Slumbay Island, Loch Carron

[NG 896 385]

A.J. Barber

Introduction

Easily accessible examples of mylonites at the Slumbay Island GCR site provide a key to understanding the structural development of the Moine Thrust Belt, as a clear sequence of small-scale structures can be established. The mylonites of Slumbay Island are formed from Lewisian gneiss and amphibolite protoliths, which have been intensely cataclastically deformed and complexly folded. The mylonites form a thrust slice that lies between a lower thrust plane ('un-named thrust' in (Figure 5.50)) and the Moine Thrust plane to the east, in turn overlain by Moine psammites. The mylonites form a 2 km-wide band along the shore of Loch Carron that narrows northwards until transected by a major fault in Glen More (Figure 5.50). Inland, both the mylonite and the overlying Moine rocks are generally very poorly exposed.

Farther west below the un-named thrust lies the Kishorn Nappe in which sandstones of the Torridon and Sleat groups are folded into a large-scale overturned syncline, the northward continuation of the Lochalsh Syncline, which rests on the Kishorn Thrust (Figure 5.53) — see Carn a' Bhealaich Mhòir GCR site report, this chapter). In the Lochcarron area, only the inverted, upper limb of the syncline is represented. Within this upper limb, the bedding of the Torridonian and the foliation within the overlying Lewisian gneisses and the Moine psammites are sub-parallel and dip eastwards at *c.* 20°.

The area around Lochcarron was mapped during the primary geological survey by B.N. Peach and J. Horne (Peach *et al.,* 1907), and the 1:63 360 geological map (Sheet 82) was published in 1913 (Geological Survey of Scotland, 1913b). The area was later remapped by M.R.W. Johnson as part of a PhD study, in which particular attention was paid to the structural features of the rocks and the structural development of the thrust belt Oohnson, 1955, 1956, 1960). The formation of the mylonite was considered by Johnson to be the earliest event to affect the rocks of the Moine Thrust Belt. Although the mylonitization has destroyed or at least masked the earlier structures in the been superimposed, enabling Caledonian rocks, the mylonitic foliation provides a structures to be separated from pre-Caledonian datum upon which later tectonic events have structures.

Description

Mylonite is well exposed over a distance of 250 m on the raised rock platform and in the backing cliffs along the southern and eastern sides of Slumbay Island, a small peninsula that projects eastwards into Loch Carron and is linked to the shore by a tombolo (Figure 5.50). At the eastern end of the peninsula, rocky exposures form roches moutonnees with ice-smoothed N-facing slopes.

The mylonites on Slumbay Island are finely laminated and foliated with pink quartzofeldspathic material, in places coarser grained and recognizable as deformed quartz-feldspar pegmatites, alternating with darker laminae rich in chlorite and epidote. Mafic bands and lenses, up to 15 cm thick, are also present and a 1 x 3 m pod of amphibolite occurs in the cliff at the eastern end of the peninsula. On the southern side of the peninsula the foliation dips steeply to the north, but the dip is variable and flattens in the central part of the shore section to expose extensive foliation surfaces.

Three sets of fold structures post-date the mylonite foliation. Similar fold structures are also found in the deformed Torridonian, Lewisian and Moine rocks of Lochcarron. The earliest formed set consists of small-scale long-limbed tight to isoclinal folds with ESE-plunging axes. The isoclines fold the mylonite layering, with the dominant foliation axial planar to these structures (Johnson, 1960, fig. 7). Macroscopic folds of this generation are not abundant in the main mylonite belt but occur in other rock units. An ESE-trending mineral lineation, orientated parallel to the fold axes, is commonly developed (Johnson, 1960). The second folds are asymmetrical and overturned to the west with subhorizontal ENE-trending axes. Locally they have an associated E-dipping, axial-planar spaced cleavage. These folds deform the

foliation and the associated ESE-trending lineation and more rarely are seen to refold the early isoclines (Johnson, 1960, figs 10a and 10b). The latest folds are kink folds, commonly occurring as conjugate sets and with no obvious preferred axial trend (Figure 5.51). No related cleavage is developed, but the fold axial planes may be marked by fractures. They affect structures related to both earlier fold sets (Johnson, 1956, 1960). Both large- and small-scale kink-folds are developed abundantly in the platy mylonites of Slumbay Island.

