Loch Moidart Road Cuttings (A861)

[NM 681 737]–[NM 697 728]

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Introduction

The Loch Moidart Road Cuttings GCR site provides a cross-strike section through the Upper Morar Psammite, the younger of the two major psammite units of the Morar Group of the Moine succession (Figure 8.25)a. Although steeply dipping and folded by both major and minor fold structures, the psammite unit shows prominent sedimentary structures, notably cross-bedding and slump folding. The Upper Morar Psammite overlies the Morar Pelite, a semipelite and pelite formation with minor psammite beds. At Loch Moidart a notably garnetiferous pelitic unit lies immediately below the contact and is exposed near Kylesbeg at [NM 678 739]. Glendinning (1988) followed Powell (1974) in showing a 'slide' or shear zone at this lower psammite–pelite contact, and correlated this structure with the Knoydart Thrust ('Slide') farther north (see North Morar GCR site report, this chapter). This correlation is no longer favoured. Increasing strain marks the upper eastern boundary of the Upper Morar Psammite Formation, which is overlain by .migmatitic pelite and semipelite of the Lochailort Pelite Formation (Glenfinnan Group). The contact is the Sgurr Beag Thrust whose trace runs through Kinlochmoidart. Late Caledonian microdiorite sheets, Permo–Carboniferous camptonite dykes and quartz-dolerite bodies, and Palaeogene dolerite dykes cross-cut the Moine rocks in the section (Figure 8.25)b.

A.G. Macgregor initially mapped the area for the Geological Survey in 1930 and 1933. Subsequently Brown *et al.* (1970) postulated that tight F2 major folds control the structure of the Loch Moidart section, with later F3 structures being restricted to rocks immediately to the east. Howkins (1961) described garnet textures from Glenuig in the underlying Morar Pelite, and Powell *et al.* (1981) detailed the metamorphic pattern of the area using calc-silicate mineral assemblages.

Description

The Loch Moidart Road Cuttings GCR site lies along the A861 and also includes the narrow raised marine benches and cliffs that reach up to 30 m above sea level in this area (Figure 8.26)a.

The road cuts provide an interrupted cross-strike section through the Upper Morar Psammite, which here is thickened by several tight F2 and F3 folds. Since the construction of the road, the sections have deteriorated and the embankment along the loch side obscures parts of the formerly exposed shore section. Some idea of the original clean nature of the section can be obtained from more recently blasted road cuts through the same formation farther north along the A830 (Fort William–Mallaig), west of Lochailort.

The Upper Morar Psammite at Loch Moidart is mostly a pale-grey, thick, well-bedded, feldspathic to micaceous psammite sequence with abundant thin semipelite beds. Thicker units of white to pale-grey, indurated, siliceous psammite occur in parts. Finely interbedded psammite and semipelite beds are common, in which grading from psammitic base to semipelitic top is seen locally. The semipelitic units are biotite-rich and locally contain garnet. Cross-bedding is locally well seen in the psammites and generally enables the determination of way-up. Trough-parallel sets are most common but trough-festoon sets occur near An Dun at [NM 6815 7353]. Glendinning (1988) measured the cross-bed foreset orientations from the Upper Morar Psammite between Ardnamurchan and Morar, and concluded that the palaeocurrents were bimodal with a primary current direction towards the NNE or north and a secondary direction towards the south or southeast.

Calc-silicate pods and lenses are abundant in both psammitic and semipelitic lithologies and represent diagenetically formed calcareous concretions in the original sandy or silty sequence. In the western part of the section, they contain zoisite + biotite + garnet assemblages, indicating epidote-amphibolite-facies metamorphism. In the eastern part of the

section, higher-grade hornblende + garnet + clinozoisite assemblages are found (Powell *et al.,* 1981). A zone with abundant clinozoisite extends some 1.7 km west of the Sgurr Beag Thrust. Powell *et al.* (1981) showed that clinozoisite occurrence corresponds to the local decrease in the anorthite content of plagioclase, caused by the breakdown of plagioclase feldspar and zoisite. In the high-grade rocks east of the Sgurr Beag Thrust, the semipelitic and pelitic units are migmatitic, and both kyanite- and staurolite + sillimanite-bearing assemblages are recorded. Plagioclase compositions in the calc-silicate rocks again become more anorthite-rich.

