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# Avernish

[NG 836 266]–[NG 835 257]

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## Introduction

The 2 km coastal section at Avernish on the northern shore of Loch Alsh exposes a section through part of the Western Unit of the Glenelg–Attadale Lewisianoid Inlier including its western contact with highly deformed Moine semipelite and metaconglomerate (Figure 7.2). In the central part of the Western Unit the felsic gneisses and amphibolitic mafic bodies are cut by mafic dykes, and show relict Archaean and Palaeoproterozoic features. However, deformation increases markedly towards its western contact. The adjacent Moine rocks are generally structurally concordant and intercalated with highly deformed Lewisianoid gneiss of the Western Unit (see also Rubha Camas na Cailinn and Allt Craicraig Coast GCR site reports, this chapter), illustrating that the Lewisianoid basement and its Moine cover were strongly deformed and metamorphosed together during the Caledonian and possibly earlier Knoydartian orogenic events. The Avernish GCR site lies immediately east of the trace of the Moine Thrust (Figure 7.17). Mylonitic and cataclastic structures at Avernish demonstrate the relationships between structural and metamorphic events in the internal parts of the mountain belt and those in the Moine Thrust Belt, which have been the subject of controversy in the tectonic interpretation of the Scottish Caledonides. The evidence at Avernish implies that high-grade rocks of the Caledonian mountain belt were juxtaposed tectonically against low-grade rocks of the Moine Thrust Belt at a relatively late stage of the orogeny.

B.N. Peach and J. Horne mapped the Avernish area during the primary geological survey of the Glenelg district (Geological Survey of Scotland, 1909). A brief account of the 'Western Lewisian' (now termed the 'Western Unit') and of the metaconglomerate, described as 'pseudo-conglomerate', is given in Peach *et al.* (1910). At this time the Moine outcrop was not recognized. Barber (1968) subsequently mapped this southern part of Lochalsh in detail, and Thomas (1973) carried out a reconnaissance geochemical study of the Western Lewisian, including the outcrop of Moine semipelite at Avernish. The lithology and structure of Avernish and surrounding area is further described in Barber and May (1976) and Barber *et al.* (1978), which form the basis of this account.

## Description

Avernish is an area of low hills in the southern part of Lochalsh, situated south of Auchtertyre. The GCR site lies on the west side of the two-pronged peninsula on the north shore of Loch Alsh (Figure 7.17). Here, the coastal section between Port Mor and Nostie Bay provides almost continuous exposure of Moine and Lewisianoid rocks on glaciated shore platforms and in low raised cliffs. Inland, bracken-covered slopes with poor exposure rise to some 100 m above sea level.

At Avernish, gneisses of the Western Unit consist of hornblende- and biotite-bearing felsic gneisses and massive amphibolitic mafic bodies. The gneisses have a coarse layered structure with felsic layers containing 5 mm plagioclase porphyroblasts, alternating with thin hornblende- or biotite-rich layers. The layers are lenticular and are rarely traceable for more than a few metres along strike. Mafic pods or lenses, from metres to tens of metres across, are enclosed by the felsic gneisses, which also form screens between adjacent mafic bodies. Contacts between felsic gneisses and amphibolite are generally gradational. Typically, the amphibolite has a black and white speckled appearance, but is locally foliated. It is composed predominantly of hornblende, plagioclase and epidote. In thin section, both felsic gneisses and amphibolites show relict coarse-grained textures, with replacement of pyroxene by amphibole, garnets partially replaced by biotite and epidote, and exsolution of epidote in plagioclase. These textures show that the mafic bodies were metamorphosed initially under granulite-facies conditions, but have subsequently been retrogressed to amphibolite facies (Barber and May, 1976). The gneisses also commonly contain small pods of hornblende derived from ultramafic rocks.

