but up to 4–5 cm across. The pebbles are flattened in the foliation but are also elongated to form rods projecting from weathered surfaces, particularly in the hinges of minor folds. Both psammites and pelites contain quartz veins concordant to the layering and irregular veins of pink quartz-feldspar pegmatites, the latter becoming more abundant towards the east.

The shear zone that separates the Eastern and Western units of the Glenelg–Attadale Inlier lies to the west of Beinn a' Chapuill. It contains a significant strip of mylonitic Moine rocks (Figure 7.2) and (Figure 7.26), including a narrow outcrop

identified as Moine pelite, along its eastern margin. However, interlayering between Lewisianoid and Moine units also occurs on a much finer scale, down to a few metres. Clough (in Peach *et al.*, 1910, p. 18) describes the cliff forming the western face of Beinn a' Chapuill as 'where rocks of the Lewisian Gneiss series occur in thin stripes between thicker masses of siliceous Moine schist, the former make ledges, along which it is possible to scramble, with almost perpendicular walls above and below'. The interlayering is also obvious from the occurrence of a thin unit of Lewisianoid rocks, including serpentinite, within the Moine on the summit of Beinn a' Chapuill, and a narrow outcrop of Moine rocks which tracks parallel to the main Moine-Lewisianoid contact to the north-east of Beinn a' Chapuill and in Gleann Beag. Moine psammites also occur in narrow strips or infolds within Lewisianoid gneisses west and south-west of Meall Buidhe (Figure 7.26).

The Beinn a' Chapuill area shows a clear sequence of structural features. The fine layering in Moine rocks is folded into intrafolial, tight to isoclinal folds. An axial-planar cleavage that forms the dominant foliation/schistosity is developed in the hinges of these early 'F1' folds. The interlayering of Moine and Lewisianoid rocks described above may be also related to this early folding (see 'Interpretation').

Later folding phases resulted in both small-and large-scale structures. Open to tight F2 folds with E-dipping axial planes refold the earlier F1 isoclinal folds, together with the compositional layering and S1 foliation. Linear structures, including quartzofeldspathic rodding and mineral lineations lie parallel to the SE-plunging F2 minor fold axes (Ramsay, 1957b). Type-2 fold interference structures are common (Figure 7.27). These structures are clearly seen in crags near Sron an Fheadain to the north of the main mass of Beinn a' Chapuill. On the eastern side of the crags, the F2 folds show S-profiles; in the central part of the outcrop the layering is vertical and folded into M-shapes, while on the western side the 'F2' folds show Z-profiles. Thus, the minor folds define a hinge zone of a large-scale F2 fold, termed the 'Beinn a' Chapuill Fold' (Ramsay, 1957b), which has younger rocks (Moine) in its core. Although technically a syncline, the fold-axis plunge varies from steep to shallow and in parts the fold effectively closes sideways. Ramsay (1957b) termed it the 'Beinn a' Chapuill antiform' (see below). To the north lies the complementary Gleann Beag Fold, which has Lewisianoid garnetiferous biotite-kyanite gneisses in its core (see Druim Iosal GCR site report, this chapter).

From variations in orientation of the foliation of both limbs of the fold, Ramsay (1957b, fig. 6) traced the hinge zone of the Beinn a' Chapuill Fold from Sron an Fheadain to the Strathconon Fault. The axial trace of the fold trends N-S in the Sron an Fheadain area, but to the south it swings to trend WNW–ESE. Ramsay (1957b) interpreted this swing in strike of the axial trace and of the D2 and earlier fabrics to be the result of refolding by a later major fold structure, the Beinn a' Chaonich–Beinn Mhialairidh Fold. The axial plane of this F3 fold trends north-east and dips about 35° to the south-east (Ramsay 1957b, p. 505). Minor folds, normally manifest as crenulations of micaceous layers, are related to this phase of folding, and locally there is the development of a crude axial-planar crenulation cleavage. Quartz-feldspar rodding and weak mineral lineations are locally developed parallel to the F3 fold axes, and plunge moderately steeply to the south-east. In addition, quartz-feldspar pegmatites are present along the axial planes of some F3 minor folds.

