
Excursion 1 Ross of Mull

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<i>Purpose:</i>	A general excursion across the Moine rocks of the Ross of Mull.
<i>Aspects covered:</i>	Metasedimentary lithologies typical of the Morar and Glenfinnan groups, amphibolites, polyphase folds and fabrics, the margin of the (Caledonian) Ross of Mull Granite, regional and contact metamorphism, Tertiary minor intrusions.
<i>Useful addresses:</i>	Hotel and B&B accommodation are available at Bunessan and Fionnphort, and also at Scoor House SW of Loch Assapol.
<i>Maps:</i>	OS: Explorer 1:25,000 Sheet 373, Iona, Staffa and Ross of Mull; BGS: 1:50,000 sheet 43S Ross of Mull.
<i>Type of terrain:</i>	Rocky coastline (some scrambling required), beaches and hillside.
<i>Short itineraries:</i>	East limb of Assapol Synform from Scoor House: Localities 1.1, 1.3, 1.6 (+/-1.13), 1.10, 1.8, 1.9 and 1.14; distance is 5km, taking a whole day. West limb of Assapol Synform from Ardalanish: Localities 1.16, 1.17, 1.19, 1.20, 1.23; distance is 4km, taking 3-4 hours. Granite relationships from Bunessan and Ardalanish: Localities 1.15, 1.24 and 1.25; distance is 4km, taking 3-4 hours. Whole area (very abbreviated) starting from Scoor House: Localities 1.13, 1.10, 1.9, 1.14, 1.19 or 1.20, and 1.23; distance is 7km, taking a whole day.

The Moine rocks of the Ross of Mull ((Figure 1.1), (Figure 1.2)) constitute the south-westernmost occurrence of the Supergroup. The inlier contains evidence that is critical in assessing the stratigraphic relationships between the Morar and Glenfinnan groups which are, respectively, thought to be laterally equivalent to the Shiaba and Assapol groups of Mull (Holdsworth *et al.*, 1987). The Moine outcrop is terminated to the west by the Ross of Mull Granite which was intruded towards the end of the Caledonian orogeny at 421 ± 5 Ma (Oliver *et al.*, 2008). Lewisian basement and Iona Group cover rocks of the Caledonian foreland occur on the island of Iona directly west of the Ross of Mull. The mid-amphibolite facies metamorphic grade of the Moine rocks is anomalously high for rocks adjacent to the Moine Thrust and the Caledonide foreland (Holdsworth *et al.*, 1987). The former had been inferred to lie in the Sound of Iona, and Potts *et al.* (1996) concluded that it had been displaced by a major normal fault. This structure had brought Moine rocks of the Knoydart Nappe into contact with the rocks of the foreland before emplacement of the Ross of Mull Granite.

Almost all the localities lie on the southern coast of the Ross (Figure 1.1). Access is most suited to cars and minibuses. Coaches should not be used without local advice. Itineraries A and B focus on Localities 1.1-1.13, and Itineraries C and D describe Localities 1.15-1.23 (Figure 1.1). Itineraries A and B describe a traverse through the units of the Shiaba (= Morar) Group and the younger Assapol (= Glenfinnan) Group. Itineraries C and D traverse the Assapol Group on the western limb, and within the core, of the regional F_3 Assapol Synform (Figure 1.2) and includes various lithologies not seen in itineraries A and B. Two additional localities (24 and 25) focus on relationships between the Ross of Mull Granite and the Moine rocks in its envelope.

Itinerary A Eastern limb of the Assapol Synform

Eastern limb of the Assapol Synform (1); access via Scoor House. Total distance is c.7 km from Scoor House and return, taking 6-8 hours.

Follow the A849 from Bunessan towards Pennyghael for about 0.5km and turn right up the very minor road leading southeast towards Scoor House (signposted Scoor 3.5km). The road initially tarmacked, becomes a partly metalled track which is liable to potholes. Public parking is available about 3km from the main road beside the track ((Figure 1.1); [NM 419 196]), above a graveyard with a ruined church (parking for about eight cars). Coaches should not be used on these roads without local advice. Continue along the track on foot as far as Scoor House [NM 419 191]. Passing the cottage and farm steadings on your right immediately before you reach Scoor House, you will note the low cliff cut into a dolerite sheet. This is a very extensive and persistent intrusion which you will come across on many places on this excursion, because it overlies or underlies much of the eastern part of the Moine inlier.

Locality 1.1 Viewpoint of the regional and local geology (Figure 1.1). [NM 4268 1931]

Follow the track that leads up the hill from Scoor House for about 300m as far as a gate into a field on the north side of which there is a sheep fank. Cross the field to a gate on the far side leaving the fank to your left. Passing through this gate, leave the track that heads off to the ENE and instead, walk up to the nearby (~100m) smooth glaciated crag from the summit of which [NM 4268 1931] there is a fine view that enables a perspective of the local and regional geology. BGS Sheet 43S and the BGS 1:625,000 North Sheet would be useful to refer to here. Looking to the south and southeast to the other side of the Great Glen Fault, the course of which runs several kilometres offshore, can be seen the low-lying islands of Islay and Colonsay, the latter comprising the enigmatic Colonsay Group rocks of uncertain affinity. In contrast, the island of Jura is dominated by prominent pale mountains of Dalradian Islay Quartzite. Further east on a clear day can be made out the low-lying Garvellach islands underlain by the Dalradian Port Askaig tillites. Looking west over the end of the Ross of Mull, both Coll and Tiree can be seen, both comprising Archaean Lewisian gneisses of the Caledonian foreland. Closer, Iona, itself largely comprising Lewisian gneiss, and probably also part of the foreland, rises up beyond the rocky exposures of the Ross of Mull Granite. To the northwest, the Treshnish Islands and Staffa and to the north and east the trap topography of the Wilderness of Burgh and of the eastern part of the Ross itself, are all formed of Tertiary basalts. These are separated from the Caledonian rocks by the Assapol Fault, the course of which can be easily seen trending west-northwest along the far shore of Loch Assapol. Nearer to hand, the position of the eastern margin of the Ross of Mull Granite can be made out with the help of Sheet 43S where rising ground to the west becomes much more rocky than that to the east, underlain by the Moine.

