
Excursion 9 Loch a' Bhraoin, Braemore and Loch Broom

Simon Kelley

Purpose:

A traverse across the Moine from a major internal ductile thrust, the Sgurr Beag Thrust, to the margin of the orogen, the Moine Thrust Zone.

Aspects covered:

The increase of deformation into the Sgurr Beag Thrust, post-thrusting deformation and formation of the Moine mylonites, shear fabrics in psammites and pelites, the Moine Thrust plane.

Useful addresses:

The Tourist Information Office, Ullapool; Inverbroom Estate (Mr Cameron, Home Farm, Inverbroom [Tel: 01854 655252]).

Maps:

OS: 1:25,000 sheets 435 An Teallach & Slioch, 436 Beinn Dearg & Loch Fannich; BGS: 1:63,360 sheets 92 Inverbroom, 101E Ullapool.

Types of terrain:

The Sgurr Beag Thrust traverse has easy walking on paths and stream sides. The traverse up to the Moine Thrust has: *Option A* – open country, climbing up to 500m; and *Option B* – easy walking on seashore and roadside.

Distance and time:

Option A – car not used after Locality 9.1, on foot 19km. A full day (8 hours). *Option B* – by car, 20km (1 hour), on foot 9.5km (4 hours).

Short itinerary:

The Sgurr Beag Thrust traverse (Locality 9.2) is a complete excursion on its own and can be covered in about 3.5 hours. The Moine Thrust can be covered briefly by a quick visit to the Corrieshalloch Gorge (Locality 9.7) and the lochside exposures (Locality 9.9), all of which can be seen in 3-4 hours.

The first section of this excursion consists of a traverse from Morar Group psammites and pelites across the Sgurr Beag Thrust into Glenfinnan Group migmatites and Lewisianoid basement gneisses. The second part, a traverse into the Moine Thrust Zone, can be approached in two ways. *Option A* (Figure 9.1 and Localities 9.1-9.7) is a walk along the ridge from Meall an t-Sithe to Creag Rainich, affording an excellent opportunity to observe the relationship between the Sgurr Beag Thrust and the Moine Thrust at their closest approach. However, this option involves a 500 m ascent and the area does not afford much shelter in bad weather. Further, the ground is used for deer stalking from August to February. *Option B* (Figure 9.1 and Localities 9.8-9.10) illustrates the increasing breakdown of earlier peak metamorphic fabrics in psammites and pelites of the Morar Group as the Moine Thrust Zone is approached. Viewing of the low-level roadside and shoreline exposures is not restricted by weather or deer stalking.

The apparently simple stratigraphy of Moine rocks in the Loch a' Bhraoin, Braemore and Loch Broom area is misleading. At the base of the succession, the Inverbroom Psammite (Figure 9.1) varies from 2.7km thick to less than 400m where it is cut out against the Moine Thrust. Common sedimentary structures indicate that it is 'right way up' throughout the area. The Sgurr Mor Pelite (Figure 9.1) lies above the Inverbroom Psammite (it also exhibits sedimentary structures indicating 'right way up') and ranges from 950m to less than 20m thick at Meall Dubh where it interfingers with the Inverbroom Psammite. This pelite is important for correlations since it contains stratabound amphibolites (Winchester, 1976). The Sgurr Mor Pelite passes upward into the Meall a' Chrasgaidh Psammite through a sedimentary transition, and this psammite occupies a belt 100m-130m wide adjacent to the Sgurr Beag Thrust. No sedimentary structures have been preserved in this highly deformed psammite.

All the units below the Sgurr Beag Thrust are part of the Morar Group. However, direct correlations between these units and those of the type area in Morar, over 150km to the south, are tenuous because units such as the Sgurr Mor Pelite are clearly laterally discontinuous. All Morar Group rocks in the area contain calc-silicate pods that have been used to determine metamorphic grade in the absence of aluminosilicate indicator minerals (Winchester, 1974).

Lying above the Sgurr Beag Thrust, the Meall an t-Sithe Pelite is the only representative of the Glenfinnan Group (Figure 9.1). This coarse-grained migmatitic pelite has clearly undergone a very different tectono-metamorphic history to rock types below the thrust. The Meall an t-Sithe Pelite contains amphibolites of tholeiitic origin (Winchester, 1976), but no calc-silicate pods nor sedimentary structures.

