
Excursion 8 Glen Strathfarrar and Loch Monar

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<i>Purpose:</i>	To study classic exposures of superposed fold systems, and Moine-Lewisian relationships in the central part of the Caledonian orogen.
<i>Aspects covered:</i>	Lewisian orthogneisses; Moine psammities, including a probable basal conglomerate; polyphase deformation structures; Sgurr Beag Thrust.
<i>Useful information:</i>	Hotel and B&B accommodation are available at Inverness, Beaully and Struy. Camp sites are situated at Lovat Bridge (2km south of Beaully), Cannich, and holiday chalets are available in Glen Strathfarrar. A car or small van is essential for this excursion as the road is not suited for coaches or trailer caravans.
<i>Maps:</i>	OS: 1:25,000 sheet 430 Loch Monar, Glen Cannich & Glen Strathfarrar; BGS: 1:50,000 82E Scardroy. Ramsay (1957) contains a folded structural map at 1:21,120 scale of the Monar region, but made before the hydroelectric dams were built, so the shores of Loch Monar as depicted are not correct today.
<i>Type of terrain:</i>	A mixture of lochside, roadside, quarry, river and hillside exposures, all of easy access.
<i>Distance and time:</i>	The excursion can be accomplished in one day.
<i>Short itinerary:</i>	If the main interest of the visit is to study the classic superimposed folding outcrops, Localities 8.1-8.4 can be completed in half a day.

Forward planning is advised to obtain access to Glen Strathfarrar. Follow the A831 towards Cannich and 800m south of Erchless Castle turn right along a narrow road into Glen Strathfarrar, which branches off the main road just before the bridge at Struy. At Inchmore the road is barred by a multi-locked gate. The road is now a private road and it is necessary to obtain a permit to proceed further at the gatekeeper's house (Tel: Struy 01463 761260) on the left of the road immediately in front of the gate. This permit is readily granted, but note that the Glen is only open from April until October. During this period, access is between the hours of 0900 to 1800-2000 depending on season, and it is closed on Tuesdays and Wednesdays until 1300. There are no places to overnight in the glen and camping is not allowed as it is a protected nature reserve (Scottish National Heritage). Proceed along Glen Strathfarrar for 20km as far as the Monar North dam site (Scottish and Southern Energy plc). The valley is especially beautiful, almost unspoilt and containing many stands of Scots Pine, a tree of slow growth characteristic of the Caledonian forest which once covered much of the Highlands.

The region consists of strongly deformed Moine metasediments and Lewisian basement. The Lewisian was emplaced as a sheet into the Moine rocks along a zone of intense D_1 deformation (the Sgurr Beag Thrust, (Figure 8.1), (Figure 8.2) before D_2 and D_3 folding. This region has played a critical role in the general interpretation of fold interference structures. The geometry of the Monar region is dominated by the D_2 Loch Monar Synform (Figure 8.1) which has a very steeply dipping southern limb, a more gently inclined northern limb and a hinge zone which generally plunges to the west. D_2 parasitic folds with S-shaped forms are apparent along the Moine-Lewisian contact along the southern part of the area (Fig 8.1), (Figure 8.2). These do not affect the D_1 Sgurr Beag Thrust on the northwest side of the Lewisian sheet, perhaps because the structure was also active during D_2 folding. In contrast to the D_2 folds, the D_3 folds which are superimposed on the limbs of the Loch Monar Synform generally have overall Z-shaped forms and have plunge directions inherited from the initial limb dips of the earlier fold (Ramsay, 1957). The significance of the special and

systematic fold geometry seen at Monar has been analysed in some detail in Ramsay & Huber (1987, pp. 480-84, 499-502).

Locality 8.1 Roadside just NE of North dam. [NH 2038 3938]

Roadside just NE of North dam. D_2 and D_3 folding within Moine psammites.