The foliation in the gneisses dips mainly towards the east or south-east, but is deflected around mafic pods. A prominent SE-plunging lineation, defined by mineral aggregates is commonly developed, but in places, a later fine mineral lineation,

plunging to the ESE, is also seen. Locally, the gneisses are cut by gently ESE-dipping shear-zones, marked by development of a platy foliation and a more-intense ESE-plunging lineation, for example along the shore section to the west of Avernish House [NG 843 261].

However, the greater part of the Avernish shore section shows little evidence of Caledonian deformation and evidently represents the relatively undeformed core of the inlier, comparable to the Eilean Chlamail–Camas nan Ceann GCR site on Loch Hourn. This comparison is reinforced by the common occurrence of 'newer' mafic dykes (cf. Ramsay, 1957b), for example west of Avernish House [NG 842 261] and on islands in Nostie Bay [NG 854 263]. The dykes vary from concordant to discordant relative to the gneissic foliation (Figure 7.18). They are formed of black, fine-grained amphibolite, studded with 2 mm-diameter pink garnet crystals, commonly with biotite-rich margins. Plagioclase feldspar is largely replaced by epidote/ clinozoisite. In parts the dykes show a weak foliation, parallel to that in the adjacent gneiss, and they are cross-cut by rare quartz-feldspar veins, which are rodded like the adjacent gneisses. The gneisses adjacent to the dyke contacts contain small pink garnets, similar to those in the dyke, but garnets are rare elsewhere.

Important exposures occur on the shore platform and in the low cliffs surrounding Rhu Scalvaig [NG 834 257]. Here, the foliation in Lewisianoid felsic gneisses dips at 300–40° to the east. To the west, Lewisianoid gneisses are in sharp contact with a narrow outcrop of gneissose semipelite. The semipelite is composed of thin biotite-rich streaks and quartz lenses, intercalated on a centimetre-scale, and is garnetiferous. Its trace-element geochemistry is similar to Moine semipelites elsewhere in the Highlands, but differs from that of the adjacent Lewisianoid gneisses (Thomas, 1973). The semipelite contains thin psammite units and concordant quartz-feldspar segregations. Its outcrop can be traced NNW through discontinuous exposures to the western side of the point (Figure 7.17). The foliations in the Lewisianoid and Moine rocks are concordant. Metre-scale, Z-profile, reclined folds with E-plunging axes affect both groups of rocks and a rodding lineation parallel to the fold axes is present.

On the western side of Rhu Scalvaig, the gneissose Moine semipelite is underlain by schistose metaconglomerate that contains thin (c. 30 cm) psammite units. The matrix of the conglomerate is dominated by actinolite, biotite and chlorite, but the abundant clasts include: lenticular blocks of layered quartzofeldspathic gneiss, up to 1 m across; rounded blocks of hornblende rock; and irregular twisted masses of vein quartz. The schistosity is commonly folded and the crests of the folds are filled by vein quartz and calcite. SE-dipping extensional shear bands are also developed. In thin section, actinolite, biotite and chlorite define the foliation, which encloses augen of relict hornblende, plagioclase and epidote. Clasts of amphibolite and hornblende rocks are surrounded by radiating aggregates of actinolite needles, suggesting that the schistose matrix was formed, at least in part, from the breakdown of the clasts. Horne (in Peach *et al.*, 1910) interpreted these outcrops as 'crush conglomerate' or 'pseudo-conglomerate', formed tectonically by the shearing and disruption of hornblende Lewisianoid gneiss. However, the rocks resemble the Moine metaconglomerate described at the Attadale and Allt Craic Coast GCR sites, and the close relationship with typical Moine psammites and semipelites indicates that they represent a basal metaconglomerate of the Moine.

