Strathan Skerray to Skerray Bay

[NC 639 638]–[NC 667 636]

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Introduction

This site provides excellent exposures of a major basement inlier within the Caledonian orogenic belt of north Sutherland (Moorhouse, 1976; Holdsworth, 1989a; Holdsworth *et* at, 2001). The basement Lewisianoid gneisses form part of the Borgie Inlier, tentatively correlated on lithological and geochemical grounds with the Lewisian Gneiss Complex of the Caledonian Foreland. Geochemical studies indicate that the inlier was affected by granulite-facies metamorphism, possibly equivalent to the Badcallian event of the Caledonian Foreland (Moorhouse, 1976). Subsequently, mineralogical evidence for this metamorphic event has been almost eradicated during the Neoproterozoic and particularly the Caledonian reworking. The western contact of the inlier with the Moine psammites is located in a zone of high tectonic strain but nevertheless is thought to represent a highly modified and inverted unconformity (Holdsworth *et* al., 2001). The Moine rocks and the bulk of the Lewisianoid gneisses display evidence for complex and polyphase Caledonian folding. Structural analysis indicates that the Lewisian inlier occupies the core of a major recumbent antiform (British Geological Survey, 1996, 1997b; Holdsworth *et al.,* 2001), albeit modified by ductile shear-zones (see (Figure 6.3)). The site provides an appreciation of the nature of the sub-Moine basement and the pattern of reworking of that basement during the Caledonian Orogeny.

Description

The westernmost part of the site, west of Port an t-Strathain, exposes medium-grained Moine psammites belonging to the Morar Group with thin discontinuous semipelite layers containing biotite, muscovite and locally garnet. Rare thin layers of feldspar grains may represent original gritty layers. Graded and finely cross-bedded units can be distinguished in lower strain areas. A prominent metamorphic foliation defined by regular colour layering and aligned micas dips moderately to the east. The layering is developed on a scale of 1–3cm and represents bedding (SO) that has been strongly modified as a result of high tectonic strain marginal to the Borgie Inlier. Thin concordant quartz veins and segregations are abundant, as commonly found in such high-strain zones within the Moine succession. A few hundred metres to the west of the site, Moine psammites contain clear examples of inverted cross-bedding and it is probable that the psammites within the site are also mainly inverted although tight folding is present locally.

The contact between the Moine psammites and the structurally overlying Borgie Lewisianoid Inlier on the coast is marked by a brittle fault that dips steeply to the east (Figure 6.21). The fault dies out inland where the contact is represented by a sharp, concordant, moderately E-dipping boundary between Moine psammites and Lewisianoid hornblende-biotite schists (e.g. at [NC 639 311]). Both lithologies are strongly foliated adjacent to this boundary, which was obviously the focus of high tectonic strain.

The main lithology within the Lewisianoid Borgie Inlier is a layered, granodioritic to tonalitic felsic orthogneiss characterized by the alternation of quarrzofeldspathic and biotite- or hornblende-rich layers (with rare garnet) on a scale of 0.5–2cm. The felsic layers are typically interleaved with mafic gneiss, originally basaltic, now invariably amphibolite. Thicker mafic bodies are also common. The gneissic layering strikes north-south in the vicinity of Strathan Skerray but swings to north-west in Skerray Bay. Dips range from 20° to 70° to the east and northeast, generally increasing eastwards. Pods of ultramafic material, commonly now hornblendite, are scattered throughout the gneiss outcrop (e.g. at [NC 651 639]). An extensive sheet of foliated and lineated amphibolite outcrops south-east of Skerray Bay (Figure 6.21), and minor examples also occur in Lamigo Bay [NC 651 635] and west of Skerray Bay at [NC 659 640]. The margins of the amphibolites are locally discordant to the layering within the adjacent felsic orthogneisses. The amphibolites mainly comprise hornblende with subordinate plagioclase and quartz and are interpreted as deformed and metamorphosed basalt or dolerite igneous intrusions.