Park just below the North dam [NH 2035 3940]. The outcrops along the northern side of the road are Locality 8.1 and show two sets of fold structures. Earlier D_2 folds generally plunge to the west, but their hinge-lines and associated linear structures frequently undulate in a sinusoidal manner. The later D_3 folds frequently appear as corrugated forms with about the same wavelength as typical corrugated iron. The fold hinges generally plunge steeply or even vertically as is the norm throughout the southern limb of the D_2 Loch Monar Synform. Where the D_3 folds are especially strongly developed the recrystallisation associated with their development has locally, partially or even completely obliterated the linear fabrics associated with the D_2 folds and these linear fabrics are overprinted by new schistosity-bedding intersections parallel to the D_3 fold hinges.

Locality 8.2 Hillside just NE of North dam. [NH 2002 3895]

Hillside just NE of North dam. Deformation of D_2 structures by D_3 folds within Moine psammites.

Cross the North dam and park just before arriving at the South dam. On the hillside on the north side of the South dam is a large cement block used as an anchor during the construction of the dam. A flat-topped outcrop 15m southeast of this block is Locality 8.2 at [NH 1998 3897] (Figure 8.2). It shows a perfect miniature model of the fold intersection geometry with eye-like basin forms being located at the intersections of crossing D_2 and D_3 synforms. The fold hinge-lines of the late D_3 structures are variable and controlled by the dips of the limbs of the D_2 synform. On the roadside just below this outcrop are excellent examples of D_3 corrugations superimposed on a moderately inclined pre-existing surface of a D_2 fold. The limbs of these D_3 folds show traces of an early lineation parallel to the D_2 old hinge lines which may be traced over the fold hinges. Each of these curving lineations is aligned in a plane (strike 095° dip 75° S). The significance of this geometry has been discussed by Ramsay (1960, 1967, pp. 470-82) and appears best explained by attributing the forms to flow in a direction which is not perpendicular to the fold axes, but controlled by flow quite oblique to the fold axis. This has been termed the 'a'-direction, and it can be found at the intersection of the lineation plane with the axial planes of the deforming folds (here with strike 037° dip 82° E). This calculation, easily carried out using a projection net, shows that the flow direction plunges 75° to 181° (see also a worked example and discussion in Ramsay & Huber, 1987, pp. 484 and 501). It can be deduced that the D_3 fold hinge lines associated with an intense rodding fabric are not simply related to the stretching direction, although they may lie close to this direction. Outcrops lower down this roadside section show almost vertically-plunging D_3 corrugations (superposed on initially steep limbs of D_2 folds) which also show D_2 lineations deformed by the folds, and calculations show that the 'a'-directions lies very close to that of the previous calculation.

Please do not hammer any of these most instructive outcrops.

Locality 8.3 Glacial pavement immediately west of South dam. [NH 1990 3884]

Glacial pavement immediately west of South dam. D_2 - D_3 interference patterns within Moine psammites.

Cross the South dam and park at the road junction. Descend to the lake side on the south side of Loch Monar to reach Locality 8.3 [NH 1990 3884] (Figure 8.2). Here are almost unbelievably wonderful outcrops of folded Moine sediments with abundant very clearly preserved interference patterns on very clean glaciated surfaces. These are classic outcrops, well suited to photography ((Figure 8.3); and see Ramsay, 1962; Ramsay & Huber, 1987, 498; Ramsay & Lisle, 2000, p. 905). The Moine sediments are mostly psammite with bands of darker semi-pelitic and pelitic material and occasional bands rich in heavy minerals. The cusped-lobate forms of D_3 folds developed at the interfaces of psammitic and pelitic bands indicative of buckling instabilities are extremely clear, and examples of competent layers with inward pointing cusps and incompetent pelitic bands with outward directed cusps abound. It is also clear that the basic fold model here is that of overall harmonic folding, related to the close packing of the initial layers, with some polyharmonic folding forms

where especially competent or incompetent sheets are involved (Ramsay & Huber, 1987, p. 406). A ductility sequence can be established: quartz-feldspar D_2 pegmatite and gneissic veins > psammite > semi-pelite > pelite. Although these folds mostly show that buckling components are present, one should not forget the geometry of the folds seen just north of the South dam indicating that they are not just simple buckle folds but have strong flattening and shear components controlled by steeply inclined flow directions and might be best termed oblique buckle folds (Ramsay, 1967, p. 396; Ramsay & Huber, 1987, p. 489).