Locality 1.2 Upper Shiaba Psammite with cross-bedding and heavy mineral bands [NM 4425 1893]

From Locality 1.1, proceed N40°E for about 400m along the side of the An Crosan ridge, staying above the extensive peaty area to the southeast which can be treacherously boggy. A rough track leads to Shiaba from approximately [NM 4302 1967] and should be followed east-southeast for about 800m. This track crosses some boggy ground and rocky knolls that expose Upper Shiaba Psammite that display poorly preserved cross-bedding that youngs and dips ~70° northwest. Crossing the shallow burn Allt Cnoc na Fearnage, a well preserved though roofless croft house is conspicuous enough to serve as a landmark for positioning in an otherwise rather featureless landscape. Locality 1.2 lies some 500m southeast of the point where the track crosses the burn (Figure 1.1). Here a number of crags comprise typical micaceous, laminated Upper Shiaba Psammite with cross-bedding and heavy mineral bands.

Locality 1.3 Shiaba Group lithologies; Tertiary intrusions and faulting. [NM 4452 1898]

From Locality 1.2, walk south-southeast towards the shore via the slope just east of a gully and then via a rough scramble down a gully cut in steeply dipping Upper Shiaba Psammite starting at [NM 4425 1898] at about 35-40m OD down to about 20m OD. A line of somewhat rounded crags, trending east-northeast (055°) comes into view, on the other (south) side of an open hollow. These expose coarse garnetiferous Shiaba Pelite (e.g. [NM 4432 1888]). There are many exposures where this can be examined and searched for sparse occurrences of staurolite and kyanite, but it is recommended that the Shiaba Pelite is also studied at Locality 1.3 in a narrow fault gully where the contact with the Lower Shiaba Psammite can also be examined. Access is possible at all states of the tide, but several points of interest will be missed if the visit takes place above middle water.

Once on the foreshore, the high water mark (HWM) should be followed to Locality 1.3. Here, a few metres southwest of an old metal deer fence running across the Upper Shiaba Psammite on the foreshore, the gully that is Locality 1.3 trends 345° exposing garnetiferous Shiaba Pelite, locally containing granitic pegmatite, in both walls. There is a rapid transition of the steeply dipping Lower Shiaba Psammite contact into the Shiaba Pelite which is well displayed on the west-southwest side of the entrance to the gully and above and beyond the head of the gully. It can be demonstrated from cross-bedding in nearby exposures of the Upper Shiaba Psammite that it is younger than the Shiaba Pelite.

The whole width of the outcrop of Lower Shiaba Psammite is very well exposed to the south and west on the wave-cut platform and in seastacks for a distance of 600-700m. These exposures display well the coarse feldspathic, somewhat migmatitic nature of the Lower Shiaba Psammite, its heavy-mineral seams, lack of obvious clastic grains and of any obvious sedimentation structures; nevertheless, dubious cross-bedding in places does hint at younging towards the Shiaba Pelite. These contrasts with the Upper Shiaba Psammite are strikingly reminiscent of the distinctions between the Upper and Lower Morar psammites further north in the type localities.

Locality 1.3 is also an excellent place for examining the complex timing and displacement history of the fault within the gully:

1. the contact between the psammite below and the pelite above, dipping 60° towards $N30^\circ W$ is displaced, apparently sinistrally, across the fault to appear in the east-northeast wall of the gully some 25m from the HWM;
2. a steep, apparently concordant dolerite dyke trending 060° across the line of the gully and a few metres from its mouth on the seaward side is neither brecciated nor displaced;
3. an irregular, flat-lying basaltic sheet cutting the pelite/psammite boundary, and seen high up in the west-southwest wall of the gully, has been displaced down to the east to appear in its east-southeast wall;
4. on the rocky foreshore on the line of the gully, there is brecciated basalt and psammite.

Thus, this is an excellent locality to discuss the Tertiary history of intrusion and faulting in the area, and it may well have some regional significance because the fault in the gully is probably a splay off the Tertiary Assapol Fault. The psammite/pelite contact can be followed along near the HWM, east-northeast from here for ~300m to the point where the Assapol Fault crosses the foreshore causing some brecciation of both pelite and basalt. From here and from the wave-cut platform at Locality 1.3, there are fine views of basaltic cliffs and spectacular waterfalls to the north-northeast.

Locality 1.4 ; Folds within the Lower Shiaba Psammite. [NM 442 185]

En route southwestwards to Locality 1.4 along or near HWM, try to walk as close as possible to the Lower Shiaba Psammite/Shiaba Pelite boundary. Exposures frequently show elliptical doubly-plunging outcrop patterns of the psammitic banding. This is taken to imply the presence of highly curvilinear folds reflecting unusually high tectonic strains in this contact zone. At the western end of the wave-cut platform at Locality 1.4, large raised slabs of Lower Shiaba Psammite near HWM display many steeply plunging small-to-intermediate scale folds of M- and W- geometry. These probably lie in the hinge zone of the open fold around which the Shiaba Pelite passes, changing its strike from northeast-southwest to approximately north-northwest-south-southeast (Figure 1.1).

Locality 1.5 F_2 sheath folds within the Lower Shiaba Psammite. [NM 4410 1841]

Southwards from Locality 1.4, the coastline becomes more difficult and dangerous to access, but the nimble-footed and stout-hearted are rewarded by the sight of remarkable F_2 sheath folds, suggestive of very high strains in the Lower Shiaba Psammite adjacent to the Shiaba Pelite. To reach the most spectacular of these, on a falling tide below mid-tide, follow the Lower Shiaba Psammite/Shiaba Pelite boundary, trending $S10^\circ E$ towards the headland. Proceed a few metres within the psammite (the pelite generally occurs in the adjacent cliffs). Having crossed a small bay filled with large boulders, largely of garnetiferous pelite, follow a concordant Tertiary dyke (0.3m wide) southwards for some 25-30m. Locality 1.5 exposes metre-scale oval-shaped patterns of bedding/banding as a result of F_2 sheath folding (see Holdsworth *et al.*, 1987, figure 1.1). It is on a rock shelf sloping gently southwards above the narrow cleft, occupied by the dyke. Note that the psammite near the contact with the pelite has a generally flaggy habit, dipping at $\sim 70^\circ$ towards $\sim 250^\circ$. The flags carry a down-dip lineation.

Return to Shiaba by walking from Locality 1.4 as far as the course of the Allt Cnoc na Fearnaiige stream, and follow the general line of the stream uphill as far as the track leading back to Scoor House. The paths leading up to Shiaba from the sea can be very obscured by vegetation in the summer.

