
Melness

[NC 571 603]–[NC 586 624], [NC 595 619]

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Introduction

The Melness GCR site lies on the north-west side of the Kyle of Tongue and stretches north-east from Loch a' Mhuilinn to Cnoc an Airbhe and the peninsula of Ard Skinid. It provides a section through four inliers of Lewisianoid gneisses, which together with the adjoining basal Moine psammites and 'early' mafic sheets, have been tightly folded and thrust towards the west during the Caledonian Orogeny (Figure 6.10). Moine–Lewisianoid contacts are well exposed and are typically strongly sheared. The 'early' mafic sheets and pods have been metamorphosed to garnet amphibolite. The site also contains possible volcanoclastic rocks in the Moine succession and much pegmatite veining. It is complementary with the Port Vasgo–Strathan Bay GCR site area just to the north, but the rocks in the Melness area show less-extreme variations in the type and degree of Caledonian strain. The site straddles the entire Talmine Imbricate Zone, which links up with the Ben Hope Thrust to the south (see Allt na Caillich GCR site report, this chapter).

B.N. Peach and J. Horne first mapped the area for the Geological Survey in the 1880s. Several geologists worked in the area subsequently (e.g. Gilbert Wilson in the 1940s and 1950s), but the bulk of the published material stems from mapping and structural studies by Holdsworth (1987). This PhD work was included in the revised map of the Tongue area (British Geological Survey, 1997b) and accompanying memoir (Holdsworth *et al.*, 2001). The area has also been featured in several papers that have discussed the structural pattern and evolution of the northern Moine (Holdsworth, 1989a, 1990; Alsop and Holdsworth, 1993, 2002; Alsop *et al.*, 1996).

Description

This area stretches north-east from Loch a' Mhuilinn across the low-relief rocky promontory immediately above Melness village, to Cnoc an Airbhe [NC 5847 6188] and the Talmine road. It also includes the well-exposed hilly peninsula of Ard Skinid farther east but excludes the intervening crofting land.

Lewisianoid gneisses form four main inliers that from west to east are labelled 'Loch a' Mhuilinn', Achnahuaigh–Cnoc an Airbhe', 'Dùn Buidhe' and 'Skinner' (Figure 6.10). Their maximum thickness is about 150–200 m. Their component gneisses vary from finely striped hornblendic felsic gneisses to more-homogeneous quartzofeldspathic gneiss, and contain abundant mafic pods and lenses and rarely small ultramafic lenses. Pegmatitic and aplitic granite veins and pods and quartz veins and lenses are common. Representative lithologies are well seen in the crags east of the Loch a' Mhuilinn sluice at [NC 5738 6126]. Farther west in the Strath Melness Burn section pink marble is found, but unequivocal metasedimentary inclusions are very rare in these inliers. The original gneissosity has been strongly sheared and folded by Caledonian deformation. The Lewisianoid gneisses are more strongly platy towards their margins, and later foliated pegmatitic granite veins zones. Good examples are seen immediately east and pods up to several metres thick are locally of Loch a' Mhuilinn, where foliated pegmatitic abundant in the Lewisianoid–Moine contact granite veins and pods up to several metres thick and abundant quartz veining are seen. These extend downwards from the slide contact for up to 70 m in the underlying pink, recrystallized, feldspathic and quartzose psammites.

The basal Moine rocks here belong to the Altnaharra Psammite Formation (Holdsworth *et al.*, 2001; see 'Introduction', this chapter). They consist of white to fawn and pale-grey, feldspathic psammites, locally gritty, with subsidiary thin, micaceous psammite interbeds. Only sparse thin semipelite and pelite interbeds occur in the psammite sequence in this area, typically close to Moine–Lewisianoid contacts. The psammites are best exposed in the wide hinge zones of medium-scale, ESE-plunging, reclined F2 folds on Ard Skinid. Here cross-bedding is preserved and in places small-scale, tight to isoclinal, possible slump folds are locally abundant (Figure 6.11). Both features imply that the sequence is locally inverted. The basal psammite beds adjacent to the Lewisianoid gneisses are commonly gritty and in

places contain amphibolitic mafic gneiss fragments. Locally, they contain epidote-rich layers and magnetite lenticles [NC 5832 6049], implying derivation from the adjacent Lewisianoid rocks. In places, small lenses of Lewisianoid gneiss can be discerned in the basal parts of the psammite succession (e.g. at [NC 5818 6125]).