North of Rhu Scalvaig (Figure 7.17) well-foliated pink quartzofeldspathic gneisses contain randomly orientated hornblende porphyroblasts up to 3 cm long. The size of the porphyroblasts apparently reflects the ferromagnesian content of the gneisses. Thick ferromagnesian layers are made up of large numbers of small hornblende porphyroblasts, while thin layers normally give rise to a few large porphyroblasts. The hornblende is poikiloblastic, enclosing quartz crystals and aggregates, zircon and epidote, similar to those found in the groundmass. The porphyroblasts generally transect the folds in the gneiss, although in one instance they have apparently grown parallel to the fold axial plane. Locally the porphyroblasts are pseudomorphed by biotite crystals that are randomly oriented, or aligned parallel to the foliation in the ground-mass. At the base of the raised cliff at [NG 834 263], platy gneisses show biotite pseudomorphs, flattened and extended on shear surfaces giving rise to an ESE-plunging mineral lineation. Similar semi-brittle features and an ESE-plunging lineation also occur in mylonitic rocks that form part of the Moine Thrust Belt to the west (see Ard Hill GCR site report, Chapter 5).

## Interpretation

The metaconglomerate at the base of the Moine succession at Avernish indicates that the Moine rocks were deposited unconformably upon Lewisianoid gneiss basement. The effects of Caledonian (and possibly Knoydartian) deformation and metamorphic events on both rock groups can be clearly demonstrated in the narrow outcrop of Moine semipelite and psammite by Rhu Scalvaig. Here, the foliations in the Moine and adjacent Lewisianoid rocks are coplanar, effectively eliminating any original stratigraphical discordance. This deformation also resulted in the tight to isoclinal interfolding of the Lewisianoid basement and its Moine sedimentary cover seen in the Glenelg–Attadale Inlier (see for instance the Rubha Camas na Caillin GCR site report, this chapter). Garnets in the Moine semipelite indicate that deformation took place under amphibolite-facies metamorphic conditions.

Z-profile folds, with a strong axial rodding lineation that plunges to the east, fold the foliation in both the Lewisianoid and Moine rocks. These folds are correlated with the Beinn a' Chapuill phase of folding (see Beinn a' Chapuill GCR site report, this chapter), the second major phase of folding to affect the Moine rocks in the Glenelg area (Ramsay, 1957b). A subsequent post-tectonic amphibolite-facies metamorphic event is indicated by the development of the hornblende porphyroblasts that cut across the folded rocks and associated rodding.

The final phase of deformation on the Avernish peninsula is the local shearing of biotite pseudomorphs after hornblende, resulting in platy zones with a strong south-easterly mineral lineation. This last phase is correlated with the formation of mylonites, the earliest structural event recognized in the Moine Thrust Belt, immediately to the west (Barber, 1965). When the evidence at Avernish is compared to that of the Ard Hill GCR site (Chapter 5), it is clear here that events in the Moine Thrust Belt are later than the main penetrative folding and metamorphism of the Moine and Lewisianoid rocks in the Glenelg–Attadale Inlier and farther east in the orogen. High-grade amphibolite-facies rocks from the interior of the orogen have been tectonically juxtaposed against greenschist-facies rocks of the Moine Thrust Belt during a late stage in the Caledonian Orogeny.