Locality 1.6 Sedimentary and tectonic structures within the Upper Shiaba Psammite. [NM 436 183]

If time permits, instead of following the burn up the hill, it can be followed down to Traigh Bhan which is Locality 1.6 (Figure 1.1). On the south-east side of the bay, at mid-tide and below, there are good exposures of Upper Shiaba Psammite preserving northwest-younging cross-bedding and showing thin (~5mm) layers of dark semipelitic schist. These schists carry the regional S_2 foliation and skeletal porphyroblasts of white mica. Restored to the horizontal, S_2 cleavage/bedding relationships imply originally west-facing, very tight F_2 folds that pre-dated the regional-scale F_3 synform. Westwards across the bay can be seen the crags forming the lowest parts of Torr na Stallachhdach [NM 4325 1827], where they have been rendered very unstable and dangerous by the presence of an easily eroded sheet of Tertiary basalt.

Locality 1.7 Upper Shiaba Psammite cut by Tertiary dolerite. [NM 4365 1805]

A difficult scramble to the south-southeast through and across very wet gullies, leads to Port na Eglaise [NM 437 181] where there are ruins, possibly of a small church. A small rocky bay comprises the roof of the basaltic sheet seen in the unstable crags on the northwest side of Traigh Bhan. This locality is the frequent haunt of a herd of feral goats that graze this part of the coast. On the headland beyond and to the southwest, a stack that comprises Locality 1.7 (Figure 1.1) is formed of the dolerite sheet and from this vantage point can be seen that the same sheet on the opposite side of the bay [NM 4325 1827] cuts a camptonite dyke, probably of Permo-Carboniferous age. The country rocks all comprise Upper Shiaba Psammite.

Itinerary B - Eastern limb of the Assapol Synform (2); access via Scoor House.

Distance is either 3 or 4.5km, depending upon inclusion of Localities 1.13 and 1.14, taking 4-6 hours.

Access is via Scoor House and Farm (for the route to the house see Itinerary A). Turn right (south) in front of the house, passing the old steading on your right; following the path around you arrive at a gate, adjacent to a cottage, that leads on to the hill. This area is very wet in bad weather. The adjacent rocks and smooth rock surface that are passed on the way to the gate form the top of the same 2-3m-thick dolerite sheet on which Scoor House stands and which you will have encountered in several places on Itinerary A.

Locality 1.8 Geological viewpoint. [NM 4208 1884]

Pass through the gate and turn left, skirting the side of the hill towards the fence that runs south-southeast up the hill from a large modern (2002) shed. Follow the fence on its western side until it reaches the top (~100m O.D.) of the very steep slope running down to Traigh na Sgurra – a beautiful sandy bay, flanked by large rock slabs (Figure 1.1). From a suitable vantage point to the west of the bay (Locality 1.8) and looking east along the coast, the control of the configuration of the headlands by the strike of the subvertical Moine rocks can be appreciated. Note also the brown colouring and distinctive columnar jointing of the same dolerite sheet that crops out at Scoor.

Locality 1.9 S_0/S_2 relationships within the Ardalanish Striped and Banded Formation. [NM 4215 1882]

In high crags some 50m east of the fence [NM 4215 1882] alternating subvertical stripes and bands of somewhat gneissose pelite and semipelitic micaceous psammite schist can be seen striking approximately 50° east of north and dipping 70° west. This is Locality 1.9. S_2 is marked by a preferred orientation of micas, producing a foliation dipping westwards at $\sim 60^\circ$. Looking northeast at the subvertical surfaces, the foliation appears to lie a few degrees clockwise of the bedding/banding; this implies that the F_2 folds are very tight and may have an interlimb angle as low as 20° . If the foliation is axial planar to the F_2 folds and the line of bedding/foliation intersection is not very steeply plunging, it also implies that there is an F_2 synform to the east and an F_2 antiform to the west. Although the distance to these inferred

structures is unknown, it may be significant that the relationship is the same as that in the psammities at Locality 1.6, nearly a kilometre to the east.

Locality 1.10 Scoor Pelitic Gneiss. [NM 4214 1876]

Return to the fence and follow it down towards the beach to the point where it bears round to the right [NM 4214 1876] and walk eastwards to Locality 1.10 (Figure 1.1) where a large crag displays very well the characteristics of the Scoor Pelitic Gneiss. Here the psammitic bands that had been a feature of Locality 1.9 are absent and the exposure consists of alternating stripes and bands of pelitic and semipelitic somewhat gneissose material, showing clear indications of original compositional layering, probably bedding. The mineral assemblage comprises quartz, plagioclase feldspar, biotite, muscovite and almandine garnet. The S_2 foliation dips generally west and looking northeast at steep faces, appears to lie slightly clockwise of the subvertical banding, i.e. as at Locality 1.9. Here the relationship, so clear at Locality 1.9, has been complicated by the overprinting by D_3 open crenulations of the S_2 planes and the planes of bedding/banding. The axial surfaces of the crenulations dip gently eastwards, while the hinges of the crenulations plunge shallowly seawards.

Locality 1.11 S_0/S_2 relationships within the Scoor Pelitic Gneiss; Tertiary intrusion. [NM 4231 1873]

Looking back up the hill and eastwards across the Blown Sand on the narrow low raised beach, the relationships of the major dolerite sheet with the Moine can be appreciated. At the eastern end of the bay, to the west of a fault gully trending 060° [NM 4231 1873], there is an exposure of interbanded pelitic gneiss and micaceous psammite which is Locality 1.11 (Figure 1.1). Looking north-northeast, the S_2 foliation again dips clockwise of the dip of bedding and is weakly crenulated. The dolerite sheet above and to the north-northeast of this locality carries xenoliths of a psammite different from that in the adjacent country rocks. These xenoliths were probably derived from the Upper Shiaba Psammite to the east, implying an east to west direction of flow of the magma.