Lewisianoid gneisses lie between two lithologically and chemically identical units of the Meall an t-Sithe Pelite (Figure 9.1). The basement gneisses are isoclinally folded with the Glenfinnan Group migmatites. Though only a 100m-150m-wide outcrop of the Lewisianoid gneisses is present, they are distinct from the Moine rocks, consisting of mainly siliceous acidic and hornblendic gneisses with minor calcareous, epidotic and pyroxenic horizons.

The Sgurr Beag Thrust section [NH 177 768] to [NH 116 723]

The first locality (Figure 9.1) of the section is on the A832 Gairloch road 4.5km from Braemore junction [NH 209 777] with the A835 Ullapool road (not to be confused with the junction close to Garve) and about 16km from Dundonnell. Roadside exposures between Braemore junction and the parking place are psammites of the Inverbroom Psammite, containing occasional interbedded pelites (Figure 9.1). Parking for three cars is available by the bridge over Allt Leacach (Figure 9.1), (Figure 9.2). This section of the A832 road ('Destitution Road') to Dundonnell was first built in 1846 to assist years of poverty and famine in the area after several consecutive years of bad weather causing crop failures.

Locality 9.1 Allt Leacach [NH 177 768]

Allt Leacach (Figure 9.1). Start of the Sgurr Beag Thrust traverse (900-800m structurally below the Sgurr Beag Thrust).

The Inverbroom Psammite exposed in the waterfalls above and below the bridge, consists of banded psammites and semi-pelites with a flat-lying D_2 planar fabric crenulated by D_3 . Occasional minor D_3 folds are exposed in the stream below the bridge. Note particularly the undulating style of the bedding planes with rare cross-bedding, the angular discordance between early quartz veins and the foliation/bedding plane, and the intensity of the stretching lineation in the psammites.

About 1.5km further down the road towards Dundonnell, an untarred track leads from the road to the SW [NH 162 761]. Parking for five cars is available in a lay-by, 100m further along the road.

Locality 9.2 Allt Breabaig [NH 156 752] to [NH 166 723]

Allt Breabaig (Figure 9.2). A section from the Morar Group rocks across the Sgurr Beag Thrust into Glenfinnan Group migmatites and the Fannich Lewisianoid basement inlier (Figure 9.1).

From the parking place, follow the track for about 1km to the bridge [NH 1585 7500]. Note the exposure of the Sgurr Mor Pelite in the stream by the lochside, 2A [NH 1565 7490] (350m below the Sgurr Beag Thrust, (Figure 9.2)) which exhibits deformed quartz veining and a stretching lineation (trending at 135°) that is stronger than that at Locality 9.1. Rare sedimentary structures are flattened in the plane of the foliation and pelite-rich horizons have been crenulated by the post-thrusting D_3 deformation.

Follow the path leading from the bridge and up the glen between Druim Reidh and Meall a' Chrasgaidh. As the path drops down to follow the burn, exposures of the Meall a' Chrasgaidh Psammite are visible in its banks, 2B (250m below the Sgurr Beag Thrust, (Figure 9.2)). Compare the near-parallelism of sedimentary structures, foliation and early quartz

veins with the equivalent relationships in Locality 9.1 and stop 2A that were further beneath the thrust. Note the increased intensity of the stretching lineation in these psammites. A later minor curved D_3 fold hinge in one of these exposures folds the foliation and lineation related to the development of the D_2 Sgurr Beag Thrust. All localities in this excursion lie on the shallow-dipping limb of a major N-S-trending D_3 syncline (Figure 9.1) overturned towards the west. Many minor folds of the D_3 generation exhibit curved hinges.

Large exposures of the planar-bedded psammites, 2C (75m-25m below the thrust, (Figure 9.2)) have been created by waterfalls further up the stream. These exposures have a 'tramline' style foliation and increasingly intense stretching lineations. It is difficult, by this stage of the deformation, to distinguish any angular discordance between the foliation and early quartz veins.

