Fannich

[NH 150 742]–[NH 171 712], [NH 185 708]–[NH 205 659]

S.P. Kelley

Introduction

The Moine and Lewisianoid rocks of the Fannich Mountains are folded into the Fannich Synform, a large-scale Caledonian structure which also folds the earlier Sgurr Beag Thrust (Figure 7.1). The Sgurr Beag Thrust juxtaposes middle amphibolite-facies pelitic and semipelitic rocks of the Glenfinnan Group, interleaved with felsic and mafic gneiss inliers of probable Lewisianoid origin, against lower amphibolite-facies psammites and pelites of the Morar Group.

The area was first mapped by J. Horne for the Geological Survey and described in the memoir for the Fannich Mountains (Sheet 92) (Geological Survey of Scotland, 1913a; Peach *et* al., 1913). Horne recognized the importance of the difference between the two pelites of the area, the Meall an t-Sithe Pelite and Sgurr Mòr Pelite formations, describing the former pelite as a gneiss. Even at this early stage there was controversy concerning the mainly felsic gneisses at the core of the Fannich Mountains. The high structural level of the gneisses in the succession (Figure 7.3), (Figure 7.4) implied some sort of stratigraphical or structural break, but the lithologies of the area seemed to form a simple syncline with the gneisses apparently overlain and underlain by Moine lithologies. In 1898, W Gunn and J. Horne postulated a thrust relationship between the Lewisianoid gneisses and the Meall an t-Sithe Pelite, but in the memoir (Peach *et al.,* 1913), a 'fan shaped anticlinorium' of nappes was preferred. Later published work on the Fannich Mountains generally placed stratigraphical breaks in the succession in order to explain the presence of the Lewisianoid gneisses (Rutledge, 1952). However, Sutton and Watson (1954) used 'way-up' criteria from the metasedimentary succession to suggest that the supposed Lewisianoid inliers lay at the top of a continuous sequence. They rejected the notion of Lewisianoid parentage and interpreted them as an integral part of the Moine succession, preferring the name 'Fannich Gneisses'. It was not until 1962 that Sutton and Watson accepted a Lewisianoid origin for the Fannich gneisses, following detailed work on the Glenelg–Attadale Inlier by Ramsay (1957b — see also Allt Cracaig Coast GCR site report, this chapter).

Winchester (1971, 1973) studied essentially the same area as Sutton and Watson (1954), and demonstrated geochemical differences between the Moine and felsic gneiss lithologies. He deduced that the gneisses were most likely of Lewisanoid origin, interleaved with the Moine metasedimentary succession. Winchester (1973) refined the Sutton and Watson (1954) stratigraphy, and extended the outcrop of the Lewisianoid 'Fannich Gneisses' south of Loch Fannich. He also interpreted spindle-shaped quartzofeldspathic pods as a basal metaconglomerate between the Meall an t-Sithe Pelite Formation and the Lewisianoid felsic gneisses. He considered, but eventually rejected, the presence of the Sgurr Beag Thrust at the boundary between the Meall a' Chrasgaidh Psammite Formation and the Meall an t-Sithe Pelite Formation.

Kelley and Powell (1985) established the presence of the Sgurr Beag Thrust at the boundary between the Meall a' Chrasgaidh Psammite and the Meall an t-Sithe Pelite around the northern end of the main Fannich Synform and in a small structural outlier immediately north-west of Loch a' Bhraoin (Figure 7.4), which is described in the Meall an t-Sithe and Creag Rainich GCR site report (this chapter).

The importance of the Fannich Mountains lies in their unique position between the type area for the Sgurr Beag Thrust in the Kinlochhourn area (Tanner 1971) (see Kinloch Hourn GCR site report, Chapter 8), where it juxtaposes Morar Group and Glenfinnan Group rocks, and the Moine rocks of Sutherland, to where the Sgurr Beag Thrust has been traced (see Chapter 6). The Fannich Mountains represent the northernmost closure of a structural outlier that lies west of the main outcrop of the Sgurr Beag Thrust and extends SSW for 42 km to Beinn Dronaig (Figure 7.1).