Locality 1.12 Top of the Lagan Mor Formation. [NM 4229 1854]

From the east end of the beach move south to the headland, a difficult scramble and, especially when wet, the fallen slabs of pelite and dolerite are extremely slippery. Near the headland at the traverse encounter a band of white pure quartzite, about a metre thick. This bed is Locality 1.12 (Figure 1.1) and marks the stratigraphic top of the Lagan Mor Formation, the main outcrop of which is in the Lagan Mhor Bay to the east. At the headland there are excellent exposures of pelitic gneiss, of quartzite and of the dolerite sheet. A second, higher, dolerite sheet marks the top of the headland. Cross-bedding younging westwards has been recorded in the quartzites. These exposures are at the top of the transitional sequence between the Shiaba Group (= Morar Group) psammities to the east and the Shiaba Pelite of the Assapol Group (= Glenfinnan Group) to the west; thus they constitute part of the evidence for a stratigraphic transition from the Morar Group to the Glenfinnan Group (Holdsworth *et al.*, 1987, figures 3 and 4).

Locality 1.13 Transition from the Lagan Mor Formation into the Upper Shiaba Psammite. [NM 4251 1834]

Lagan Mor Bay is Locality 1.13, and a traverse across the bay for some 60m (Figure 1.1) shows the intensely flaggy nature of the interbanded, subvertical $N10^\circ E$ -striking pelite/quartzite of the Lagan Mor Formation. Towards the east, quartzite passes into siliceous psammite, locally with cross-bedding in which the angles between sets of lamination have been severely reduced. At the headland on the eastern side of the bay [NM 424 183] the rocks have passed by transition into the rather flaggy, highly strained psammities with poorly preserved cross-bedding that have been referred to as the Upper Shiaba Psammite by Holdsworth *et al.* (1987). These psammities pass, also by transition, stratigraphically downwards into weakly strained psammities of fluvial or shallow marine origin (see also Glendinning, 1988). They carry complex sedimentary structures, including beautifully preserved cross-bedding with somewhat over-steepened cross-lamination, slumps and dewatering structures (Figure 1.3). The best localities are around [NM 4251 1834]. *Please photograph, not collect.* Younging is unequivocally towards the west across bedding that strikes just west of north and is subvertical. Access to and within the immediate vicinity of this locality is difficult with strong fissuring that, on the landward side, can be treacherously covered by thick vegetation.

One locality (14) is especially valuable in demonstrating the complex structural history of the rocks on the eastern limb of the Assapol Synform; this is described below. Being accessible from Scoor House, the locality could be visited in conjunction with either Itinerary A or B.

Note

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The note accompanying Locality 1.7 indicated that Itinerary B could be run in reverse, if time permitted at the end of Itinerary A. This would have the advantage of passing through the whole sequence from oldest to youngest. That note recommends joining Itinerary B at [NM 425 184]; this is only a few tens of metres east along the coast from Locality 1.13 described above. This precise location can be identified by the presence of a subvertical ~1m basaltic dyke approximately concordant with the bedding/banding in the psammite; the continuation of the dyke to the south is clearly visible across the Slochd a Mhuilt inlet. The dyke itself is remarkable for the spinifex texture involving feathery pyroxene crystals at its margins.

Locality 1.14 — F_2/F_3 relationships within the Ardalanish Striped and Banded Formation on the eastern limb of the F_3 Assapol Synform. [NM 4165 1847]

This can be accessed from Scoor House using the gate at [NM 4190 1905] mentioned at the start of Itinerary B. From the gate, walk southwest for about 200m, crossing a marshy burn/drain (do not follow this to the sea) and a low ridge trending north-south towards the sea. Using a gap in the substantial stone dyke, pass along the western side of the ridge, at the eastern edge of an extensive marshy area formerly cut for peat. This marshy area is drained by a small burn that plunges over a fall [NM 4169 1862] and flows via a narrow alluvial strip almost due south to the sea. (Please note that although the burn itself is not shown on either the 1:10,000 map or 1:25,000 map, the V-shaped contours defining its valley are shown.) The mouth of this valley, here some 25m wide, and in close proximity to the foreshore is Locality 1.14 (Figure 1.1). Two parts of this locality are of particular interest:

1. on the east side in the subvertical wall of the valley, looking towards N25°E, is a pair of almost upright F_2 folds verging towards a synform to the east-southeast. The plunge of a D_2 lineation on the folded foliation surfaces is 30°NNE, unequivocally steeper than the crenulation lineations caused by the crumpling of the foliation surfaces by small-scale F_3 folds. Looking north-northeast, it can be seen that the S_2 foliation transects the banding clockwise, while the axial planes of the D_3 crenulations transect the banding and S_2 anticlockwise;
2. the rocky knoll in the centre of the valley mouth [NM 41655 18476],
3. just above HWM, can be used to demonstrate most of the structural history of the area. Looking at the seaward side of the knoll, a pair of tight F_2 folds, with S-shaped vergence, is disposed generally horizontally. These are transected by axial planes of F_3 crenulation cleavage dipping 70°E. A tight S_2 crenulation cleavage related to the F_2 fold pair is shallowly inclined/subhorizontal; these crenulations have crumpled an earlier penetrative mica fabric (S_1). On the western side of the valley, the banding and early foliation (S_2) have been bent down to become subvertical, and thus complete an F_3 fold pair that verges westwards to a synform, the distant Assapol Syncline.

Itinerary C Structures and lithologies within the Ardalanish Striped and Banded Formation on the western limb of the Assapol Synform; access from Ardalanish.

Distance from Ardalanish and return is c.3 km, taking 4-5 hours.

In Bunessan, leave the A849 and turn up the steep hill that passes behind the Argyll Arms Hotel. After about 600m, turn left (south) following for about 2km the narrow metalled road signposted to Uisken. A narrow metalled road joins the Uisken road from the right (southwest). Follow this past the Ardachy Hotel towards Ardalanish Farm. About 0.5km along this road it is joined from the left by a track running alongside some ruined outbuildings. Parking for minibuses or cars is provided beside the track near its junction with the metalled road [NM 3731 1930], shown with 'P' on the 1:25,000

Ordnance Survey topographic map.

Access to several of the localities, notably 1.15 to 1.18, is easy and involves no more than walking along a fairly rough track and thereafter along the extensive sands interspersed with rocky knolls and reefs that is Ardanish beach. Beyond the eastern limit of the beach, however, access to Localities 1.19 and 1.20 requires quite strenuous scrambling over rocky and bouldery terrain which becomes more difficult eastwards, especially under wet conditions produced either by rain or an outgoing tide. The access to exposures on the main beach (Localities 1.15-1.18) is, to a small degree, tide-dependent. Ideally they would be visited at or below mid-water on an ebbing tide; this would also reduce problems of access further to the east (Localities 1.19 and 1.20). Access to Locality 1.19 is quite easy at low water, but Locality 1.20, a tidal island, and a very rewarding, highly photogenic locality, should be attempted only by fit people capable of strenuous scrambling and minor rock climbing, and then only on an ebbing tide.