Three phases of deformation, D1–D3, have been identified in the Moine rocks (Alsop *et al.,* 1996; Holdsworth *et al.,* 2001). The main fold structures are of D2 and D3 age. F2 structures are generally highly attenuated, tight to isoclinal, reclined folds with axes parallel to a prominent ESE- to SE-plunging mineral and extension lineation (L2), defined by quartz-feldspar aggregates. A bedding-parallel S1 mica fabric is folded around F2 fold hinges, and in semipelitic horizons a closely spaced S2 crenulation cleavage is developed axial planar to the folds. Minor F1 folds are rare. D2 structures are locally refolded by open to tight, asymmetrical, reclined F3 folds whose axes generally plunge sub-parallel to L2. D2 and D3 structures are common throughout the outcrop of the Lewisianoid gneisses. The gneissic layering in the Borgie Inlier represents an original pre-Moine, high-grade foliation, which has been modified extensively during the D1–D3 tectonic events outlined above. A mappable F2 synform occurs *c.* 250 m to the west of the Moine-Lewisianoid boundary, and an F3 fold pair is developed within the Lewisianoid gneisses east of Strathan Skerray ((Figure 6.21); Holdsworth *et* al., 2001). Metamorphic grade is difficult to evaluate accurately due to a lack of suitable lithologies. However, the presence of syn-D2 garnets within Moine semipelites and an L2 hornblende lineation within the gneisses suggests that lower amphibolite-facies metamorphism accompanied Caledonian reworking. The Moine and Lewisianoid rocks are cut by late brittle faults that trend approximately both east-west and north-west-south-east (Figure 6.21); none show evidence of significant displacement.

Interpretation

The Borgie Lewisianoid Inlier is interpreted as a part of the continental basement upon which the Moine metasedimentary rocks were deposited unconformably during the early Neoproterozoic. Lithological and geochemical comparisons have led to correlation of the inlier with the Lewisian Gneiss Complex of the Caledonian Foreland (Read, 1931; Soper and Brown, 1971; Moorhouse, 1976). Geochemical studies of the Borgie and other basement inliers have shown that these gneisses are depleted in elements such as potassium and rubidium, consistent with them having undergone granulite-facies metamorphism, possibly equivalent to the late Archaean Scourian event of the Caledonian Foreland. Pyroxene-garnet gneisses preserved in areas of low Caledonian strain within the Borgie and other Lewisianoid inliers may represent relic assemblages formed during this high-grade event (Moorhouse, 1976; Holdsworth *et al.,* 2001). Friend *et al.* (2008) obtained U-Pb SHRIMP zircon ages of *c.* 2880 Ma from the south-east part of the Borgie Inlier. This age was interpreted to date the formation of the Archaean igneous protoliths of the gneisses. The data showed evidence of significant isotopic disturbance at *c.* 1600 Ma. Some of the less-deformed mafic intrusions within the Borgie Inlier may represent reworked members of the mafic Scourie Dyke Suite (see Chapter 3). They exhibit doleritic textures and contain garnets with plagioclase coronas, features typical of metadolerites of the Scourie Dyke Suite that intrudes the Archaean gneisses of the foreland. They are unlike the amphibolites of the Bettyhill Suite that are prominent a little farther east (see Ard Mor GCR site report, this chapter), but when strongly deformed it is difficult to separate the two sets of intrusions.

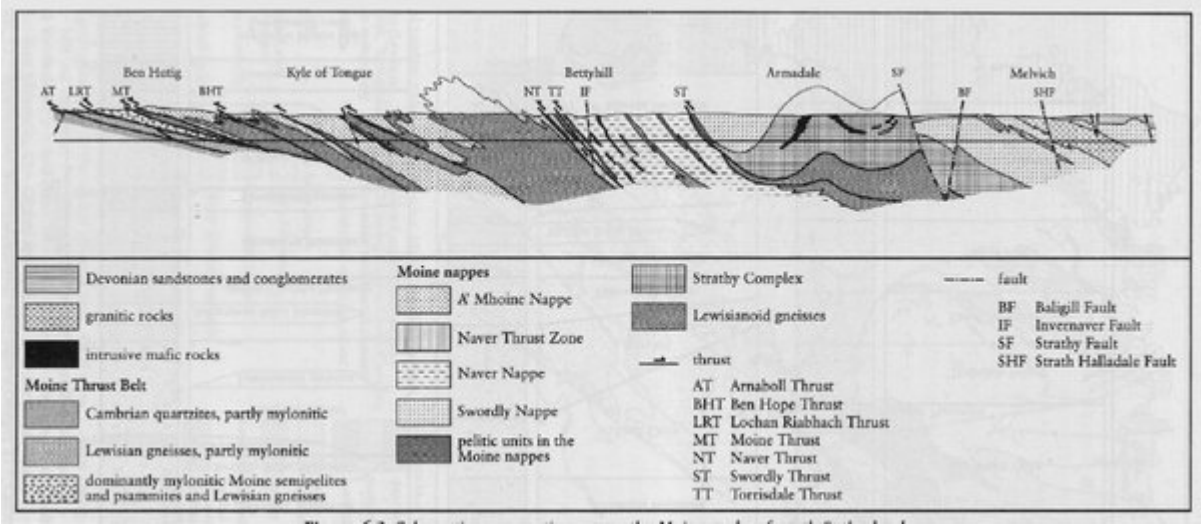
The ESE- to SE-trending L2 mineral and extension lineations in the Moine and Lewisianoid rocks between Strathan Skerray and Strathan Bay are broadly traceable across north Sutherland into the Caledonian Moine Thrust Zone (Holdsworth *et al.,* 2001). Hence D2 and D3 folding and associated metamorphism are considered to be of Caledonian (Ordovician–Silurian) age. F2 and F3 folding have been interpreted to be the result of an essentially continuous, progressive deformation event (Alsop *et al.,* 1996), linked to Caledonian tectonic transport towards the WN'W, parallel to L2. Tight to isoclinal interfolding of Lewisianoid basement and its Moine cover occurred widely during D2 (Holdsworth, 1989a; Holdsworth *et al.,* 2001; see also Ben Klibreck GCR site report, this chapter). Any angular discordance that once existed in the vicinity of the Moine–Lewisianoid unconformity has been diminished as a result of the high D2 strains, and the structural elements in both units are now near-parallel. D1 deformation and metamorphism of the Moine Supergroup and presumably its underlying basement probably occurred at *c.* 800 Ma (Strachan *et al.*, 2002b).