Description

The Fannich Mountains form a broadly triangular area, some 10 km across in its wider southern part, that lies to the north of Loch Fannich. It contains eight peaks over 900 m, but much of the lower slopes are blanketed by peat, till and morainic material. Rock outcrops are found on the steeper hillsides and cliffs, in the stream sections, and along Loch Fannich. The most accessible sections are in the hills and streams north of Fannich Lodge, along the shore of Loch Fannich, and in the Allt Breabaig.

The Moine lithologies of the area are readily split into two structurally distinct successions, attributed to the lower Morar Group and the upper Glenfinnan Group, separated by a tectonic break, the Sgurr Beag Thrust (Figure 7.3), (Figure 7.4). The thrust is marked by a high-strain zone that can be traced around the later synform from the shores of Loch Fannich northwards, returning south to the west of the loch in the flat-lying limb (Figure 7.4). The Morar Group comprises the Inverbroom Psammite Formation (Holdsworth *et al.,* 1994), the Sgurr Mòr Pelite and the Meall a' Chrasgaidh Psammite (Figure 7.3). The upper succession consists of intercalated Meall an t-Sithe Pelite (Glenfinnan Group) and Lewisianoid gneisses.

The Inverbroom Psammite and Sgurr Mòr Pelite formations locally contain well-preserved sedimentary structures such as small cross-bedded channel fills and slump-folds, whereas in the Meall a' Chrasgaidh Psammite all early structures have been brought into parallelism by subsequent deformation. Where seen, the sedimentary structures indicate that the succession is 'right-way-up'. The Inverbroom Psammite Formation typically consists of psammite beds 10–15 cm thick with minor pelites, rare calc-silicate layers and some heavy-mineral bands. Massive psammite units up to 2 m thick and coarse gritty units are also present. The psammites pass gradationally upwards into the Sgurr Mòr Pelite Formation, a massive schistose biotite pelite with subsidiary interbedded semipelites. Calc-silicate rock lenses are common and concordant amphibolites are recorded in parts. North of Loch Fannich, around [NH 207 667], several massive psammite beds crop out within the steeply dipping Sgurr Mòr Pelite. The pelite grades up into the Meall a' Chrasgaidh Psammite Formation, which occupies a belt 100–300 m wide and consists of thinly layered psammites and minor semipelites. It represents the uppermost Morar Group lithology in the Fannich Forest. In the stream section south-west of Allt a' Choire Mhòir at [NH 198 675], thin dark-grey psammites contain hornblende, sphene and epidote but no micas. Sutton and Watson (1953) found similar minerals in psammites of the Scardroy area, which they correlated with the Meall a' Chrasgaidh Psammite. Above the Sgurr Beag Thrust, the Meall an t-Sithe Pelite Formation (Glenfinnan Group) occupies the major part of the Fannich Synform, resting everywhere upon the Meall a' Chrasgaidh Psammite. It forms the upper part of Sgùrr nan Clach Geala (Figure 7.5)a and has a wide outcrop across Sgùrr Mòr [NH 176 689] and Sgùrr Breac [NH 158 711] to Loch Toll an Lochain. This pelitic unit is a dark-grey, gneissose, locally migmatitic, garnetiferous muscovite-biotite semipelite and pelite with distinctive claret-coloured garnets and abundant quartz-feldspar segregation pods and veins, generally orientated parallel to the overall foliation (Figure 7.5)b. Concordant and discordant amphibolite pods are present, and although pelitic lithologies dominate, psammites are seen on Sgùrr nan Each [NH 185 697].