Locality 1.15 — Regional and contact metamorphism of the Assapol Group Moine. [NM 3753 1884]

From the car park, pass through the gate and walk south-southeast along the track, noting the extensive flat very gently sloping fields, especially to the northeast of the track. These surfaces comprise higher (older) and lower (younger) raised beaches. The higher beach at 15-20m O.D. has coarse cobble/pebble deposits, and the lower at ~10m O.D. has much finer silty/ sandy deposits. Both have excellent back (fossil cliff) features and the lower beach has raised stacks and sea caves. The lower beach is extensively covered by Blown Sand.

Locality 1.15 is Dun Fuinn which would have been an offshore rocky island at the time the lower raised beach was cut. The exposure, originally described by MacKenzie (1949), comprises largely Assapol Group pelitic and semipelitic schists, remarkable for their metamorphic mineral assemblage. In addition to garnet and micas, some 3-4cm-wide bands contain blades of kyanite 1-2cm long. The high-pressure Al_2SiO_5 polymorph kyanite formed during the early period of Barrovian regional metamorphism that also produced the garnets. Because the exposure lies within the aureole of the Caledonian Ross of Mull Granite (Zone 2 of Wheeler *et al.*, 2004, figure 1.1), rims of pink andalusite, the low-pressure polymorph, are common around the kyanite blades (Wheeler *et al.*, 2004, figures 1, 4).

Abundant tourmaline also occurs at the head of a shallow gully within the exposure at its western end. These may also be linked to the effects of the granite, the exposed margin of which lies some 500m to the west.

Locality 1.16 — Migmatitic fabrics and polyphase folds. [NM 3772 1876]

Locality 1.16 is a low elongate crag that emerges from the beach sand and extends south-southwest from HWM for some 100m down the beach. The crag consists of interbanded psammite, semipelite and pelite; the last is commonly garnetiferous and carrying quartzofeldspathic *lits* appears somewhat migmatized. The migmatitic segregations have been shredded by the apparently penetrative fabric that is interpreted as S_2 , axial planar to sub-isoclinal folds, and well displayed at the northern end of the exposure. Calc-silicate stripes and lenticles up to a few centimetres thick are an important feature of this exposure. These are characteristically pale-weathering and comprise amphibole, garnet, plagioclase feldspar, quartz and epidote. In several parts of the exposure they have clearly been folded into sub-isoclinal ($F_2?$) folds and subsequently refolded by more open ($F_3?$) structures.

Locality 1.17 Garnetiferous amphibolites. [NM 3778 1870]

Locality 1.17 lies some 60m east of Locality 1.16 (Figure 1.1). It is best examined on its eastern side where it exposes large pods of metabasic garnetiferous amphibolite. The red almandine garnets, commonly a centimetre in diameter, contrast vividly with the dark green groundmass consisting of hornblende, plagioclase quartz, epidote and titanite. Contacts between the metasediments and amphibolite at this locality appear to be concordant with the metasedimentary layering. The protolith of the meta-amphibolite is basaltic with MORB ('mid-ocean ridge basalt') chemistry. Its concordant pod-like form is not unique to this locality, but it is unusual and elsewhere the forms are sheet-like and commonly cut bedding.

Locality 1.18 Relationships between amphibolites and host metasediments. [NM 3805 1855]

Locality 1.18 lies ~250m east of Locality 1.17 and is situated about half way down the beach at low tide (Figure 1.1). It is important for establishing the original intrusive relationships of the metabasic amphibolites and the metasediments. The margin of the 3.5m-wide (not thick) amphibolite at its eastern side strikes N37°E and dips 70°NW. It unambiguously cuts the bedding in the psammitic country rocks which strike N44°E and dip 50° NW. The marginal zone of the amphibolite carries abundant large (~1cm) garnets that rapidly decrease in size while increasing in abundance away from the margin.

Localities 1.19-1.21 demonstrate the nature of the tectonic structures which have been imposed on Assapol Group rocks during polyphase deformation.

Locality 1.19 East-verging F_3 folds. [NM 3816 1837]

Locality 1.19 can be reached at all states of the tide, but is best approached at low water (Figure 1.1). It comprises a ~2m-wide gully with subvertical sides, running approximately east-west for about 15m and ending at its eastern end with a shingly more open space surrounded by low crags to north and south, but a much higher cliff to the east. Access to this gully is possible at low water directly from the eastern end of Ardalanish beach, following a sandy inlet that leads off to the east. Otherwise the gully should be approached by scrambling eastwards from higher up the beach, across and around crags surrounded in most part by shingle, turf and boulder-strewn terrain.

Several structural features are worth noting:

1. at the southern side of the western entrance to the gully, on a low, sand-abraded rock face are well displayed ptigmatic folds of thin (~1cm) pegmatitic veins as well as stripes of siliceous psammite, set in a more micaceous matrix. The exposure can be used to demonstrate the minimum shortening accomplished by the D_3 deformation and the variable wavelengths of buckle folds where the competent layers are of different thickness;
2. along both sides of the gully F_3 folds and related crenulations and crenulation cleavage (S_3) in pelitic bands are well displayed, while a lineation (L_2) on the folded banding lies obliquely to the F_3 fold hinges. The F_3 folds verge eastwards to an F_3 antiform;
3. at the eastern end of the gully [NM 3816 1837] a fold pair, antiform/ synform, at least an order of magnitude larger than those displayed on the gully walls, similarly verge towards an antiform to the east;
4. in the southern wall at the end of the gully, one limb of the antiform is brecciated and, at first sight, appears faulted. However, there is little sign of displacement and psammite flags can be traced, essentially continuously through the breccia;
5. the psammitic flags carry regularly spaced, quartz-filled tension gashes.

Locality 1.20 — F_3 folds. [NM 3824 1832]

Locality 1.20 can be reached from Locality 1.19 by climbing out of the east end of the gully by climbing up the lowest part of the vertical face and walking/scrambling south-southwest down the fold hinge zone as far as the next east-northeast-trending gully some 20m to the south (Figure 1.1). Alternatively, return to Ardalanish beach and, if the tides permit, walk down the beach to a gain access to the gully via a sandy inlet. This gully marks the line of a strike-slip fault. Walk eastwards along the gully noting the many subvertical garnetiferous amphibolite bodies, many locally crosscutting, exposed in the gully walls. Because of the lateral-slip displacement of the fault these cannot be matched in detail across it.