Exposures of the planar-bedded psammites above the waterfalls exhibit occasional dark bands, less than 1cm thick, lying nearly parallel to the foliation. These bands are haematized cataclastic zones, almost certainly associated with late brittle movements on the Moine Thrust Zone that lies only 6km to the west or 1.5km vertically below these exposures.

The lower boundary of the Meall an t-Sithe Pelite is heralded by waterworn exposures of pelitic migmatites in the banks of the burn, 2D (Figure 9.2). The actual contact is exposed on the Meall an t-Sithe to Creag Rainich ridge (*Option A*) where it is found in its original shallow lying position, in contrast to the steeply-dipping outcrops in the southwest Moine (see Excursions 4 and 5). Folds of thrust-generation age can be seen at [NH 155 741] by making a diversion at the end of the traverse on the way back to the farmhouse (or close to the summit of Meall an t-Sithe, *Option A*). These are a feature of the Sgurr Beag Thrust elsewhere (Rathbone & Harris, 1979), but are rare in this area.

In the first exposures above the Sgurr Beag Thrust, the *lit-par-lit* texture that is characteristic of these rocks has been destroyed by deformation associated with displacement along the thrust. Note that the shallow-lying foliation and stretching lineation (still trending 135°) are stronger than those further from the thrust.

Pelitic migmatites have retained their *lit-par-lit* texture further up the stream, 2E (50 m above the thrust, (Figure 9.2)). The migmatization is thought to have occurred during the Neoproterozoic Knoydartian event and the migmatitic fabric was subsequently deformed during Caledonian thrusting.

The composite fabric exhibits later crenulations, due to the post-thrust D_3 deformation.

Pale coloured acidic Lewisianoid basement gneisses are exposed in the stream bed and by the stream a few metres above the ruined croft, 2F (150m above the thrust, (Figure 9.2)). These are characterized by stronger foliations and stretching lineations than those in the Moine rocks further downstream. The orientations of the foliation and lineation correspond closely with those seen in the Moine psammites. Refolded isoclines in some exposures testify to the complex polydeformational history of the rocks.

The Fannich outcrops of Lewisianoid basement gneiss have been the subject of controversy throughout the history of their study. The original Geological Survey workers disagreed over their outcrop pattern, some believing that it represented a Lewisian basement core to the Moine rocks in a 'fountain of nappes', and others that the outcrop represented a block of Lewisian translated to its present position along a thrust plane. No field evidence was produced for the latter view, but they believed that it lay at the boundary between the Meall an t-Sithe Pelite and the Meall a' Chrasgaidh Psammite (now generally accepted to be the position of the Sgurr Beag Thrust). Some years later, Sutton & Watson (1954) discounted the idea that the gneisses of Fannich were basement at all, and maintained that they were an integral part of the Moine succession. Subsequent work on the geochemistry of the gneisses (Winchester, 1971) re-established their basement affinities. Although the Lewisianoid gneisses and Moine migmatites (above and below the gneisses) are certainly interfolded, the precise structural relationship still remains uncertain.

Return to the bridge [NH 1585 7500]. Exposures of sheared isoclines in the Meall a' Chrasgaidh Psammite lie close to the 450m contour on the NE-trending spur at the head of the glen [NH 155 742]. From these exposures, simply walk down the spur and rejoin the path to the bridge.

Option A

From the bridge, proceed NW to the summit of Meall an t-Sithe (2 km distance, 350m climb).

Locality 9.3 Meall an t-Sithe [NH 141 765]

Meall an t-Sithe (Figure 9.1). An exposure of the Sgurr Beag Thrust.

The contact between the Meall an t-Sithe Pelite (Glenfinnan Group) and the Meall a' Chrasgaidh Psammite (Morar Group) is exposed just below the summit to the north (Figure 9.1). Many intrafolial folds of thrust-generation age (D_2) are exposed in the Meall a' Chrasgaidh Psammite below the thrust to the NE. A suite of pegmatites characterized by large K-feldspars (10-50mm) and post-dating the thrust movements, occur sporadically in all rock types, exhibiting low levels of post-intrusion deformation. This suite becomes highly deformed in the structurally underlying belt of mylonites associated with the Moine Thrust Zone.