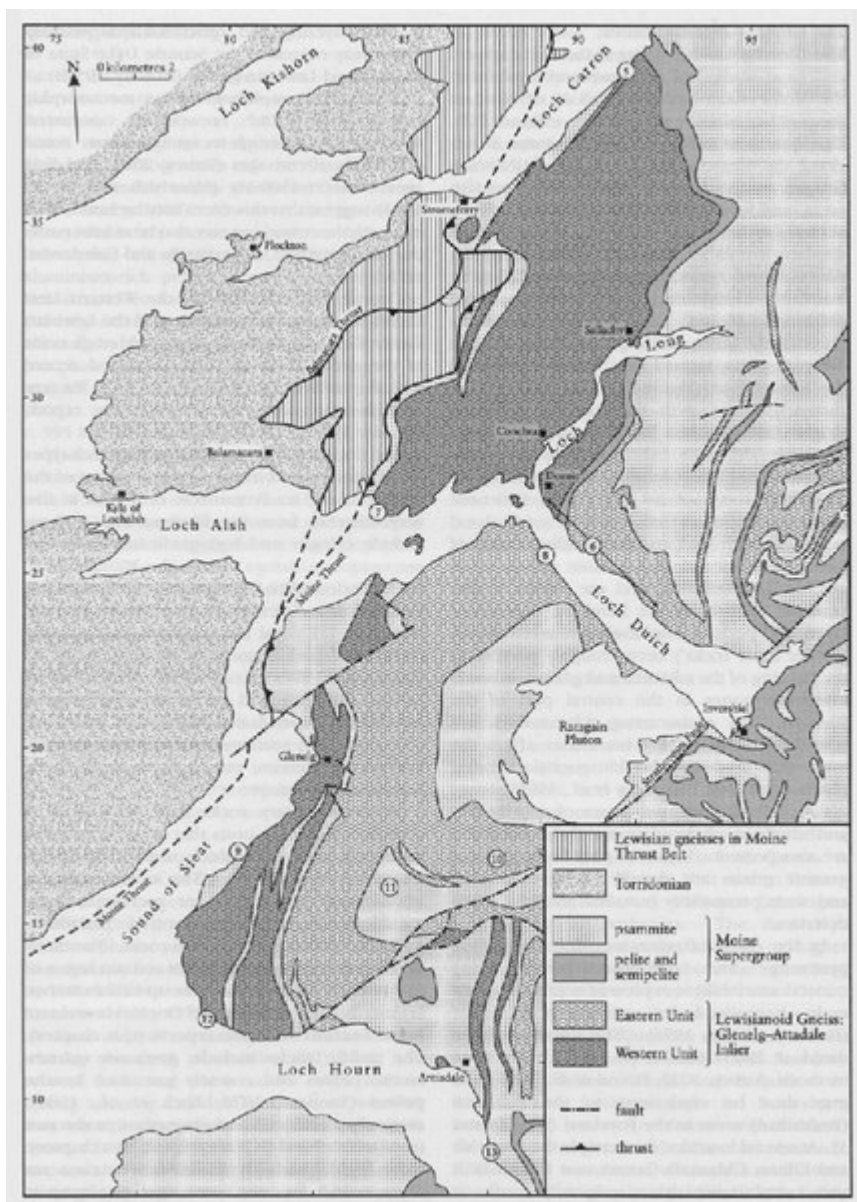
Lewisianoid gneisses and amphibolites in the eastern part of Avernish peninsula show coarse-grained textures and cross-cutting dyke relationships, which indicate that these rocks, in the central part of the Western Unit of the Glenelg–Attadale Inlier, were relatively unaffected by deformation during the Caledonian Orogeny. Caledonian effects are only evident in rocks immediately adjacent to the Moine outcrop, or in localized shear-zones, where the gneisses develop a strong platy foliation, reclined folds and an ESE mineral lineation.