Passing along the gully eastwards, into the next bay, a very rocky boulder strewn inlet, note in its north wall in particular, good examples of 'necking' and boudinage extension of the psammite layers. These are the result of the extension of the competent psammitic layers and are accompanied by tension gashes, similar to those at Locality 1.19.

In the bay itself, scramble across the boulders, which are exceptionally slippery when wet, to the tidal island situated opposite a cliff some 30m high.

The cliff, the face of which is probably the fault along which you walked to gain access to the locality, displays spectacular intermediate-scale folds that verge towards a major antiform the hinge zone of which lies some 100m to the

east. The lithologies involved in these structures are striped and banded pelites and psammities with abundant calc-silicates. The crest of the major antiform which forms the roof of a cave marked on the 1:25,000 Ordnance Survey topographic map is not normally accessible from the west, but can be reached, with difficulty, from Uisken to the east (see Itinerary D, below). It forms the lowest structural level of a complex antiformal zone that extends westwards for some 300m from the inlet known as Slochd nam Ba [NM 385 184].

The island itself displays Assapol Group lithologies very well, on clean surfaces. Some psammitic bands, several centimetres thick, have very sharp contacts with extremely micaceous material on one side but pass by rapid transition into micaceous material on the other as the pelitic component of the metasediment increases. These occurrences can be readily, but perhaps not safely, interpreted as graded bedding, indicating the original way-up of the sediments. If this interpretation is to be believed, however, it would imply that the F_3 folds at this locality at least, are downward-facing, and if widely applied would be at variance with more convincing younging evidence elsewhere on the Ross.

Leaving the island to return to Ardalanish, glance up the scree slope to the north, to where the structural features displayed on a very large fallen and tilted block are worth a detour. These include excellent examples of pygmatically folded pegmatitic veins and of the 'cusp and lobe' mode of buckle folding of alternating psammite (competent) and pelite (incompetent) layers.

Itinerary D

Western limb, continued, and core of the Assapol Synform; access from Uisken. Distance from Uisken and return is c.3km, taking 3-4 hours.

For access to Uisken, proceed as for Ardalanish, but instead of turning right towards the Ardochy Hotel and Ardalanish Farm, continue on the road from Bunessan, past the telephone kiosk to the coast. Here, in the small scattered settlement of Uisken, at the head of a sandy bay with scattered rocky reefs and islands, there is limited parking (out-of-season!) for about eight cars and minibuses.

Locality 1.21 — Hinge and eastern limb of F_3 antiform. [NM 384 183] to [NM 398 188]

This locality requires mid- and falling tide. It is recommended that you do not follow the coast from Uisken, but instead walk cross-country over, in places, somewhat boggy terrain and largely raised beaches. To do this proceed southwest from the parking area (bearing approximately 235°) reaching the head of Slochd nam Ba [NM 385 184] after about 600m. If possible, it would be courteous to call at the house with outbuildings immediately above the road that led down to Uisken.

The northwest coast of Slochd nam Ba exposes, along the top of the crag, the most eastern of the intermediate-scale antiforms that comprise the major antiformal area mentioned in Itinerary C. Access is strictly for the physically capable. On the southeast side of the Slochd, walk ~150m south-southwest to the point where a substantial east-west-trending hollow feature cuts across the strike. En route there are small-scale paired folds that plunge shallowly south-southwest giving a clear indication of a larger scale synform to the east and an antiform to the west. Proceed eastwards along the hollow feature, noting the regular $\sim 60^\circ$ east-southeast dip of the strata and the more steeply inclined S_3 foliation giving clear indications of a synform to the east.

Return to Uisken Bay and walk eastwards across the sands, using a small stile [NM 3945 1890] to gain access to the rocks to the east. The section along the coast from here to Slochd Mhi Chriscain [NM 3975 1880] requires some difficult scrambling and minor climbing. It would be easier to leave the shore area, walking away from the coast across the scrubby moorland, only returning to the coast to reach Localities 1.22 and 1.23.

Locality 1.22 — Discordant amphibolite and F_2/F_3 structures. [NM 3965 1864]

Locality 1.22 exposes a thick strongly cross-cutting garnetiferous amphibolite (Figure 1.4). There is considerable structural complexity whereby garnetiferous amphibolite is repeated by an F_3 antiform that intervenes between the two

amphibolite outcrops; the complexity is compounded by a further antiform, the hinge of which can be clearly seen to plunge steeply (~60°) seawards by looking over the edge and to the east of a 10-20m cliff at the headland of the Slochd. Because the latter and the F_3 antiform that repeats the amphibolite are adjacent, i.e. without an intervening synform, it is inferred that the inaccessible structure must be a F_2 fold.

Locality 1.23 — Hinge zone of the F_3 Assapol Synform (Figure 1.2). [NM 3980 1885] to [NM 4100 1880]

Locality 1.23 comprises the coast between [NM 3980 1885] and [NM 4100 1880] (Figure 1.1) The coast between Localities 1.22 and 1.23 at the head of Slochd Mhi Chriscain is very jagged and can be difficult to traverse especially at high water. It may be advisable to walk away from Locality 1.22 via the moorland and to drop down to the head of the bay to visit Locality 1.23 which comprises a set of low crags above and below HWM. This exposure lies in the core of the Assapol Synform (Figure 1.2), (Figure 1.5) and displays abundant upright minor folds with overall W-shaped vergence; they plunge shallowly south-southwest, although having somewhat curvilinear hinge lines. A rodding fabric, possibly a product of D_2 , passes around the hinges of these folds. Eastwards from this locality, the F_3 minor folds and the S_3 bedding/banding relationships consistently indicate a F_3 synform core to the west. It is noteworthy that this persists at least as far east as Locality 1.14 where relationships between D_1 , D_2 and D_3 structures and fabrics can be established.