Conclusions

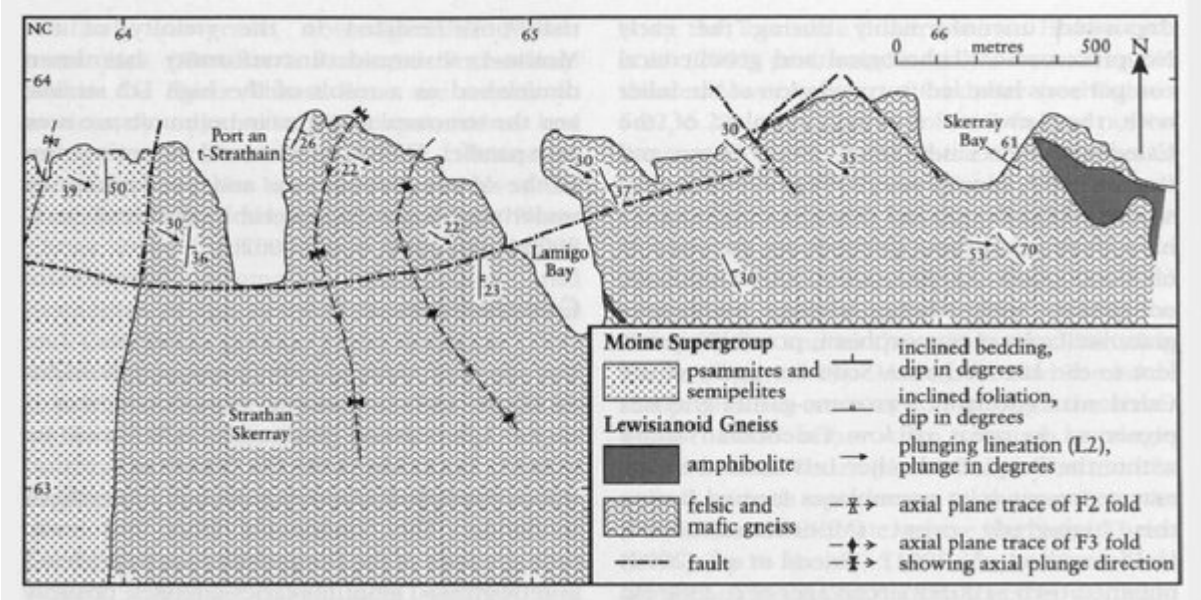
The site is of national importance as it provides excellent and continuous exposure across a major Lewisianoid basement inlier and its western boundary with the Moine succession within the Caledonian orogenic belt of northern Scotland. The Lewisianoid felsic and mafic orthogneisses of the Borgie Inlier are interpreted as retrogressed granulite-facies gneisses, possibly originally contiguous with the Archaean Lewisian Gneiss Complex of the Caledonian Foreland. They represent part of the continental basement upon which the Moine Supergroup was deposited in the Early Neoproterozoic. Both

Lewisianoid and Moine rocks were affected by polyphase folding and amphibolite-facies metamorphism during the Caledonian Orogeny. Tight recumbent interfolding of the Moine and Lewisianoid rocks was associated with WNW-directed translation towards the Caledonian Foreland. Pervasive reworking of the basement gneisses accounts for the general concordance of the metamorphic foliation in the basement with that in the Moine cover.

References



(Figure 6.3) Schematic cross-section across the Moine rocks of north Sutherland.



(Figure 6.21) Map of the Strathan Skerray to Skerray Bay GCR site.