## Conclusions

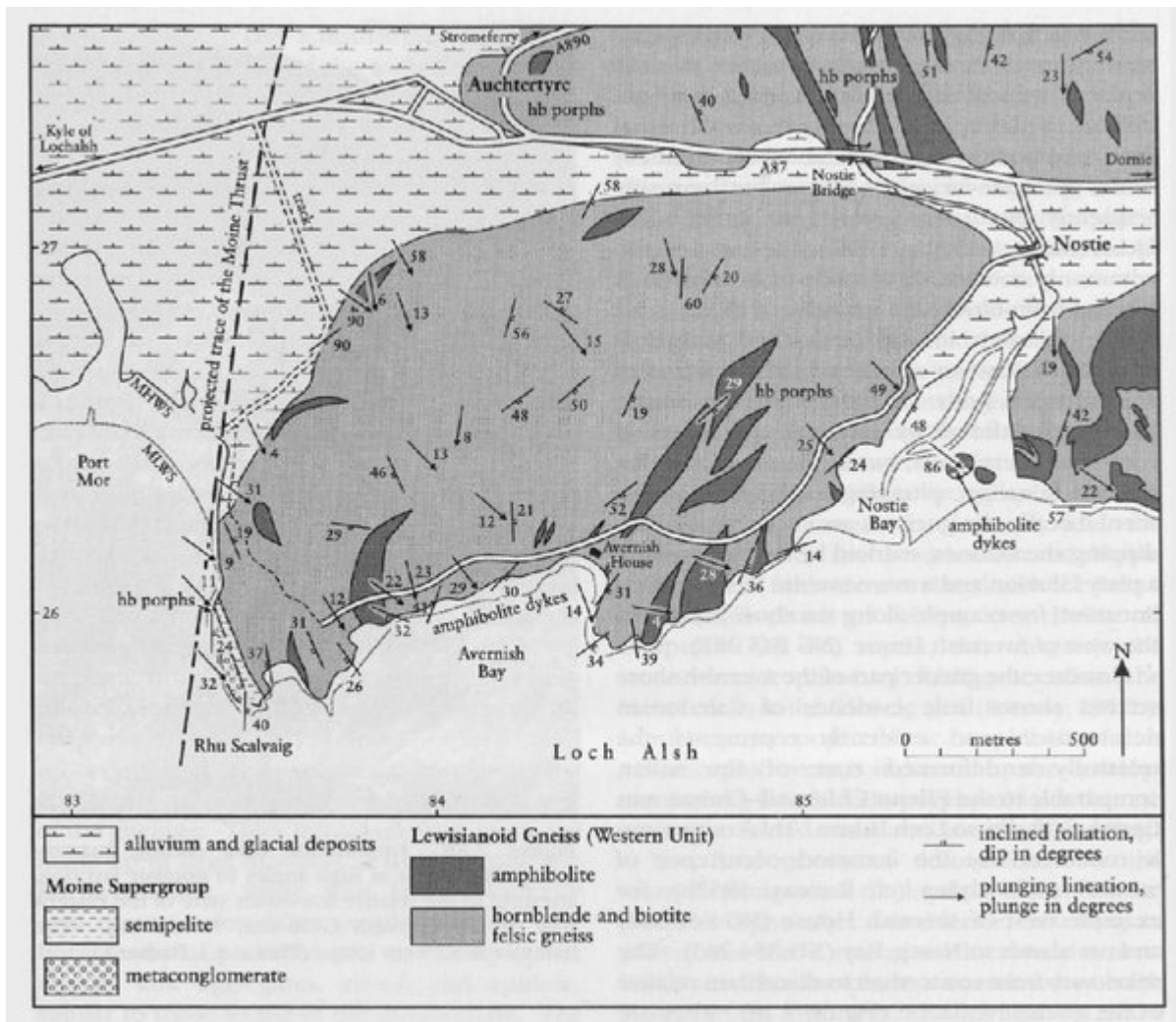
The occurrence of Moine semipelite and psammite at the Avernish GCR site, associated with a basal metaconglomerate containing clasts of the adjacent Western Unit of the Glenelg–Attadale Lewisianoid Inlier, confirms the original unconformable relationships between the Moine succession and the basement Lewisianoid gneisses. However, the parallel interlayering of the Moine and Lewisianoid rocks demonstrates that the two rock groups were both strongly deformed and tightly folded during the Caledonian Orogeny and possibly during the earlier Neoproterozoic Knoydartian event (cf. Rubha Camas na Caillin GCR site report, this chapter). Localized mylonitic deformation in the Lewisianoid gneisses, the latest event in the tectonic history of the Glenelg–Attadale Inlier, is correlated with the earliest structural event in the Moine Thrust Belt. Hence, Caledonian deformation in the Moine Thrust Belt occurred significantly later than in the interior of the orogen. In contrast, outcrops of Lewisianoid gneisses and amphibolites to the east of Rhu Scalvaig demonstrate that the central parts of the Glenelg–Attadale Lewisianoid Inlier were little affected by Caledonian deformation. Here, the original Archaean and Palaeoproterozoic relationships are still largely preserved.