Follow the ridge westward for about 3km to the summit of Meall Dubh at [NH 103 748] (Figure 9.1). Between Meall an t-Sithe and Meall Dubh, psammites that were intensely deformed during displacements on the overlying ductile thrust are increasingly affected by cataclastic bands nearly parallel to the foliation, and the post-thrusting pegmatites become folded or exhibit boudinage. Close to tight D_3 folds also affect the thrust-related foliation in this area.

Locality 9.4 Meall Dubh [NH 103 748]

Meall Dubh (Figure 9.1). Closest approach of the Sgurr Beag Thrust and the Moine Thrust in the Northern Highlands.

The outcrop of the Sgurr Beag Thrust on the summit of Meall Dubh is 2km east of the (brittle) Moine Thrust plane, is only 400m directly above it and within the zone of deformation associated with the thrust zone.

The Meall a' Chrasgaidh psammite in this area (Figure 9.1) represents an intermediate stage between the coarse, annealed psammites forming the Sgurr Beag Thrust foliation and the fine-grained mylonites of the Moine Thrust Zone. The psammites exhibit kink folds, bands of cataclasite and zones of breccia up to 50cm thick. The foliation of the pelitic migmatites above the thrust is disrupted but not destroyed by the mylonitization. Shear bands indicating a top-to-the-WNW sense of overthrusting are found in both migmatites and pelitic horizons of the Meall a' Chrasgaidh Psammite. A detour to the summit of Creag Rainich affords a superb view of the whole Moine Thrust Belt. Note the juxtaposition of the foreland Lewisian gneisses, Lewisian slices in the thrust zone, and the Lewisianoid basement inlier of Fannich. These were originally at least 150km apart and have been brought into juxtaposition having undergone very different histories.

Descend SW, from the summit of Creag Rainich to the westernmost burn leading into Allt Teanga nan Caiseachan (Figure 9.1).

Locality 9.5 Allt Teanga nan Caiseachan [NH 090 746] to [NH 093 736]

Allt Teanga nan Caiseachan (Figure 9.1). Break-up of the Sgurr Beag Thrust fabric during mylonitization.

Exposures of the Meall a' Chrasgaidh Psammite are crossed in the upper part of the stream by shear bands up to 10cm across, forming lenses or pods of undeformed, pre-mylonitic psammite up to 3m long. The movement sense of the shear bands indicates displacement towards the WNW. In the centres of the shear bands, a fine, thinly-banded mylonitic foliation and stretching lineation are parallel to the same features in the Moine mylonites (i.e. shallowly-dipping foliation with the lineation trending towards 110°). In the unaffected rocks, the foliation still carries the characteristics of the coarse-grained Sgurr Beag Thrust fabric (stretching lineation trending towards 135°).

About 1km downstream, as another stream joins from the east, leave Allt Teanga nan Caiseachan and contour round to the west towards the Moine Thrust. The first exposures of Moine mylonites form a small 'quarry-like' area with a stream running down the centre [NH 085 733], as Loch an Nid comes into view.

Locality 9.6 Loch an Nid [NH 085 733]

Loch an Nid (Figure 9.1). The Moine Thrust.

The Moine Thrust plane passes between finely banded psammitic Moine mylonites, with breccia zones and kink bands and coarse-grained Lewisian amphibolites cut by late shear zones. The Moine mylonites in the slopes beneath the cliffs exhibit an intense mylonitic foliation, though low strain augen of less deformed Moine rocks up to 50m long remain, within 100m of the thrust plane. The thrust itself cuts through the Lewisian-Torridonian unconformity and thus the Lewisian gneisses below the thrust give way to Torridonian sandstones further north. Pods of Cambrian quartzite strung out along the thrust plane form prominent knolls on the hillside [NH 085 739] and [NH 084 746]. These probably represent remnants of a horst block eroded from a ramp at a deeper level in the thrust zone.

Return to the farmhouse and the A832 by the path along the northern shore of Loch a' Bhraoin.

Option B

From the bridge [NH 1585 7500], return to the road and drive back along the A832 to the Braemore junction (Figure 9.1). The first locality of this option lies about 1km along the A835 towards Ullapool. Parking is available for many cars and coaches in the Corrieshalloch Gorge car park on the north side of the road.