Once east of the hinge zone of the Assapol Synform, the vergence of the F_2 folds and the F_3 folds is in the opposite direction, while the F_3 fold plunge becomes shallowly inland to the north-northeast. The F_3 folds are pointing to a synform to the west, while the F_2 indicate an antiform to the west. The F_2 and F_3 are normally easily distinguished; the axial planar fabric S_2 of the F_2 folds commonly appears penetrative, while the S_3 is unambiguously a crenulation fabric. The interference of the two sets of folds and fabrics is well seen in many localities along the coast section designated as Locality 1.23. Notably, these relationships can be studied on Eilean Dubh (e.g. [NM 4010 1875]) and on the unnamed headland [NM 403 187] to the east across Port Bheathain. Interference between the two sets of structures is common, e.g. on a north-facing crag [NM 4041 1886].

Two further localities are recommended to point the contrast between the phenomena in pelitic and psammitic rocks associated with the emplacement of the Ross of Mull Granite.

Locality 1.24 — Contact metamorphic phenomena within the aureole of the Ross of Mull Granite. [NM 365 217]

Contact metamorphic phenomena within the aureole of the Ross of Mull Granite. Distance is less than 1km, taking c.1 hour. [NM 365 217]

The locality is reached by means of the A849 towards Fionnphort from Bunessan, and lies ~2km west of Bunessan. The track leading to Bendoran Cottage has been gated near the roadside, and parking is limited. Walk to the cottage and turn left following paths up the craggy hill Torr na h-Annaid [NM 365 217], to the east of the cottage. This is Locality 1.24 (Figure 1.1). Here you are in the contact zone of the granite where it has intruded striped and banded pelitic/semipelitic gneiss, reminiscent of the Scoor Pelite. Zones and veins of granite with rather diffuse margins, possibly the result of partial melting *in situ*, transect the banding. These commonly contain cm-scale xenoliths. The quartzofeldspathic gneissic lenticles are preserved in the country rocks. Sillimanite knots, possibly after kyanite, are locally well displayed. *These should not be hammered.* The rocks lie within Zone IV of Wheeler *et al.*, 2004 (figures 1, 6, 7) who recorded cordierite coronas around garnet, euhedral garnet, K-feldspar and prismatic sillimanite at this locality. The Moine country rocks here are strongly hornfelsed, but there is little or no sign of the forceful wedging of magma into planes of pre-existing fissility. This is in strong contrast to the granite relationships to the flaggy Assapol Group psammites well displayed at Locality 1.25.

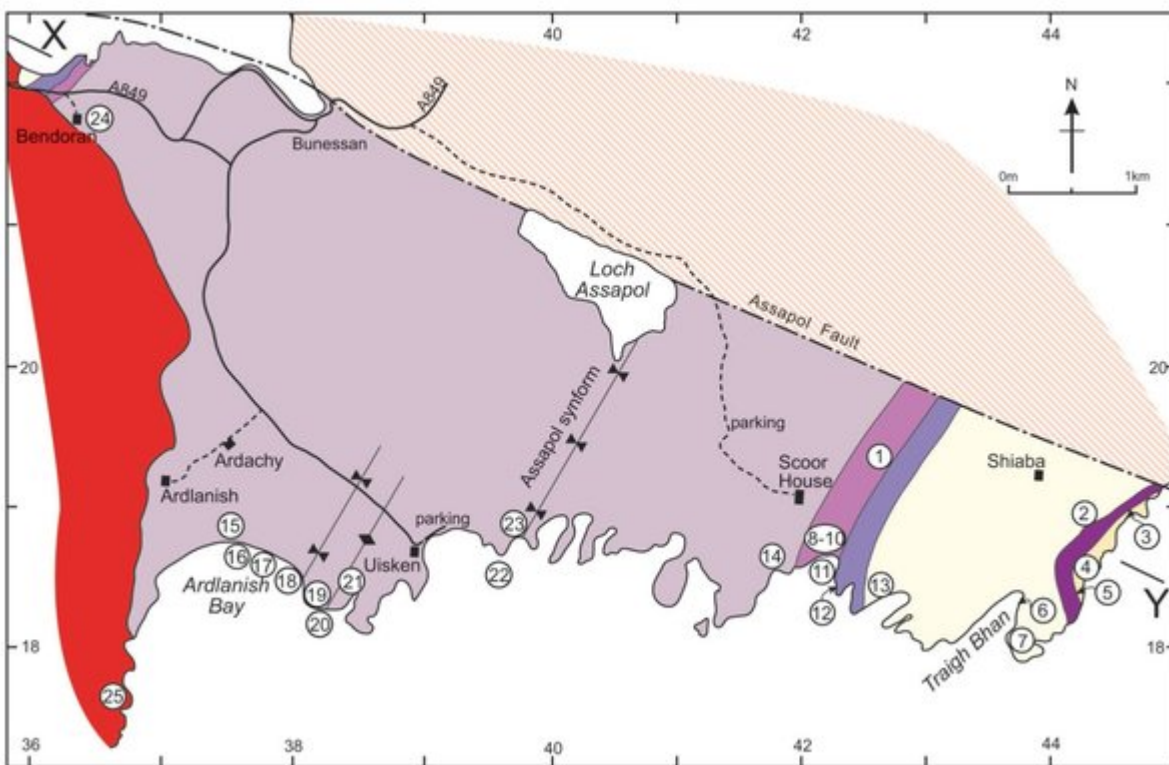
Locality 1.25 Margin of the Ross of Mull Granite. [NM 3680 1765]

Margin of the Ross of Mull Granite. Distance from Ardalanish and return is c.4km, taking 3 hours. [NM 3680 1765]