The Avernish GCR site is of national importance, as it demonstrates the critical relationships between Lewisianoid basement inliers and their Moine cover, and enables the sequence of structural and metamorphic events in the interior of the orogen to be compared with that in the Moine Thrust Belt.

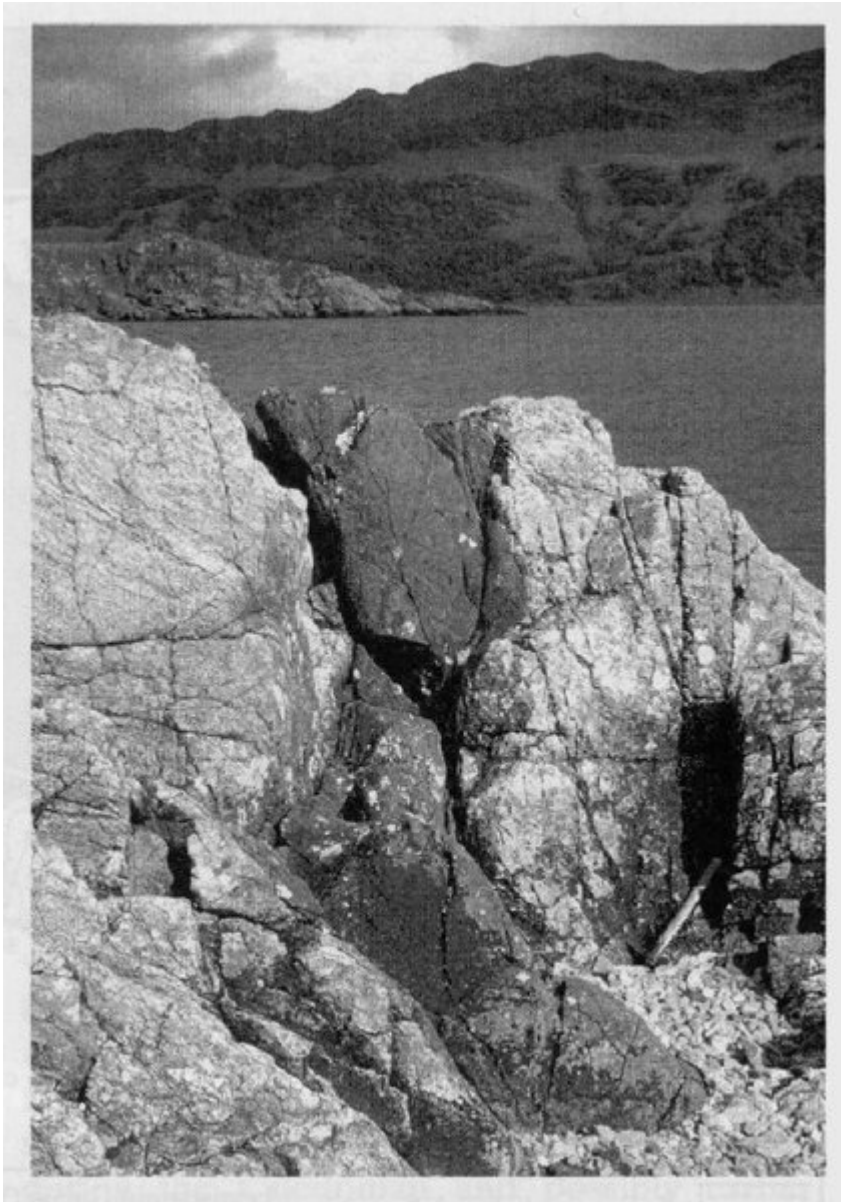
## [References](#)



(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 7.17) Map of the Avernish GCR site. After mapping by A.J. Barber.



*(Figure 7.18) Amphibolite dyke cutting quartzofeldspathic gneiss at high angles to gneissic layering, attesting to the relative low-strain state of the eastern part of the Avernish GCR site, Nostie Bay. The hammer is 37.5 cm long. (Photo: A.J. Barber.)*