Locality 9.7 The Corrieshalloch Gorge [NH 204 782]

The Corrieshalloch Gorge (Figure 9.1). Initial deformation associated with the Moine Thrust in psammities and pelites.

Exposures in the immediate vicinity of the car park are not very informative. Walk westwards downhill along the A835 to a large roadside cutting at [NH 2007 7849]. *Care should be taken here as traffic can be fast-moving along this stretch of road.* The exposures here are interbedded psammities and pelites of the Inverbroom Psammite (Figure 9.1). The psammities acted as rheologically competent layers and suffered relatively little deformation during the thrusting. Note that the quartz veins and pegmatites cross the psammities at high angles. Pelite rock types on the other hand acted as less competent layers and there is widespread evidence for simple shear across these layers, giving shear strain values as high as eight. Quartz veins and pegmatites are highly deformed within the pelites, indicating shear towards the WNW. A particularly important aspect of the metamorphic fabric within the pelites is the development of shear bands, creating lenses of undeformed, pre-mylonitic fabric between 0.25mm and 10cm long, and indicating overthrusting towards the WNW.

No stop is complete without seeing the Falls of Measach, formed by runoff water during the last glacial retreat. The view from the suspension bridge is truly spectacular, especially after heavy rain.

Return to the parking area and follow the road towards Ullapool. Approximately 6km further on, turn left along the single track road signposted for Letters, Ardindrean and Rhiroy. (*This road is unsuitable for coaches; the turning place at Rhiroy is only large enough for cars or minibuses*). Turning right at the first crossroads, follow the road past the chapel and along the shore of Loch Broom. The road along the southern shore of Loch Broom originally reached only as far as the first houses and was extended to its present length in the mid 1930s. Prior to this time the only way in and out was by boat. The population which was at its peak around 1846 lived by crafting and fishing, but the number of people living in this community has now dwindled to less than 35% of its earlier peak, excepting weekend visitors and geologists.

Locality 9.8 Loch Broom [NH 171 858]

Loch Broom (Figure 9.1). Increasing deformation associated with the Moine Thrust Zone mylonites.

As the level of the road rises above the shore of Loch Broom, about 1km past the chapel, massively bedded Inverbroom Psammities and interbedded pelites are exposed just above and occasionally at the roadside. Early pegmatites within the psammitic rock types lie at low angles to the foliation and exhibit pinch and swell structures (incipient boudinage). The fabric in the pelitic rocks is dominated by shear bands, and the grain sizes of the pelites have been reduced from their peak metamorphic sizes (250-500 μm) to typical mylonitic sizes (10-50 μm), apart from resistant muscovites that are rotated toward parallelism causing a strong planar fabric.

The crags of Cnoc an Droighinn [NH 149 888] represent the end of an ENE-trending ridge reaching to the Moine Thrust in the west (Figure 9.1) and continuing across Loch Broom to the east. The structure of the ridge is an anticline in the Moine rocks, caused by a ramp structure in the underlying thrust zone. The ramp structure is exposed at Dundonnell and as such can only be recommended as a separate excursion. Coarse-grained psammities and pebble bands in the Inverbroom Psammite can be traced from Cnoc an Droighinn into the Moine mylonites at [NH 118 874], demonstrating that the mylonite foliation is not parallel to the earlier bedding/foliation planes. About 0.5km towards Rhiroy, the wood between the road and the shore gives way to open pasture. Parking is available in two long passing places less than 100m further along the road.

Locality 9.9 Loch Broom shoreline [NH 156 892] to [NH 149 911]

Loch Broom shoreline (Figure 9.3). Traverse across the Moine Thrust.

The traverse is best attempted at low tide, though this is not essential (consult the Ullapool Tourist Office for times of the tides).

Descend through the field to the shoreline where the Inverbroom Psammite is exposed 9A (Figure 9.3). Massive psammite banding seen in the Inverbroom Psammite further from the thrust is broken up into irregular lenses of psammite separated by small shear zones or shear bands. The lenses vary in size, reaching up to 3m in length. Lenses of remaining psammite are increasingly broken into smaller lenses or flattened into the new foliation as the process of shear band formation increases in intensity towards the thrust. The early foliation in all pelitic horizons is broken up by shear bands, all indicating thrusting towards the WNW (Kelley & Powell, 1985).