Hence, in the Beinn a' Chapuill area, three major folds control the outcrop pattern. The F2 Beinn a' Chapuill and Gleann Beag folds control the distribution of the main lithological units, but the later F3 Beinn a' Chaonich–Beinn Mhialairidh Fold that has generated the near right-angle refold pattern that controls the orientation of the earlier D2 structures.

Interpretation

Clough (in Peach *et al.*, 1910) presented the arguments for an original unconformable relationship between the Lewisianoid and Moine rocks in the Glenelg area (see Attadale and Allt Craic Coast GCR site reports, this chapter). From the structures mapped in the Moine and Lewisianoid rocks at the Beinn a' Chapuill GCR site, the sequence of tectonic events that affected both the Moine sediments and the gneissose Lewisianoid basement can be established.

The earliest phase of deformation that affected the Moine and Lewisianoid rocks resulted in the interlayering of the two rock groups and may well have been Knoydartian (see Storey, 2002). This deformation was particularly intense in the Moine rocks, and resulted in folding of the original bedding laminae into tight to isoclinal 'F1' folds and the development of a pervasive foliation, generally parallel to the attenuated bedding. The deformation was accompanied by pervasive recrystallization and probably amphibolite-facies metamorphism. The 'F1' folds were certainly responsible for some of the

interlayering of the Moine and Lewisianoid rocks, representing original synclines and anticlines (see also the Rubha Camas na Cailinn GCR site report, this chapter). Ramsay (1957b, p. 504) reported that later ('F2') tight folds are coaxial and have similarly orientated axial planes to the 'F1' structures yet locally re-fold the 'F1' isoclinal folds. He regarded both sets of folds as having formed in essentially similar strain regimes related to the same phase of movement, in contrast to folds of later phases, which he attributed to differently orientated strain regimes. The re-folded isoclinal folds are responsible for many of the interference structures seen in the Moine outcrops.

The second phase of deformation is represented on a large scale by the 'F2' Beinn a' Chapuill Fold which folds the interlayered Moine and Lewisianoid layers, together with the earlier foliation and the associated isoclinal folds. The folding of interlayered Moine and Lewisianoid in Beinn a' Chapuill is shown on Clough's cross-section (in Peach *et al.*, 1910, fig. 1) as a synform. Ramsay (1957b), on the other hand, analysed the foliation orientation and deduced that the fold limbs converge upwards in the central part of the Moine outcrop (Ramsay, 1957b, fig. 7). Thus he interpreted the Beinn a' Chapuill Fold as a synclinal antiform. The Lewisianoid rocks of Gleann Beag to the north occupy a complementary synform, followed by a further antiform cored by Moine rocks on Meall Breac farther to the north-east.

Amphibolite-facies metamorphism occurred during or following this 'F2' phase of deformation, resulting in the development of granoblastic textures in the psammite, the formation of a mica foliation in pelitic layers and the development of quartz and quartz-feldspar rodding and the mineral lineation. The penetrative ESE- to SE-plunging rodding and mineral lineation suggest that the whole complex was transported northwestwards towards the foreland. This movement rotated many of the fold axes in both Lewisianoid and Moine rocks such that they also now plunge to the ESE.