Garnetiferous amphibolite and hornblende schist forms both thick and thin sheets in the Moine and Lewisianoid rocks. These mafic bodies were originally cross-cutting intrusive dolerite sheets and sills, and some are still discordant to bedding and the Moine-Lewisianoid boundaries. A sheet c. 60 m thick trends north across the Melness area and is regionally discordant to the Skinnet Lewisianoid Inlier (Figure 6.10). Another highly garnetiferous hornblende schist unit occurs on the shore section at [NC 5907 6114] close to the Moine-Lewisianoid contact. Its margins are sheared and show retrogression to biotite and chlorite with development of white plagioclase-quartz-rich veins. This sheet apparently cross-cuts the Lewisianoid gneiss inlier boundary to the northwest. Other thin amphibolite sheets are finely interlayered with gritty and epidotic basal psammites, and may represent mafic volcanic material at the base of the Moine succession. The best examples occur immediately north-east of the Skinnet Lewisianoid Inlier, notably at [NC 5934 6138], where pink and grey, laminated silicified 'cherry' units that show sheath folding are locally associated with the interlayered amphibolite and psammite. Similarly inter-layered units are seen along strike on the coast south-west of Talmine Island around [NC 5903 6222]. Both massive and interlayered amphibolitic metabasic rocks have been affected by all the deformation phases (Holdsworth, 1989a).

Examples of the 'Port Vasgo Microdiorite Suite' (Holdsworth *et al.*, 2001) are seen on the south-eastern coastal section of the Ard Skinid peninsula at [NC 5944 6155] and [NC 5985 6175], and on the south side of Talmine Bay at [NC 5864 6267]. Although partially foliated and metamorphosed, the microdiorite dykes do retain chilled margins and cross-cut the D2 folds and ductile thrusts. They are further described in the Port Vasgo–Strathan Bay GCR site report (this chapter).

Structure

The distribution of the Lewisianoid inliers in the Melness area is largely a product of Caledonian folding and thrusting. The original nature and geometry of the Moine–Lewisianoid contacts is particularly important but difficult to assess in many instances. The local abundance of epidote and other detrital material and rare conglomerate lenses in the basal Moine lithologies imply that the Moine succession was originally deposited unconformably on Lewisianoid basement gneisses. However, most Moine–Lewisianoid contacts have been strongly sheared and appear to have formed a locus for ductile thrusting. On the south-west side of Cnoc an Airbhe, around [NC 5829 6185], highly deformed conglomerate lenses and psammites of the basal Moine units young away from the Lewisianoid inlier to the south. Although the Lewisianoid–Moine contact has been highly modified by shearing during D2, it appears to represent a modified unconformity.

As in the adjacent Port Vasgo–Strathan Bay GCR site, three main deformation and metamorphic events can be recognized. The D1 deformation phase was accompanied by peak metamorphic assemblages of lower-amphibolite grade, now dated as early Neoproterozoic in age (Strachan *et al.*, 2002b). Tight F2 folding and ductile thrusting are the dominant structures and F2 fold axes plunge gently east, down the dip of the S2 cleavage. They are co-linear with a strong, E-plunging quartz and hornblende lineation, L2. D2 deformation was accompanied by greenschist- to epidote-amphibolite-facies metamorphism. It occurred either during the Early Ordovician (Grampian) or the Late Silurian (Scandian) (Dallmeyer *et al.*, 2001; Strachan *et al.*, 2002a).

D2 shear-zones range from a few metres up to 40 m thick. They are strongly platy zones with a planar fabric defined by newly crystallized muscovite and recrystallized quartz and feldspar grains. They are found along Lewisianoid–Moine contacts, but have also developed on the highly attenuated limbs of D2 folds, particularly in the Moine psammites. Locally strongly foliated quartz-feldspar pegmatites are developed adjacent to the western lower Lewisianoid–Moine contact of the Loch a' Mhuilinn Inlier. The marginal shear-zone and pegmatites are apparently folded by a tight F2 fold, and subsequently have been refolded by a more-open F3 fold to give the current outcrop pattern.