As well as having been subjected to amphibolite facies metamorphism during both folding phases, the rocks here have been subjected to melting and the development of migmatite veins. Those veins formed during the D_2 events form coarse feldspar-quartz-mica sheets sub-parallel to the bedding. These are plicated by well developed D_3 folds, often of ptygmatic habit, whereas those veins developed during the D_3 events form narrow pegmatite sheets located in the limbs of the D_3 folds and which cross-cut the earlier folded D_2 sheets. Note that these D_3 sheets rarely occur along the actual hinge zones of the D_3 folds, but are practically always developed in the fold limb which has been most strongly deflected from that of the original orientation of the banding after D_2 fold development. Other features of these outcrops are the presence of occasional late dykes of the schistose lamprophyre type and a few thin late cross-cutting pegmatite dykes which, although they cross-cut the D_3 folds, have been slightly affected by the last shortenings of the D_3 events. These pegmatites are the outermost part of an intense pegmatite swarm (Ramsay & Huber, 1987, p. 324) which may well be related to an unexposed Caledonian granite situated at depth. Return to the vehicles and proceed along the road south of the South dam.

Locality 8.4 Roadside outcrops west of the road. [NH 1996 3848]

Roadside outcrops west of the road. D_3 folding of D_2 linear structures within Moine psammites.

On the west of the road at Locality 8.4 [NH 1996 3848] are very good examples of vertical or steeply plunging D_3 folds (imposed on the steep limb of the Loch Monar D_2 synform) folding D_2 linear structures. There are thick bands of pelitic material interbedded with the psammites. These show few of the D_3 corrugations seen in banded psammites, but contain a well-developed alignment of micas sub-parallel to the axial planes of the D_3 folds. Proceed further along this road towards the Upper Power station in the Uisge Misgeach river valley.

Locality 8.5 South of the Upper Power Station. [NH 1840 3772]

South of the Upper Power Station. Lewisian–Moine relationships.

Park at [NH 1832 3810] (Figure 8.1). Follow the pipeline south-southeast to a small quarry which is Locality 8.5. Here the contact between Lewisian gneisses and Moine psammites is well exposed. The Lewisian consists of orange-weathering quartz-feldspar gneiss with lenses of hornblende- and biotite-rich material. Although this gneiss has been reduced in grain-size it is quite unlike the pegmatitic gneissic bands seen in the Moine rocks. The adjacent Moines are psammites with pelitic bands clearly of sedimentary aspect. Both Lewisian and Moine rocks show steeply plunging D_3 folds. Return to the parked vehicle and drive to the main park place [NH 20353940].

Locality 8.6 Lakeside outcrops west of Monar Lodge. [NH 1988 4050]

Lakeside outcrops west of Monar Lodge. D_3 folds cut by pegmatite dykes.

From the parking place, proceed by foot along the road towards Monar Lodge. From the north of the Lodge take a small footpath along the loch side to glaciated pavements exposed on the foreshore which are Locality 8.6 [NH 1988 4050] (Figure 8.1). There are excellent examples of Z-shaped D_3 folds plunging 30° to 40° to the SW. We have crossed the axial surface of the D_2 Loch Monar Synform (it passes through Monar lodge) and are now situated on the northern limb of this fold, hence the plunge of the D_3 folds is significantly less than most of those seen in the Monar damsite outcrops. The D_3 folds are cross-cut by impressive pegmatite dykes. These are coarse-grained (crystals up to 10cm) quartz-feldspar-mica dykes with more finely crystalline margins. The dykes, although cross cutting the D_3 folds, are

themselves quite strongly folded and shortened by overlapping thrust-like sectors. Return to the vehicles.

Locality 8.7 River section of the Garbh Uisge. [NH 2180 3927]

River section of the Garbh Uisge. Highly strained Lewisian and Moine rocks within the D₁ Sgurr Beag Thrust Zone.