Johnson (1960) found that the mylonites and all the earlier structures are disrupted and brecciated in the neighbourhood of the thrust planes. An example occurs in the cliff at the south-west corner of Slumbay Island where the mylonite is cut by such a subhorizontal thrust surface, marked by a 1 m-wide brecciated zone. The development of brittle thrust planes is the last structural event related to thrusting.

In the upper part of the Kishorn Nappe the Lewisian gneisses show localized shear-zones, transitional upwards into mylonite gneiss and laminated augen mylonite. This development culminated in the formation of the fine-grained platy mylonites that form the main mylonite belt, as exposed at Slumbay Island.

Interpretation

Lewisian basement gneisses incorporated in the Moine Thrust Belt show a range of pre-Caledonian structures and metamorphic fabrics, as well as structures imposed during the Scandian Event. In parts it can be difficult distinguishing between Caledonian and pre-Caledonian structures. The value of the mylonites in the thrust zone is that the slate is effectively wiped clean; the mylonites can be treated as a relative time datum in the development of the Caledonian Orogeny.

The mylonites in the Moine Thrust Belt at Lochcarron show a clear sequence of structures. Mylonite formation occurred at an early stage in the development of this part of the thrust belt. Johnson (1960) related the mylonitization to formation of the Lochalsh Syncline and the inversion of the Torridonian and Lewisian rocks. This phase of deformation also brought bedding and foliation in the Torridonian and Lewisian rocks into parallelism at the unconformity.

Johnson (1960, fig. 2) mapped several dyke-like amphibolite bodies in the Lewisian rocks structurally above the overturned Torridonian unconformity. The dykes trend E–W or WNW–ESE, effectively parallel to the majority of Scourie dykes in the Lewisian gneisses of the foreland to the west. However, it seems unlikely that the Lewisian gneisses of the Kishorn Nappe are regionally inverted, although it would partly explain the concentration of strain along the unconformity (see Carn a' Bhealaich Mhoir GCR site report, this chapter, for further discussion).

The main mylonite belt in Lochcarron now occurs in a thrust slice that has been moved a significant distance to the WNW It presumably links to a more-widespread high-strain mylonite zone, now concealed beneath the overthrust Moine succession. The mylonites were formed under elevated temperatures and pressures aided by the availability of hydrous fluids. Lewisian gneisses became ductile, with the development of shear surfaces and grain-size reduction while undergoing continuous dynamic recrystallization. Quartz-rich gneisses were intensely deformed, whereas amphibolites proved more resistant to deformation and thus tend to be preserved. The earliest folding, which resulted in the long-limbed isoclines, is viewed as an intrinsic part of the mylonitization. Inhomogeneities in the layering would generate asymmetrical folds that would rapidly become overturned and tighter before being sheared out (Talbot, 1979). With increasing strain fold axes, initially formed at a high angle to the direction of movement, would rotate until they were near-parallel to the movement direction as represented by the ESE-plunging mineral lineation (e.g. see Cobbold and Quinquis, 1980).