The effects of the D3 deformation are mainly to modify the basic pattern, established during D2. However, F3 medium-scale folding of the thrust and folded pile is mainly responsible for the main strike swings and 'hook-shaped' Lewisianoid outcrop patterns, which resemble the type-3 interference patterns of Ramsay (1967). F3 minor folds are best

seen in areas where their axial planes lie at a high angle to the S2 fabric, for example on the north-east and south-west ridges of Cnoc an Airbhe. A further example is seen in thinly interlayered psammite and garnetiferous amphibolite at [NC 5934 6136]. Here, tight F3 minor folds with a penetrative S3 axial-planar fabric, clearly re-fold the S2 fabric. The F3 folds are commonly almost coaxial and coplanar with the F2 and L2 structures, although their axial-plane orientations show more variation than those of F2 folds (see Holdsworth *et al.*, 2001, fig. 12b). Minor D3 shear-zones show westerly translation and appear to be related to the F3 folding, but more commonly D3 shear-zones have reactivated the earlier D2 structures. The D3 structures have formed under greenschist-facies conditions, and chlorite and biotite (after hornblende) mainly define the related S3 fabrics (Holdsworth *et al.*, 2001).

Two minor N-trending, steeply W-dipping normal faults are seen at [NC 5933 6134] where they bound a 1.2 m-wide fracture zone. These may relate to Devonian or Mesozoic fault patterns, which dominate the offshore geology (see also Coldbackie GCR site report, this chapter).

Interpretation

The area has similar problems of interpretation to those in the adjacent Port Vasgo–Strathan Bay GCR site area. In the Melness area the focus is on the nature of the Moine–Lewisianoid contacts and the overall D2 and D3 structural pattern.

Evidence for the unconformable nature of the Lewisianoid–Moine contacts is not as compelling as that found farther west in Strath Melness or in the Port Vasgo–Strathan Bay GCR site, as most contacts are strongly attenuated in the Melness GCR site. The Lewisianoid inliers are interpreted both as thrust-bounded sheets and as antiformal cores of kilometre-scale, tight F2 folds. The two easterly inliers, Dùn Buidhe and Skinnet, appear to have ductile shear-zones at their western margins and to wedge out northwards (Figure 6.10). In contrast the two more westerly 'hook-shaped' inliers, Loch a' Mhuilinn and Achnahuaigh–Cnoc an Airbhe, appear to result from F2 + F3 fold interference. The fold pattern in the wider Talmine area was analysed by Alsop and Holdsworth (2002), who modelled it as a product of Caledonian differential shearing and coeval generation of perturbations.

Abundant pegmatitic and quartz veins and pods, accompanied by recrystallization and pinkening of the underlying psammites, are best seen close to the western Moine–Lewisianoid contact of the Loch a' Mhuilinn Inlier (see above). These features suggest that the shear zone has been the site of considerable fluid movements, either during D1 or at an early stage of the D2 deformation. In contrast, the finely interlayered amphibolite and psammite lithology found immediately above the most easterly Skinnet Lewisianoid Inlier may represent thin metavolcanic units in the stratigraphically lowermost Moine rocks. Amphibole-rich mafic units occur in a similar stratigraphical position in Strath Melness, a few kilometres to the WNW.