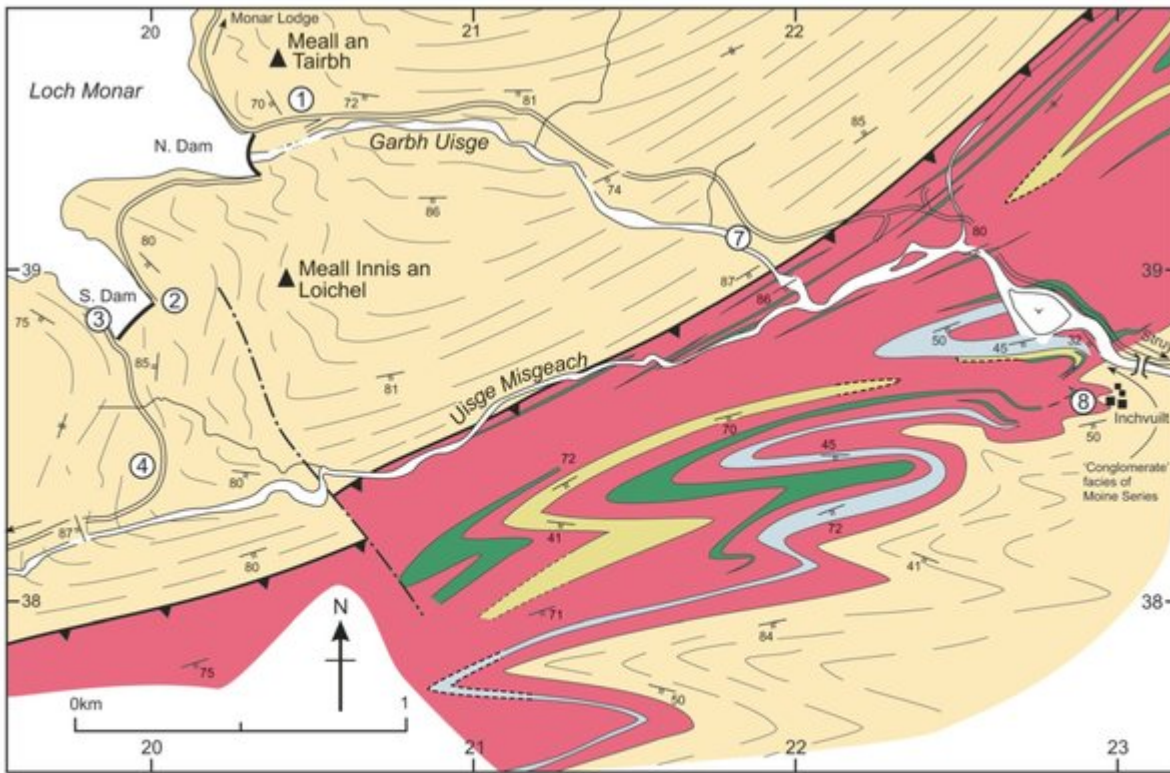
Return along the road descending into Glen Strathfarrar. After about 1.5km make a roadside stop [NH 2180 3919] and descend about 30m into the river section of the Garbh Uisge to Locality 8.7 at the northern contact of the Moine and Lewisian (Figure 8.2). Here one becomes aware of the difficulties in distinguishing the two units. The banding in Moine and Lewisian is almost vertical, quite parallel and all the rocks show a well developed D₂ linear fabric plunging 30° towards 225° (the axial direction of the Loch Monar Synform). To the NW, the rocks are grey, well-banded psammites clearly part of the Moine. Descending the river to the SE, the rocks are banded orange-buff coloured gneisses containing sheets and boudins of amphibolite and clearly of Lewisian aspect. However, because of the convergent appearance of Moine psammites and Lewisian quartz-feldspar gneisses, the contact is difficult to locate with precision, even though the outcrops are extremely good. The well-banded and foliated nature of these outcrops may reflect the presence of a D₁ tectonic slide at this contact, probably the Sgurr Beag Thrust (Tanner *et al.*, 1970). Another point of interest at this locality is the presence of some dark, non-metamorphic camptonitic dykes (Permian) intruded parallel to the layering. Return to the vehicles.