Lewisianoid granodioritic and granitic gneisses extend NNW from Torran Ruadh [NH 190 671] to the western flank of Sgùrr nan Clach Geala and across the Allt Breabaig to the northern end of Druim Reidh (Figure 7.4). A 1 km-long section is seen in the upper part of the Allt Leac a' Bhealaich (NH 17 70). The gneisses also crop out more sparsely around the western part of Loch Fannich, extending west onto An Sgùman [NH 138 691]. They are typically strongly layered and folded quartz-plagioclase-biotite gneisses with subsidiary epidote. Scattered hornblende and amphibolite pods from a few centimetres to *c.* 1 m across are common. Thicker sheets and irregular lenses of amphibolite and hornblende schist are also present, for example on Creag an Fhuarain [NH 177 713], where an amphibolite sheet defines a large, very tight, reclined fold and attains a thickness of 250 m in its hinge zone (Peach *et al.,* 1913, p. 67).

In the Moine rocks a bedding-parallel schistosity (S1), folded by F2 isoclinal folds provides the only evidence of the earliest D1 deformation. F2 folds are most numerous close to the top of the Morar Group in the Meall a' Chrasgaidh Psammite Formation, adjacent to the Sgurr Beag Thrust. No large-scale F2 folds are seen in the Morar Group in the Fannich area, although the associated S2 schistosity is ubiquitous. Close to the Sgurr Beag Thrust, S2 and L2 are also strongly developed. Within the Meall an t-Sithe Pelite, the S2 fabric is a pervasive schistosity. Near to the Sgurr Beag Thrust the petite becomes more highly deformed, in parts resembling an augen gneiss, and close to isoclinal F2 folds of the quartz-feldspar segregation veins are common. The later F3 folds associated with the broad Fannich Synform are the most common folds throughout the area and crenulate the D2 foliation/schistosity in the pelitic units. The open asymmetrical F3 Fannich Synform has an E-dipping axial plane and controls the regional outcrop pattern. It folds the

interleaved Moine and Lewisianoid rocks, the S2 structures and fabrics, and the Sgurr Beag Thrust itself (Kelley and Powell, 1985). The eastern limb of the synform is characterized by moderate to steep westerly dips and is best exposed in streams flowing south from the Fannich Mountains to Loch Fannich. The gently E-dipping western limb is exposed close to the A832 road between Braemore Junction [NH 209 777] and Dundonnell (Figure 7.4).

A section through the gently dipping western limb is exposed in the Allt Breabaig [NH 174 707]–[NH 163 751]. In the northern part of the burn section, highly strained Meall a' Chrasgaidh Psammite is exposed until the Sgurr Beag Thrust is reached. The thrust is well exposed in the stream and on the surrounding slopes, where tight to isoclinal F2 folding is seen. Farther upstream, Lewisianoid felsic gneisses are characterized by coarser textures and a strong stretching lineation. Tight to isoclinal folds are very abundant. Winchester (1971) showed that the gneisses could be distinguished readily from the surrounding Moine rocks on the basis of their whole-rock geochemistry.

Interpretation

The structural sequence in the Fannich Mountains has been folded by the Caledonian-age F3 Fannich Synform. This synform folds the Sgurr Beag Thrust and related D2 structures, and forms part of a large structural outlier of Glenfinnan Group rocks. The thrust marks the position of the Morar Group–Glenfinnan Group boundary and also coincides with a metamorphic break between the lower-grade Sgùrr Mòr Pelite (Morar Group) in the footwall and the higher-grade Meall an t-Sithe Pelite (Glenfinnan Group) in the hangingwall. As the thrust is approached a profile of increasing strain defines a shear zone, marked by development of a more-platy pervasive cleavage/schistosity (S2), an increased parallelism of D2 and earlier structures, an abundance of tight to isoclinal folds, and intensification of the L2 lineation. The Sgurr Beag Thrust places apparently younger rocks (Glenfinnan Group) over older rocks (Morar Group), but the presence of Lewisianoid gneisses and its correlation to a similar structural geometry to the south has resulted in its interpretation as a thrust.

Although peak metamorphic ages have not been determined directly from the Fannich area, they are most probably around 450 million years old, similar to ages derived farther south (Brewer *et al.,* 1979). However, Tanner and Evans (2003) showed that the Sgurr Beag Thrust near Lochailort may have an important component of Knoydartian (*c.* 740 Ma) movement.