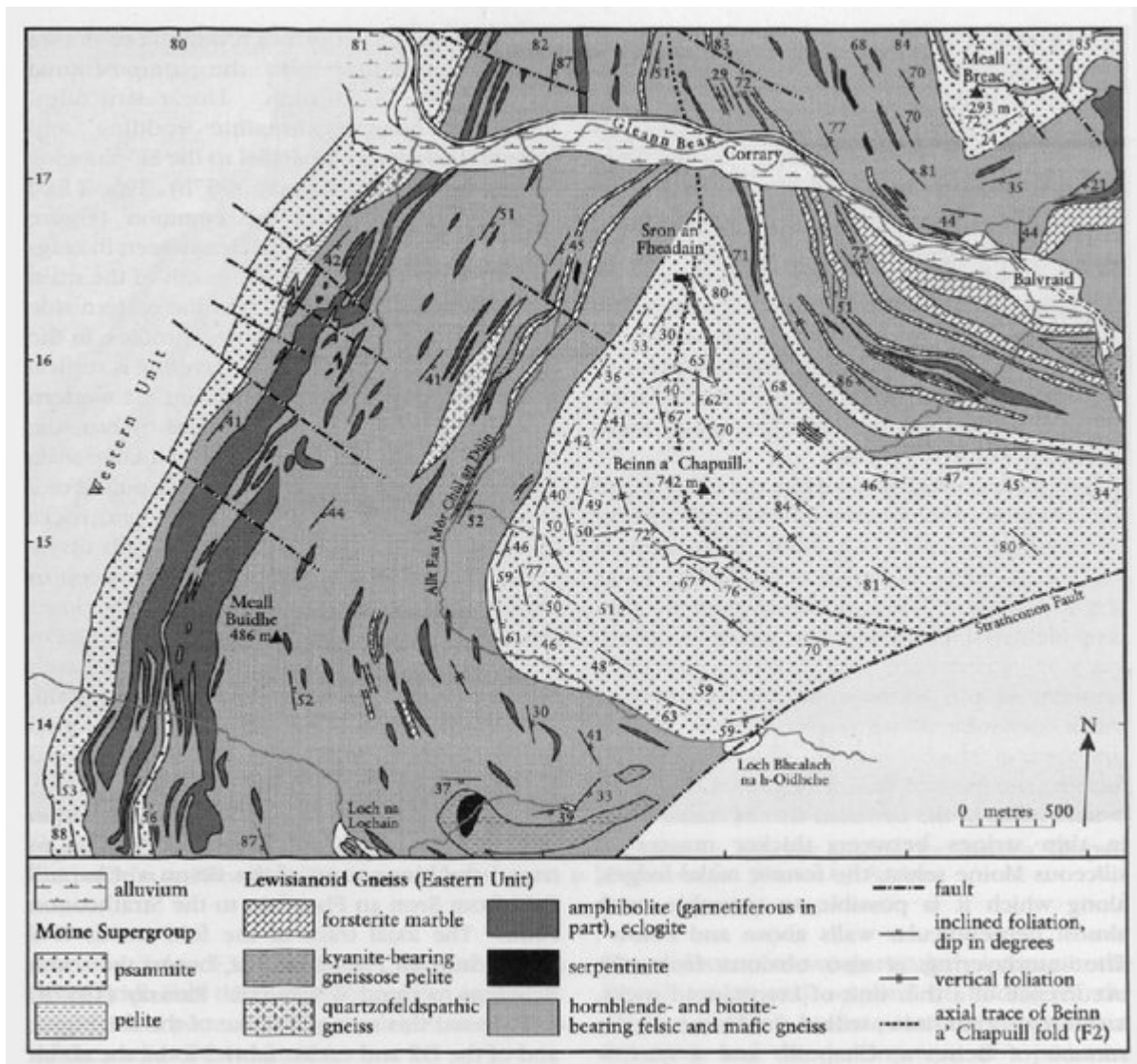
The third phase of deformation is represented by the 'F3' Beinn a' Chaoinich–Beinn Mhialairidh Fold. This fold deforms the earlier 'F2' Beinn a' Chapuill Fold and all its associated structures. Ramsay (1957b) provided a comprehensive analysis of the effects of the third phase of folding on the earlier structures. The folding was accompanied by only minor recrystallization and crenulation of mica in fold hinges suggesting that the metamorphic grade was lower during this deformation phase. Clough (in Peach *et al.*, 1910) suggested that this phase of folding was linked to sinistral movements along the Strathconon Fault, which strikes near-parallel to the fold axial plane and truncates the Moine outcrop to the south-east. However, Ramsay (1957b) pointed out that features associated with the present fault trace are all brittle structures, but this does not preclude the possibility of more-ductile deformation at an earlier stage of fault movement when the rocks lay at deeper crustal levels.