Locality 8.8 Moine-Lewisian contact north of Inchvuilt [NH 2294 3874]

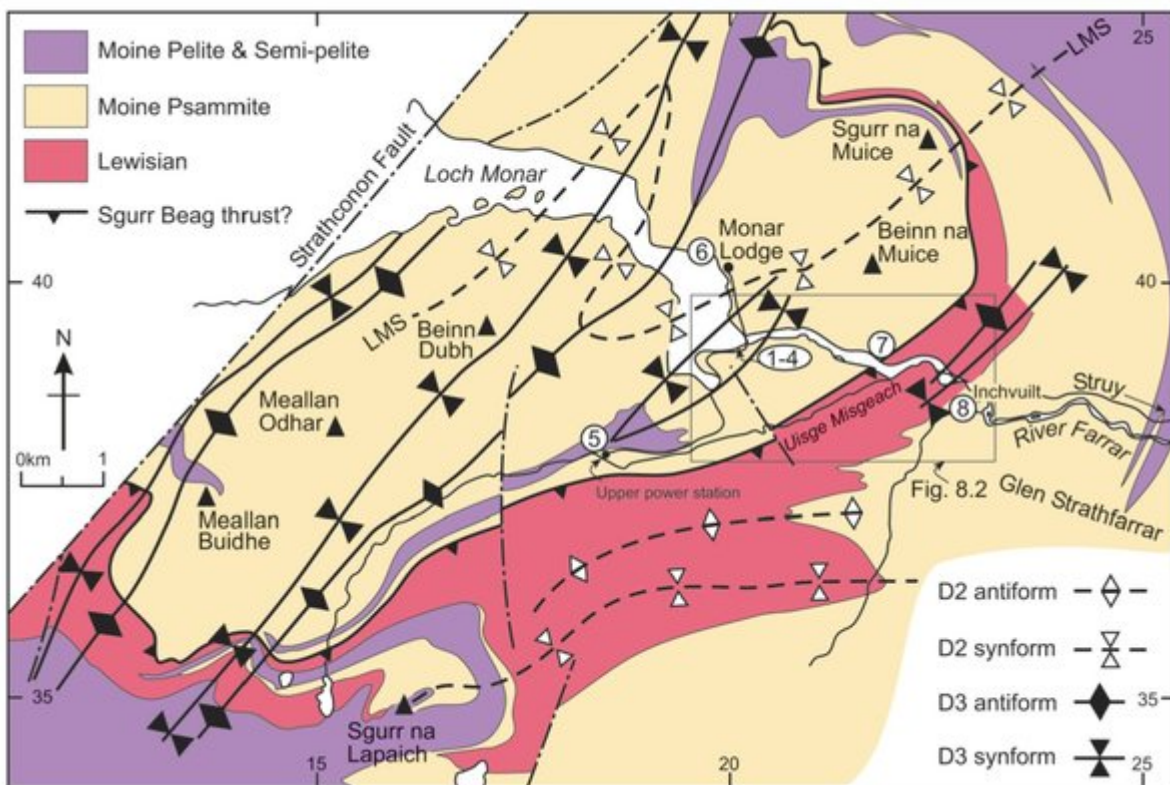
Moine–Lewisian contact north of Inchvuilt; probable basal Moine conglomerate on the east side of the Lewisian inlier.

Drive to the bridge which crosses the River Farrar at Inchvuilt (Figure 8.2) [NH 2304 3874]. Park and cross the footbridge to outcrops at Locality 8.8 of Moine rocks on the south side of the river by an electric pylon [NH 2294 3874]. Lewisian rocks of calc-silicate and amphibolitic types are exposed a few metres to the west. The Moine semi-pelites contain elongated and rodded lumps of quartz and quartz-feldspar-mica rock resembling pebbles and interpreted by E. M. Anderson as being the basal conglomerate of the Moine with the adjacent Lewisian gneiss (Anderson, in Peach *et al.*, 1913). Although this interpretation has been questioned (Ramsay, 1956) it is probably correct. Return down the valley to the gate where it will be necessary to log-out of the valley.

[References](#)



Geological map of the southern limb of the Loch Monar Synform showing localities around the eastern end of Loch Monar, together with details of the internal lithologies found in the Lewisian sheet.



General geological map of the Monar region and upper parts of Glen Strathfarrar.