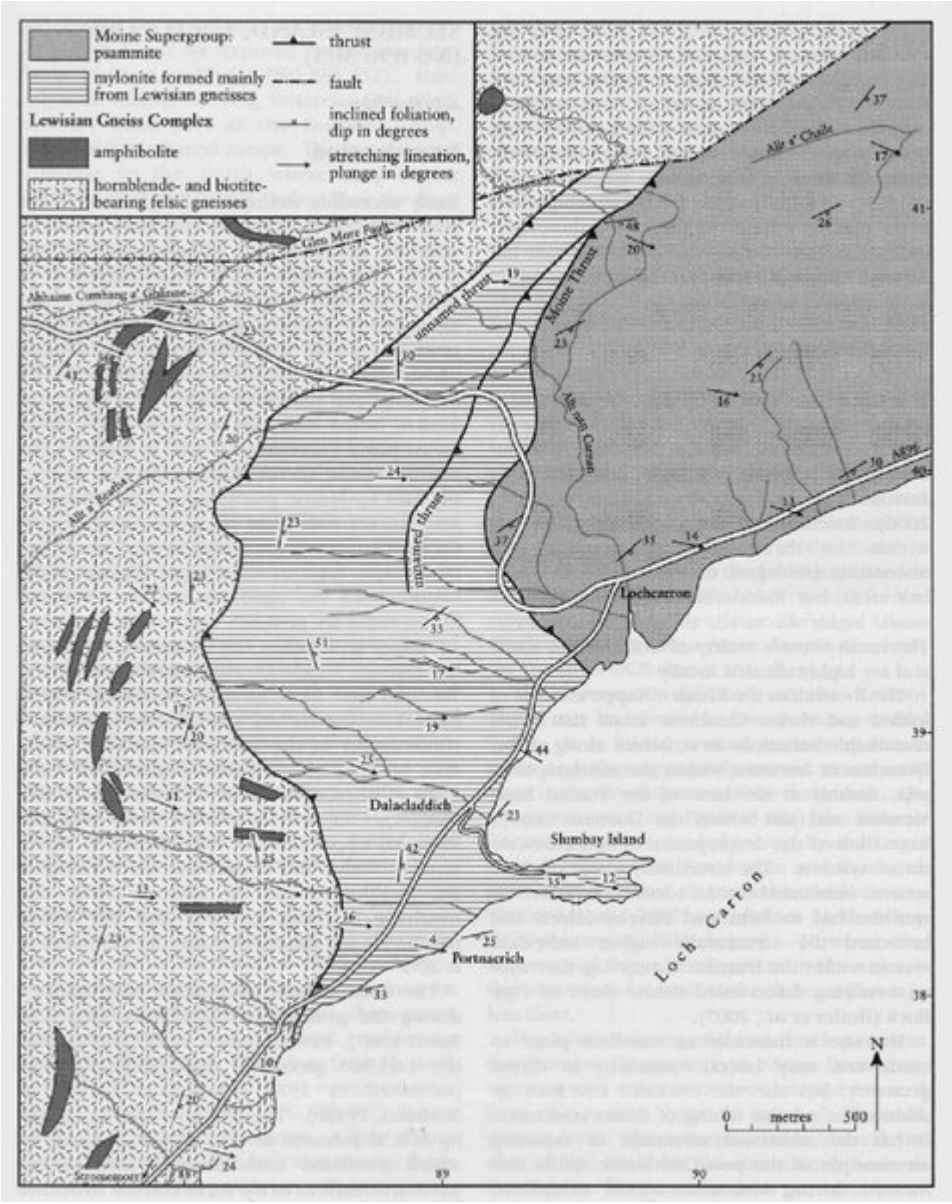
The later fold phases that affect the mylonite layering and early-formed structures represent renewed compressional episodes during the exhumation and cooling of the mylonites and associated rocks. The secondary W-verging, asymmetrical folds represent continued westward movement of the rock units in the thrust belt at a stage in uplift and unloading, whereas the kink folds are semi-brittle structures formed under conditions in which vertical relief of stress was possible beneath a shallow overburden.

The final event in this part of the thrust belt was the movement of the rock units along thrust planes in a phase of brittle thrusting, which brecciated the mylonites and later fold structures, and disrupted the earlier structural pattern. This sequence of events in the mylonites of Slumbay Island records the continual westward movement of the rock units forming the thrust belt, under declining pressures and temperatures, during uplift and removal of the overburden.