Conclusions

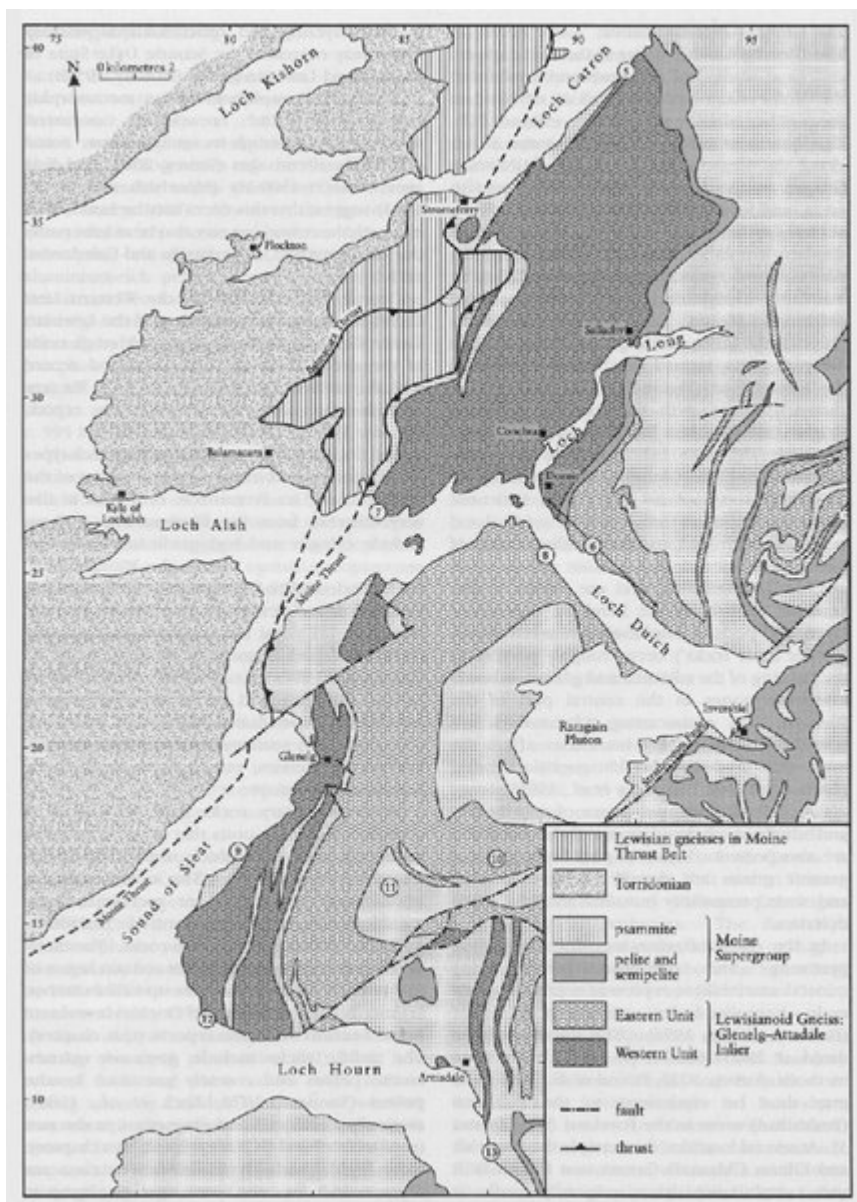
Beinn a' Chapuill exposes one of the clearest and best-documented examples of a kilometre-scale re-folded fold in the British Isles. The excellent exposure on the mountain has facilitated analysis of the complex structural sequence of deformation phases that led to the interlayering, folding and re-folding of Lewisianoid basement gneisses and their cover of Moine metasedimentary rocks. Three deformation phases include an early phase of isoclinal folding probably resulting in the fine-scale interlayering of Lewisianoid gneisses and Moine rocks. This was followed by a set of reclined tight folds (F2) that include the Beinn a' Chapuill Fold itself and was associated with amphibolite-facies metamorphism. These F2 folds were subsequently re-folded on a large scale by a NE–SW-trending fold, whose axial plane strikes north-east, near-parallel to the Strathconon Fault.

Ramsay's seminal work on the effects of folding on the geometrical relationships between early structures and later superimposed folds, based on his studies at Beinn a' Chapuill and at Loch Monar, led to the establishment of a school of structural studies which has had a profound influence on the development of structural geology throughout the world over the past 40 years (see Ramsay, 1967; Ramsay and Huber, 1983, 1987). Hence, the site is of international importance.