A few metres further along the shore, 9B, minor folds ranging from close to isoclinal in style deform the foliation. The folds exhibit a wide range of styles and axial trends, though their axial planes coincide to within 10°. The minor folds in these exposures are most probably of one generation apart from late kink zones. Curved hinge lines in some exposures indicate that the folds, which formed during the shearing event causing the mylonitization, nucleated perpendicular to the movement direction and were rotated towards it during progressive deformation (Kelley & Powell, 1985). This pattern of minor shear-related folds is characteristic of shear zones (Alsop & Holdsworth, 2004a and references therein).

The rocks develop a stronger planar foliation, 9C, with thinly interbanded psammitic and pelitic mylonites resembling slates in some exposures. However, the increase in the intensity of planar structures is disrupted by shears (see 9A) and minor folds (see 9B) (Figure 9.3).

The already complicated pattern of the psammitic mylonites is further disrupted by kink zones that are related to brittle movement of the thrust, 9D. These exposures are less than 50m above the thrust plane, and the mylonites become extensively brecciated as the thrust is approached with thin zones of cataclasite occurring parallel to the earlier foliation.

The thrust plane is exposed as a sloping exposure, 9E, of Torridonian sandstone forming the footwall, as the Moine mylonites that formed the hanging-wall have been eroded. The sandstones do not have any apparent internal structures, but are heavily brecciated and cut extensively by quartz veins. A few metres further on, the sandstones exhibit sedimentary layering and cross-bedding that are undeformed. The Torridonian sandstones are not thick in this thrust sheet (the Kinlochewe Thrust sheet) as shown by the outcrop of coarse-grained Lewisian amphibolitic gneisses on the shoreline at Blarnalearach [NH 148 912] (Figure 9.3).

Return to the parking place via the shoreline or follow the stream at the Lewisian exposure to the track and return along the road.