The Fannich Synform is thought to pre-date the early Scandian development of mylonites along the Moine Thrust Belt. D2 and D3 macro-and micro-deformational textures in the Fannich area can be traced along Loch a' Bhraoin towards the Moine Thrust Belt where they are overprinted by mylonitic fabrics (Kelley and Powell, 1985; see Meall an t-Sithe and Creag Rainich GCR site report, this chapter). Hence, the Fannich Synform probably formed prior to the time indicated by the K-Ar cooling ages obtained by Kelley (1988). Kelley showed that mica K-Ar ages varied with grain size, implying that the grains were partially reset during late Caledonian dynamic recrystallization, probably during D3, when the Fannich Synform was formed. The mean cooling ages in Fannich for 250–500 tun grain-sizes were 434 ± 9 Ma for muscovite and 434 ± 8 Ma for biotite (Kelley, 1988). Muscovite ages of 440–435 Ma were obtained close to the Moine Thrust Belt (see also Freeman *et al.,* 1998). These Scandian ages suggest that pervasive deformation and fluid effects related to the ductile movements on the Moine Thrust penetrated the hangingwall Moine and Lewisianoid succession for several kilometres above the thrust. The effects can be traced laterally some 18 km east of the Moine Thrust trace.

The Lewisianoid felsic gneisses have been variously interpreted as Moine lithologies (Sutton and Watson, 1954) and Lewisianoid inliers (Peach *et al.,* 1913; Winchester, 1971, 1973). The gneisses are repeated across F3 open to tight folds but also have been affected by earlier D2 tight to isoclinal folds on various scales. They have been strongly reworked by the various Caledonian and probably earlier Knoydartian deformation and metamorphic events. Hence, they lack the diversity of features of the less-deformed Lewisianoid gneisses found in the larger Scardroy and Borgie inliers. They are both underlain and overlain by the Meall an t-Sithe Pelite, but it is unclear whether these boundaries represent modified unconformities (i.e. they are tight to isoclinal folds) or are the site of D1 or D2 slides or thrusts.