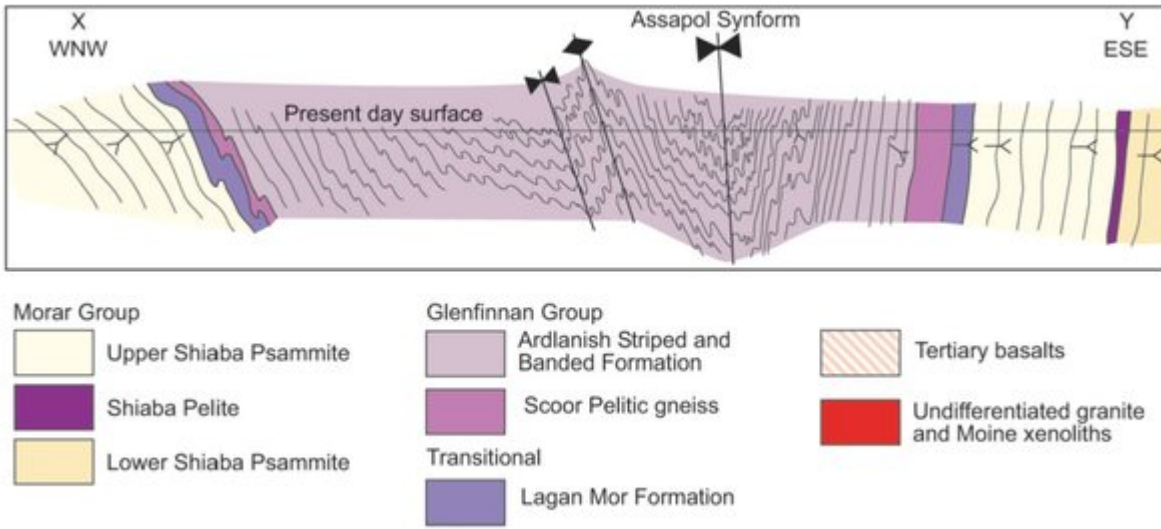
It would be advisable to seek permission from the farmers at Ardlanish Farm before visiting this locality. The locality is accessed by the same route as that leading to Itinerary C. However, from Locality 1.15 the excursion should turn westwards, making towards the western end of Ardlanish beach, while passing through rocks of Zones II and III of Wheeler *et al.* (2004, figure 1). At the end of the beach a path should be followed southwards across the low raised beach to Slochd na Beiste [NM 3683 1827] where a low stone dyke can be easily crossed, and a steep path can be followed a few tens of metres up the slochd, a gully with rocky walls, as far as a col on its west side (you are here at the granite margin). Drop down from here on to the low raised beach below and walk down to the shore, to which the approach can be very boggy in wet weather. Proceed along the coast southwards past Carraig Mhor with its offshore rocky island, and continue to the next headland to the south [NM 3680 1765]. This is Locality 1.25 (Figure 1.1).

A great range of igneous features can be studied at this locality, although the spectacular wedging of the granite between the psammitic flags is the most obvious (see also Zaniewski *et al.*, 2006). The precise contact of the pluton is not easily determined, because there is a gradual transition from granite with xenoliths and psammite essentially *in situ* with abundant granite wedges. This is in marked contrast to the contact with the pelite at Bendoran (Locality 1.24). Additional features of interest at this locality include an excellent example of a graphic granitic pegmatite dyke cutting a large hornfelsed metabasic body, a porphyritic felsite sheet about 4m thick, dipping 15°-20°N and displaying feldspar phenocrysts having cores of fresh microcline and red, heavily altered sodic plagioclase rims, as well as rounded, heavily corroded quartz xenocrysts, and a northwest-trending Tertiary dolerite dyke

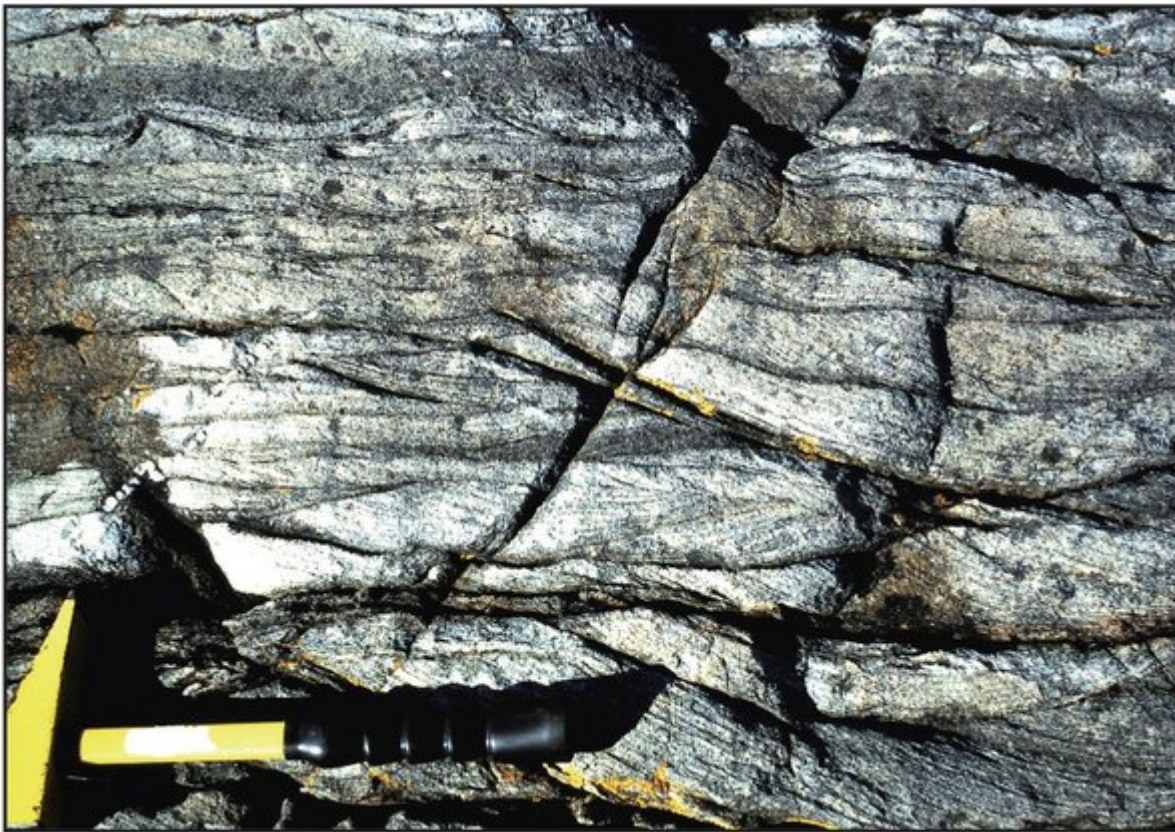
References



Simplified geology map of the Ross of Mull, showing the localities described in the text.



NW-SE cross-section across the Moine rocks of the Ross of Mull (modified from Holdsworth et al., 1987).



Cross-bedding and cross-lamination within the Upper Shiaba Psammite at Locality 1.13.



Garnetiferous amphibolite cutting obliquely across bedding within host Moine psammite at Locality 1.22.



F₃ folds within the core of the Assapol Synform at Locality 1.23.