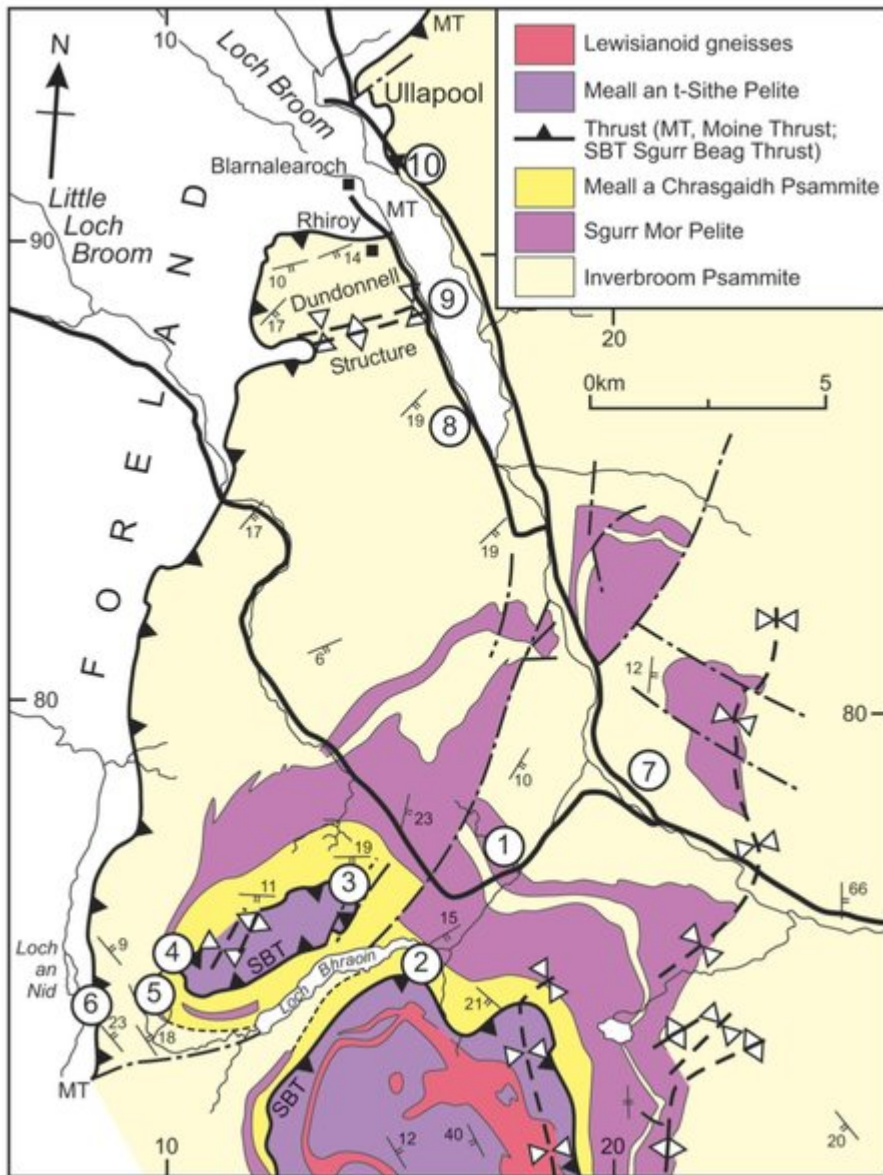
The two stone forts marked as brochs on the 1:25,000 map, Dun Lagaidh [NH 142 913] and Dun an Ruigh Ruadh [NH 149 901], are two of the rare stone forts on the west coast of Ross-shire. Not much remains of their walls, but Dun an Ruigh Ruadh is easily accessible above the road at Rhiroy. They were excavated by Mackie (1975) who found evidence of occupation at Dun Lagaidh as early as the 7th century BC; thick deposits suggest a lengthy period of use. A second phase of occupation gave rise to a circular dry stone walled defensive structure, though it was not a broch. Mackie considers that the structure was an Iron Age galleried dun, which would have been built earlier than the classic brochs of Glenelg and the Western Isles. Later occupiers in the 12th and 13th centuries repaired the structures using mortar. For those continuing towards Ullapool, one further locality situated just above the Moine Thrust is worthy of a visit.

Locality 9.10 The Moine mylonites [NH 149 922]

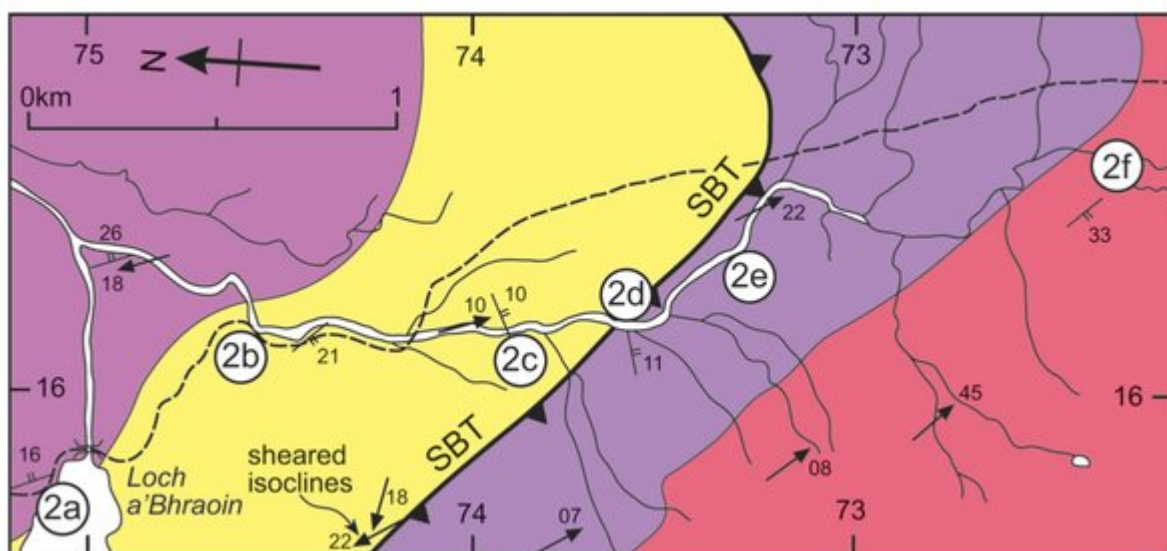
The Moine mylonites (Figure 9.1). Roadside exposures of the Moine mylonites on the A835.