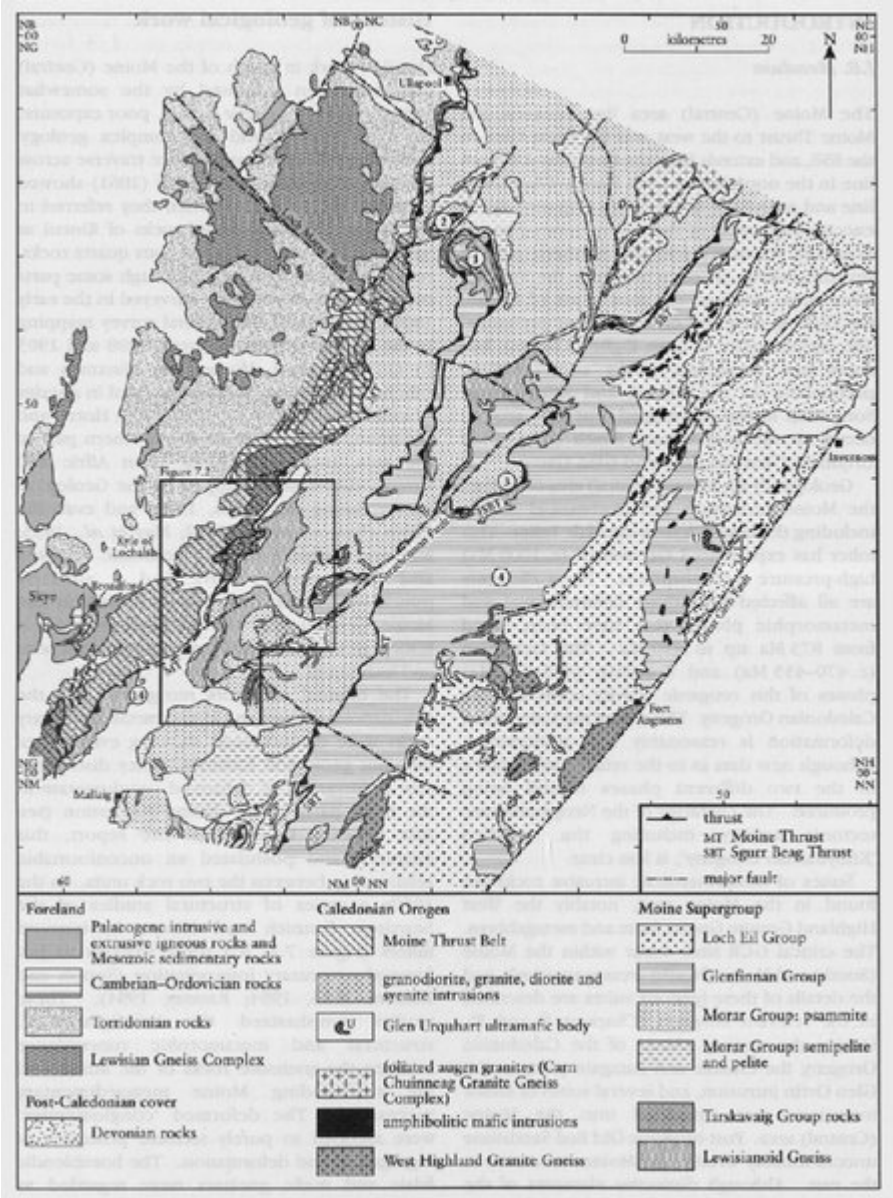
The gneisses have been correlated with the foreland Lewisian Gneiss Complex to the west, as this is the closest Archaean/Proterozoic gneiss terrain, but a strict Lewisian parentage is not fully proven. They retain enough features to allow their complex pre-Caledonian Lewisianoid parentage to be recognized, although their highly deformed nature and

limited outcrop inhibit further investigation.