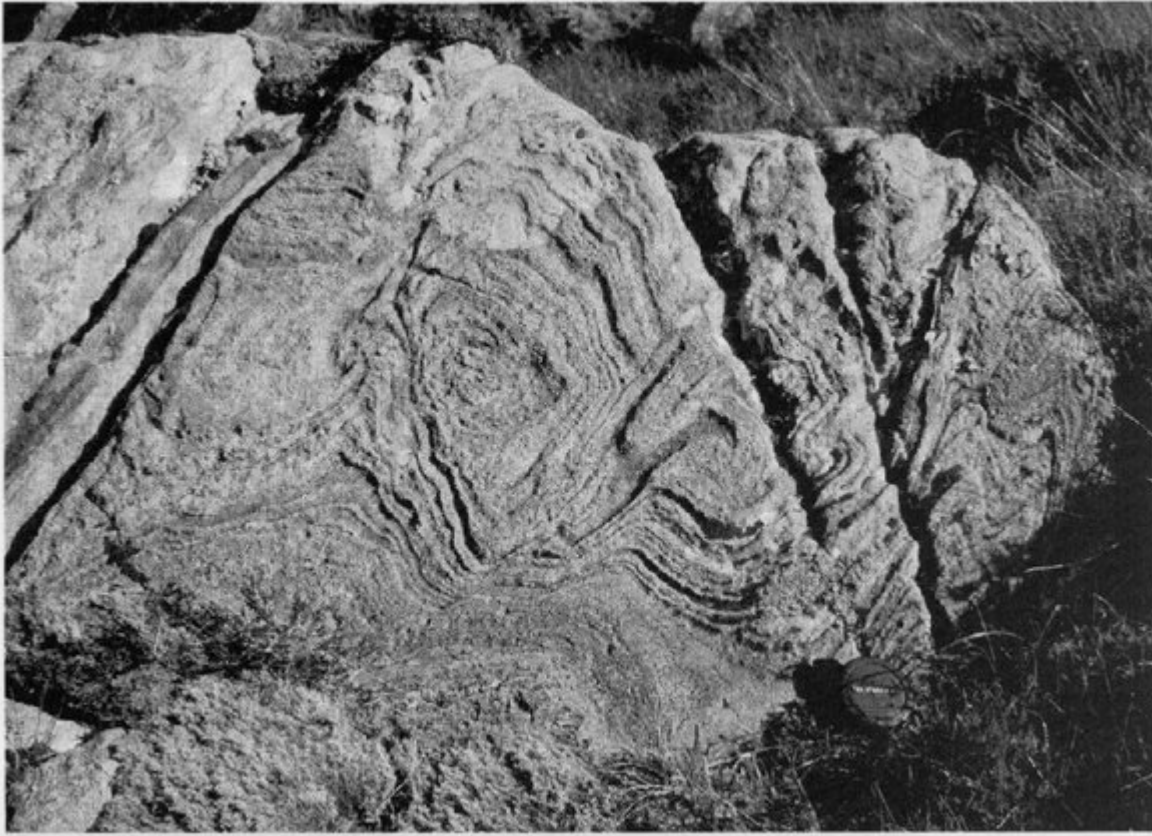
[References](#)



(Figure 7.26) Map of the Beinn a' Chapuill GCR site, after Ramsay (1957b). The outcrop pattern of the Moine is the result of large-scale fold interference between the two main fold phases.



(Figure 7.2) Geological sketch map of the Glenelg-Attadale Inlier and surrounding area (after Barber and May, 1976), showing the location of the GCR sites within or marginal to the Glenelg-Attadale Inlier. 5 — Attadale; 6 — Dornie—Inverinate Road Section; 7 — Avernish; 8 — Totaig; 9 — Allt Craaig Coast; 10 — Druim Iosal; 11 — Beinn a' Chapuill; 12 — Eilean Chlamail—Camas nan Ceann; 13 — Rubha Camas na Cailinn.



(Figure 7.27) Fold interference structure in layered Moine psammite, near the hinge of the Beinn a' Chapuill Fold at Sron an Fheadain. The lens cap (lower right) is 5.2 cm across. (Photo: A.J. Barber.)