Conclusions

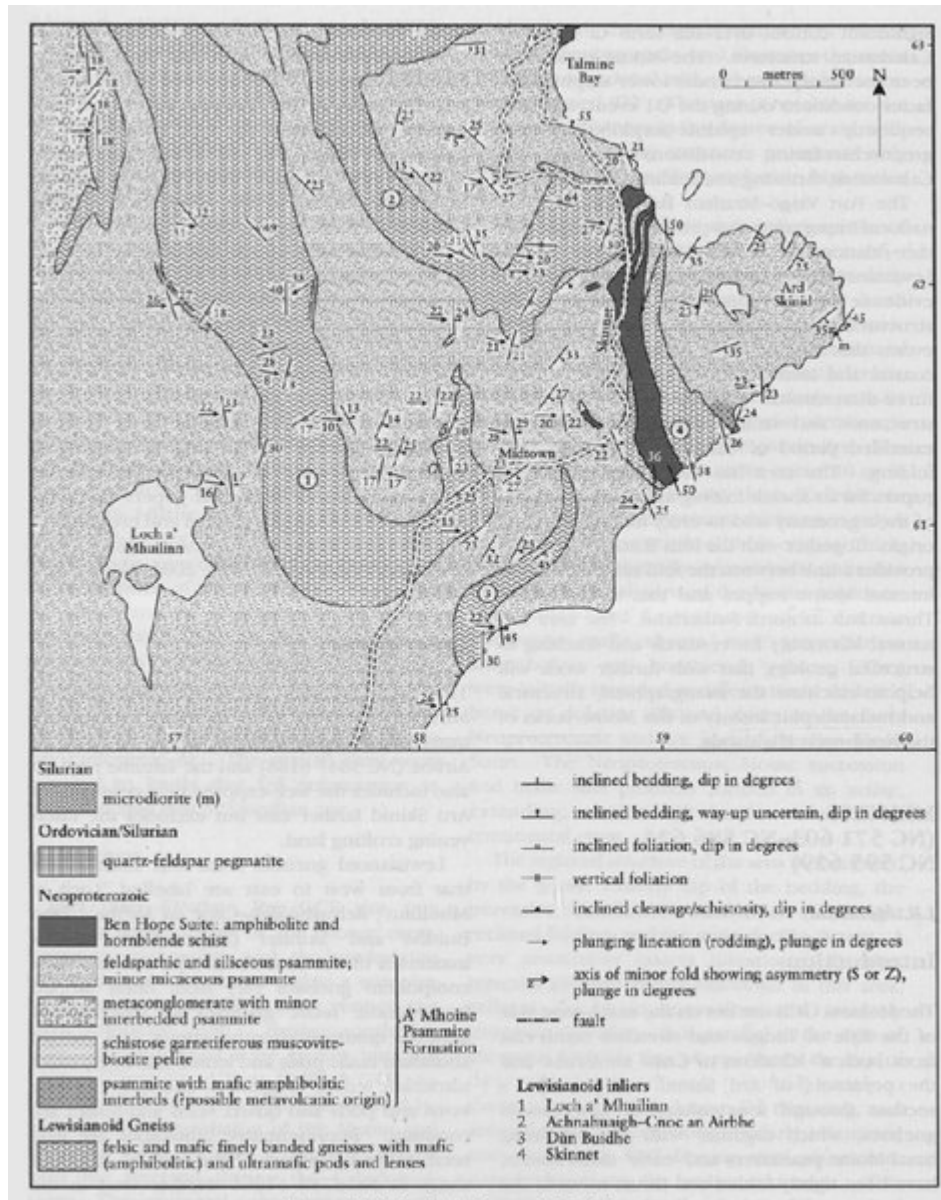
The Melness GCR site area in north Sutherland provides a section through a complex, ductile thrust zone, termed the Talmine Imbricate Zone'. This zone is a northern extension of the Ben Hope Thrust that itself lies within the M Moine Nappe. The main units represented are Lewisianoid gneisses, which here form four inliers, the basal Moine psammites of the Altnaharra Psammite Formation, and 'early' mafic sheets, now metamorphosed to garnet amphibolite. The site is complementary with the Port Vasgo–Strathan Bay GCR site area to the north but the rocks in the Melness area show less-extreme variations in the degree of Caledonian strain.

The Moine rocks consist of locally gritty, feldspathic and micaceous psammites with cross-bedding and possible slumped bedding structures visible in lower strain areas. Moine–Lewisianoid contacts are well exposed and are typically strongly sheared. In places epidotic and other detrital material, and more rarely conglomerate lenses, are present, implying that the Moine rocks lie unconformably on the Lewisianoid basement inliers, at least in places. Thin amphibolite layers are intimately inter-layered with basal psammites, and may represent basic volcanic material. The sequence, including the Lewisianoid gneisses, has been deformed and metamorphosed during Neoproterozoic times and subsequently tightly folded and thrust westward during two main phases of the Caledonian Orogeny. Two Caledonian fold phases, F2 and F3, are recognized; both have fold axes that plunge gently eastwards down the dip of their axial planes. A locally prominent