Conclusions

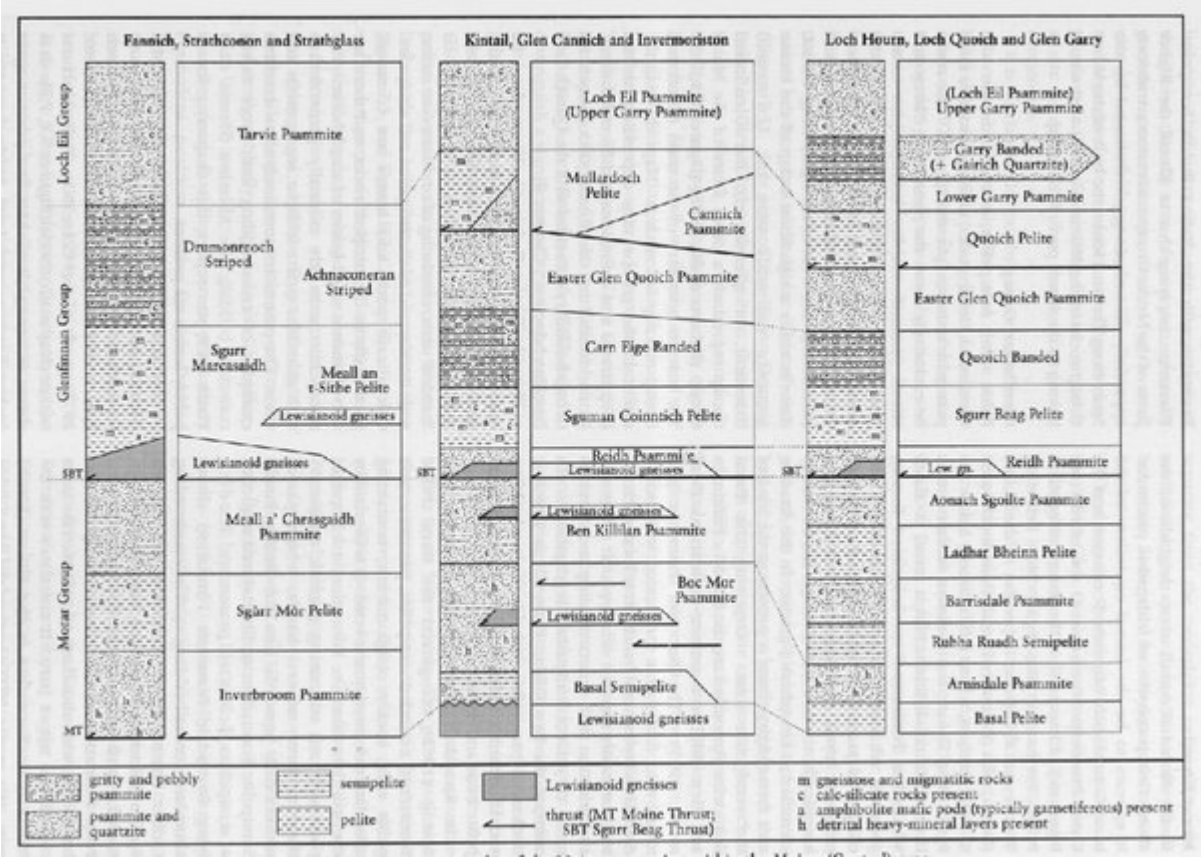
In the Fannich Forest area Moine rocks of the Glenfinnan Group and Lewisianoid felsic gneisses form a structural outlier west of the main outcrop. These distinctive units were intercalated early in the tectonic history of the area, and subsequently the composite succession has been thrust to the WNW over Morar Group rocks along the Sgurr Beag Thrust. The later asymmetrical open to close F3 Fannich Synform has folded the main penetrative Caledonian and earlier structures, the metamorphic fabrics and the Sgurr Beag Thrust. This F3 deformation in turn pre-dated the formation of the Moine mylonites during the mid-Silurian-age Scandian Event. The Fannich site contains one of the northernmost and structurally simplest exposures of the Sgurr Beag Thrust, yet the thrust can still be correlated southwards to the type area (see Kinloch Hourn GCR site report, Chapter 8). Earlier studies in the Fannich area presented radically different interpretations of the Lewisianoid gneiss inliers. The site is nationally important from the historical aspect, and because its geology links folding, thrusting and metamorphic fabrics and mineralogies in the internal part of the Caledonian Orogen with those in the nearby Moine Thrust Belt. It retains the potential for further detailed studies of the relationships between its different geological elements.