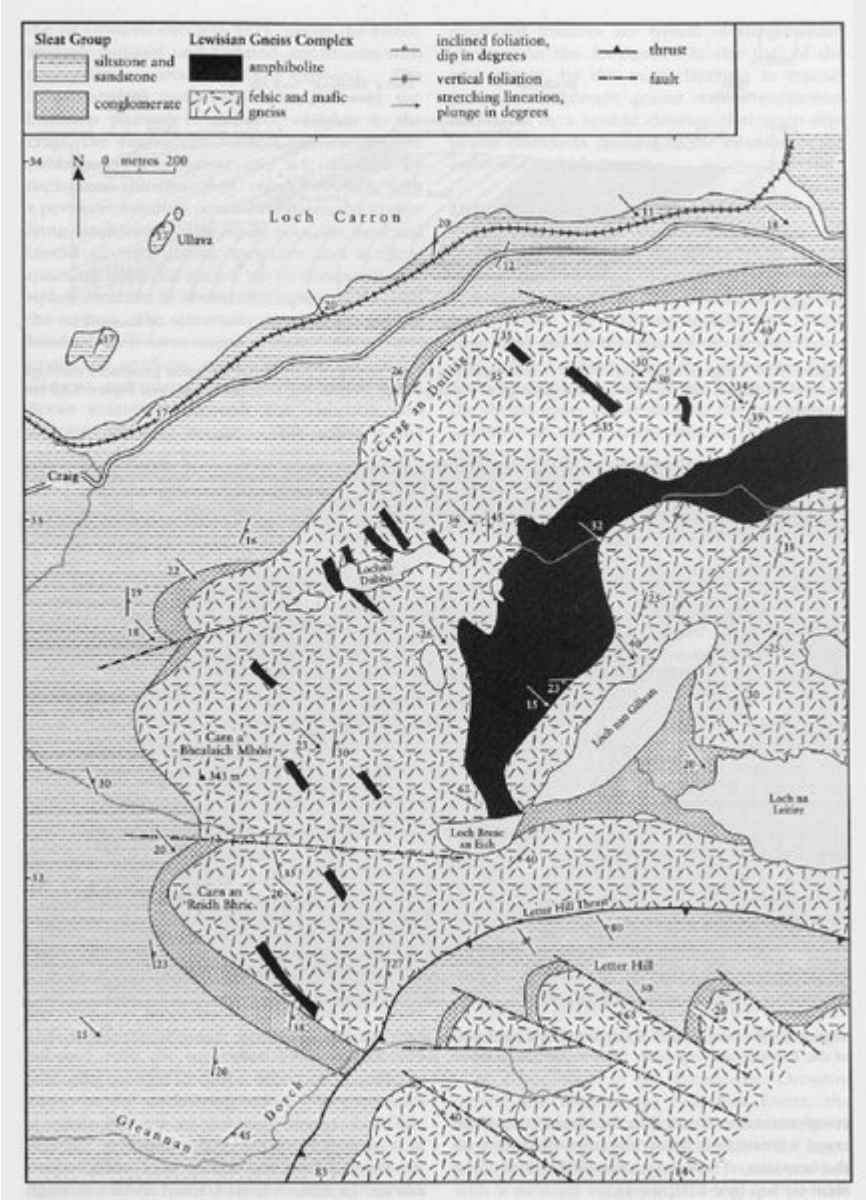
Conclusions

The clear and easily accessible exposures of Slumbay Island in Loch Carron are of national importance in that they show the characteristic features of mylonite development in the Moine Thrust Belt. Three distinct fold phases can be distinguished in the mylonites. Fold styles range from early-formed, tight to isoclinal minor structures through asymmetrical minor folds, to kink folds. A late phase of localized brittle thrusting and brecciation post-dates the folding events. The early-formed folds and related ESE-plunging lineation and axial-plane foliation are interpreted as an integral part of the mylonitization event. The overall structural sequence demonstrates that the rocks in this part of the Moine Thrust Belt were initially deformed at depth farther east under greenschist-facies metamorphic conditions, resulting in the formation of the mylonites. The mylonites were subsequently uplifted, folded and thrust westwards towards the foreland. In the final phase of deformation, the mylonites, together with the associated rock units, were broken and disrupted during late-stage westward movements over the foreland along discrete thrust planes. The well-exposed structures at Slumbay Island show a structural sequence that can be matched in other places along the Moine Thrust Belt.