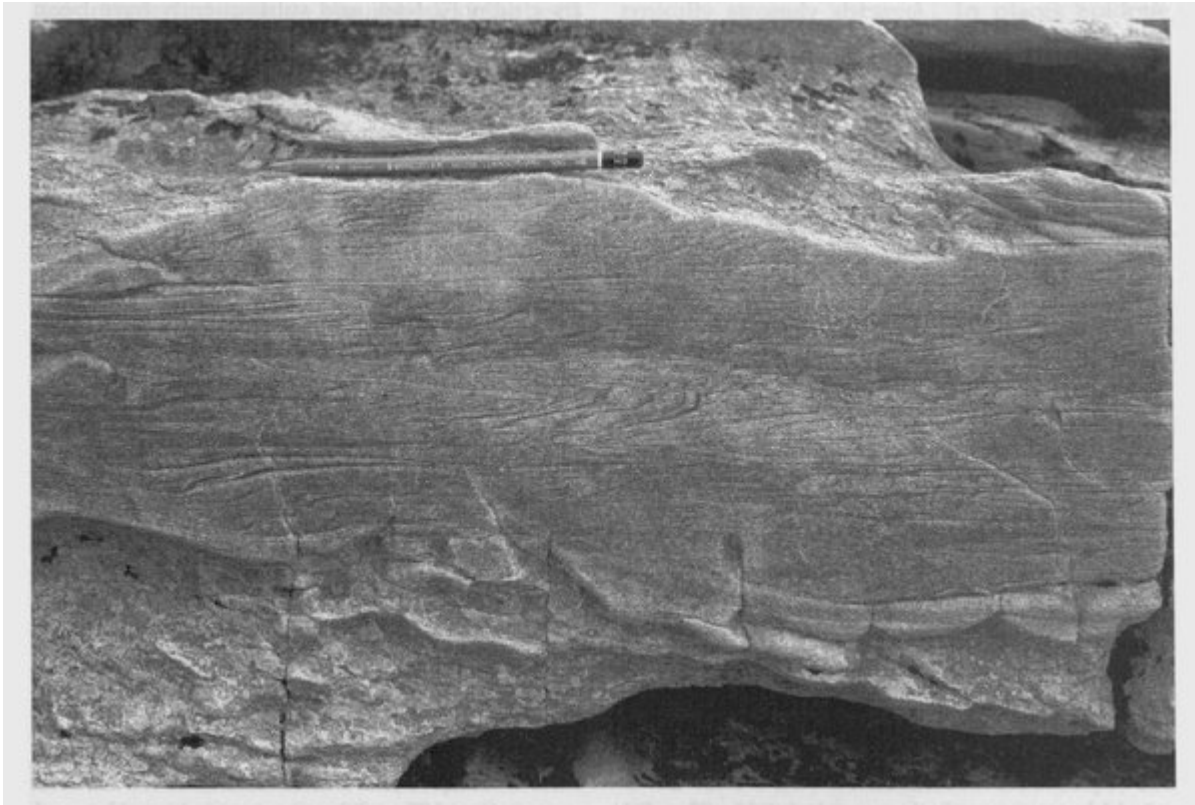
quartz or hornblende lineation, L2, also plunges gently east, parallel to the F2 fold axes. The Caledonian D2 and D3 fold and ductile thrust patterns control the main outcrop pattern, with D3 folding responsible for some of the strike swings and 'hook-shaped' outcrop patterns.

Quartz-feldspar segregations and pegmatite pods are common within the gneisses. The site is of regional importance and is ideal for further work on Moine–Lewisianoid relationships, the nature of Caledonian deformation, and for demonstrating structural features.

References



(Figure 6.10) Geological map of the Melness area.



(Figure 6.11) Inverted slump-folds in the Altnaharra Psammite Formation, south end of Ard Skinid. The pencil is 16 cm long. (Photo: J.R. Mendum, BGS No. P552293, reproduced with the permission of the Director, British Geological Survey, © NERC.)