References

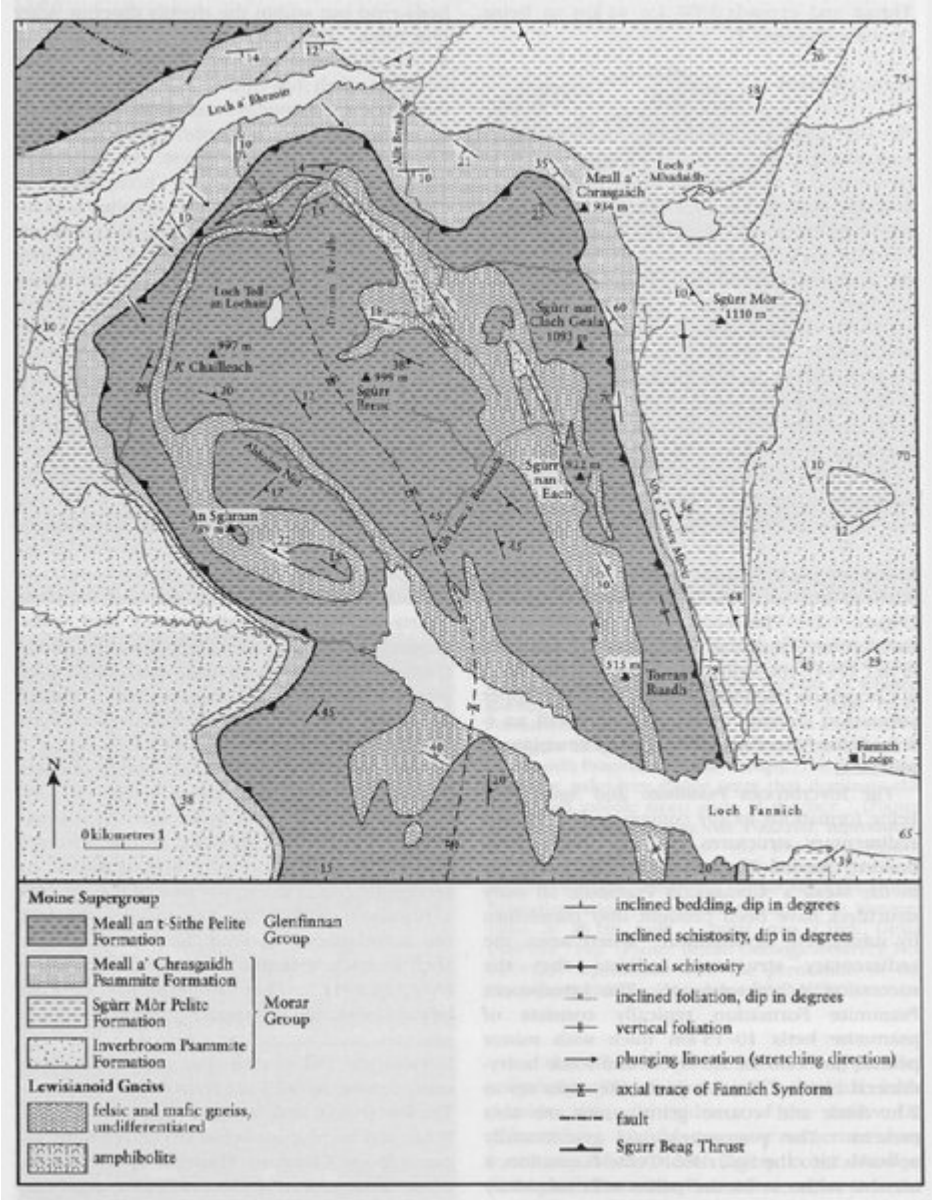


(Figure 7.1) Geological map of the Moine (Central) area, with the location of the GCR sites: 1 — Fannich; 2 — Meall an t-Sithe and Creag Rainich; 3 — Loch Monar; 4 — Abhainn Gleann nam Fiadh; 14 — Ard Ghunel. GCR sites 5–13 are

located within or marginal to the Glenelg–Attadale Inlier and are shown on Figure 7.2.



(Figure 7.3) Tectonostratigraphy of the Moine succession within the Moine (Central) area.



(Figure 7.4) Geological map of the Fannich Mountains. Based on Geological Survey of Scotland (1913a) (Sheet 92), and Kelley and Powell (1985).

(Figure 7.5) (a) View south-west of the east face of Sgùrr nan Clach Geala [NH 184 715]. The uppermost dark-grey part of the mountain consists of foliated gneissose semipelite of the Meall an t-Sithe Pelite Formation (Glenfinnan Group), which is separated by the Sgurr Beag Thrust from the underlying Meall a' Chrasgaidh Psammite (Morar Group). The psammites form the paler-grey, flaggy crags that dominate the lower and middle steep parts of the Eace. (Photo: British Geological Survey, No. P002105, reproduced with the permission of the Director, British Geological Survey, © NERC.) (b) Foliated gneissose muscovite-biotite semipelite of the Meall an t-Sithe Pelite Formation (Glenfinnan Group). The hammer head is 16 cm long. Sgùrr nan Clach Geala [NH 184 715]. (Photo: British Geological Survey, No. P215729, reproduced with the permission of the Director, British Geological Survey, © NERC.)