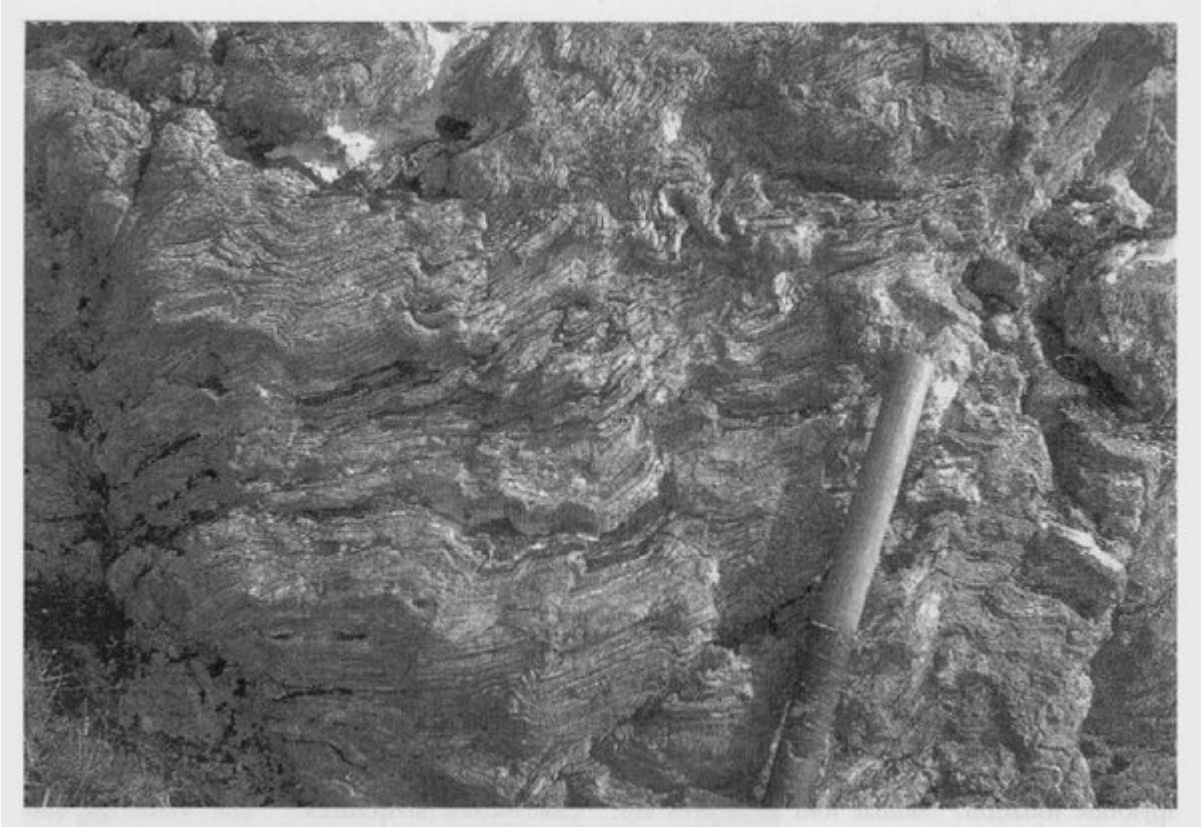
References



(Figure 5.50) Map of the area around the Slumbay Island GCR site (based on mapping by M.R.W. Johnson).



(Figure 5.53) Map of the area around the Carn a' Bhealaich Mhoir GCR site. After Kanungo (1956).



(Figure 5.51) Close-up view of laminated mylonite below the Moine Thrust, with abundant late kink-folds, some of which form conjugate sets (e.g. left of centre). Western shore of Slumbay Island. (Photo: A.J. Barber.)