Park in the large lay-by on the south side of the road at [NH 151 920]. The geology in the road cutting immediately opposite is now rather obscured by wire mesh, so walk carefully along the north side of the road for about 200m to the NW. A large road cutting exposes flaggy Moine psammitic and semi-pelitic mylonites that are only a few metres above the Moine Thrust (although this is not exposed on the road section). Quartz and pegmatite veins occur nearly parallel to the intense foliation and both carry the mylonitic stretching lineation (plunging towards 110°). In contrast to the previous locality, at least two sets of folds are present here. A series of smallscale intrafolial isoclinal folds were probably formed during early stages of mylonitization. A more prominent set of mesoscopic folds have S-geometry and are open in style; axes plunge to the SE, down the dip of the fold axial planes. These folds deform the mylonitic foliation and carry a tight axial-planar crenulation fabric in pelitic bands. The two sets of folds are analogous to the 'F₂' and 'F₃' folds described within the Morar Group in Excursions 10 and 13, and are thought to have formed during a single phase of progressive ductile deformation associated with westerly-directed overthrusting of the Moine rocks onto the Caledonian foreland.

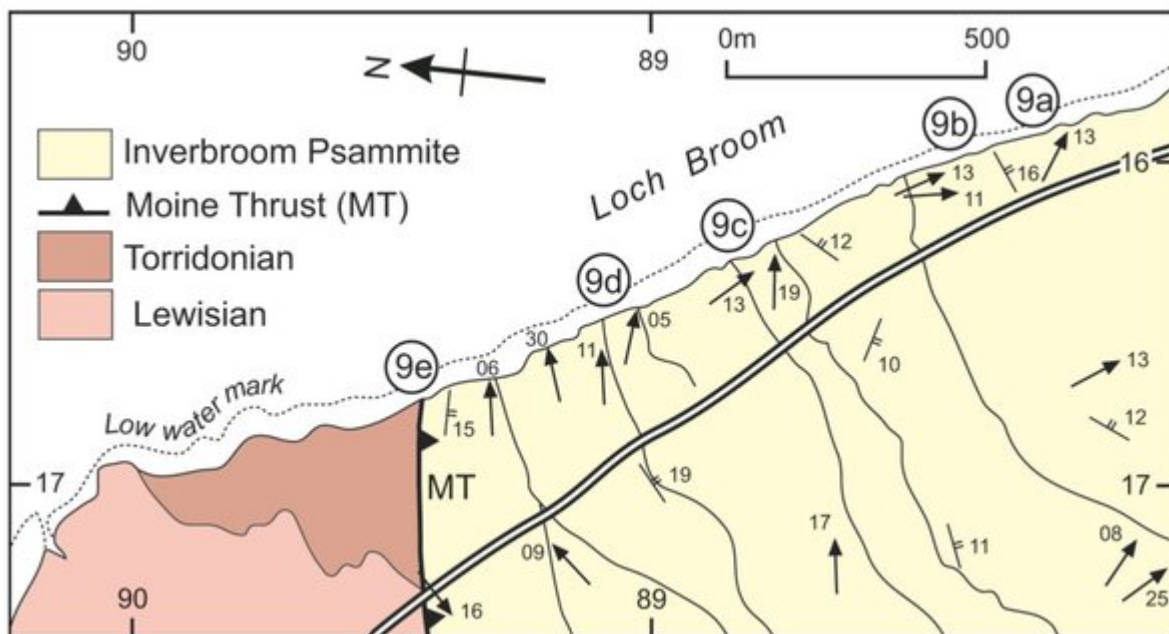
References



Geology of the Moine rocks between the Fannich mountains and Ullapool, showing the localities to be visited.



Sketch map for Locality 9.2. See (Figure 9.1) for key.



Sketch map for Locality 9.9.