Quartz pods and veins up to 60 cm thick are locally common throughout the section and are generally fairly randomly orientated. Around [NM 6898 7320] aplitic and pegmatitic granite veins also occur, forming variably orientated, pink and white irregular veins up to 30 cm thick. The aplitic granite veins commonly cross-cut quartz veins and they post-date the F2 and F3 folding. Garnet-muscovite-bearing pegmatitic granite veins up to 1 m wide are also present in the section (e.g. on An Dan).

The section shows several major, tight, upright folds with a wavelength of between 700 m and 2 km. F2 folds are the dominant structures. A broad F2 anticlinal hinge zone is exposed in the cliffs west of Kinlochmoidart pier at [NM 6965 7287]. The related syncline to the west is tighter and marked by a 2 m-wide microdiorite sheet with sheared margins. Associated with this F2 fold pair are tight minor folds with a prominent axial-planar schistosity. Farther WNW at [NM 6934 7296] tight minor F2 folds are well exposed on the middle limb of a large-scale Z-profile F3 fold pair, whose axes plunge gently south. A steeply pitching, almost down-dip L2 intersection lineation is also present. A further example of the complex effects of F2 folding is seen at An Dun [NM 6815 7354], where the cross-bedding is prominent in, and adjacent to, the hinge zones of F2 folds, but has been strongly attenuated on F2 fold limbs. Here, F2 axes plunge gently to moderately northwards, whereas F3 axes plunge gently to the north or south (Figure 8.26)b.

Microdiorites are abundant along the Loch Moidart section and range from subvertical dykes to gently dipping sheets up to 2 m thick that cross-cut the folds and pegmatitic veins. Smith (1979) showed that the transition from greenschist- to amphibolite-facies metamorphic assemblages in the microdiorite sheets occurs within the section. Permo-Carboniferous quartz-dolerite dykes are also common in the area (e.g. at [NM 6992 7312]). A 2.5 m-thick E-trending camptonite dyke at [NM 6872 7333] has the appearance of a fine-grained basalt but is a barkevikite + plagioclase-bearing lamprophyre. There are also numerous, thick Palaeogene dykes of olivine- and feldspar-phyric tholeiitic basalt and dolerite of the Skye swarm that trend approximately north. These probably belong to the Preshal Mhor type (Thompson, 1982).

Interpretation

The Loch Moidart section provides a traverse through the Upper Morar Psammite Formation and through the transition zone between lower-grade, structurally less-deformed rocks in the west, and higher-grade, more structurally complex rocks to the east. The psammitic nature of the Moine rocks is not ideally suited to show the effects of these changes. To the east, pelitic rocks contain kyanite, staurolite and then sillimanite, with the rocks becoming migmatitic (middle-amphibolite facies) above the Sgurr Beag Thrust. In the west the pelitic rocks below the psammite unit contain essential garnet + biotite; the calc-silicate and pelite lithologies contain assemblages typical of the epidote-amphibolite facies. This metamorphic pattern reflects the peak metamorphic conditions associated with the D3 deformation at *c.* 455 Ma (Late Ordovician). The variation in metamorphic grade shown by the later microdiorite sheets (Smith, 1979) reflects the pattern prevailing at a late stage of the orogenic cycle, in the Silurian (*c.* 425–420 Ma), after significant uplift had occurred.

Brown *et al.* (1970) and Powell (1974) both argued that D3 structures were abundant in Glenfinnan Group rocks east of Lochailort and Kinlochmoidart but appeared to terminate farther west. However, Powell *et al.* (1981, 1983) and Powell and MacQueen (1976) later recognized D3 deformation structures farther west in Skye, which they linked to those seen in the Loch Eilt and Glenfinnan areas (see Fassfern to Lochailort Road Cuttings GCR site report, this chapter). Powell (1974) initially recognized the Morar Antiform as a D2 structure, but it is now generally accepted that it is basically a D3 structure. A N-plunging antiform near Loch na Bairness [NM 656 758] *c.* 2 km north-west of the site area, is a southerly en echelon extension of the Morar Antiform and thus also probably a D3 structure. Although the Sgurr Beag Thrust has been interpreted as basically a D2 structure, significant reactivation and further thrusting occurred during the D3

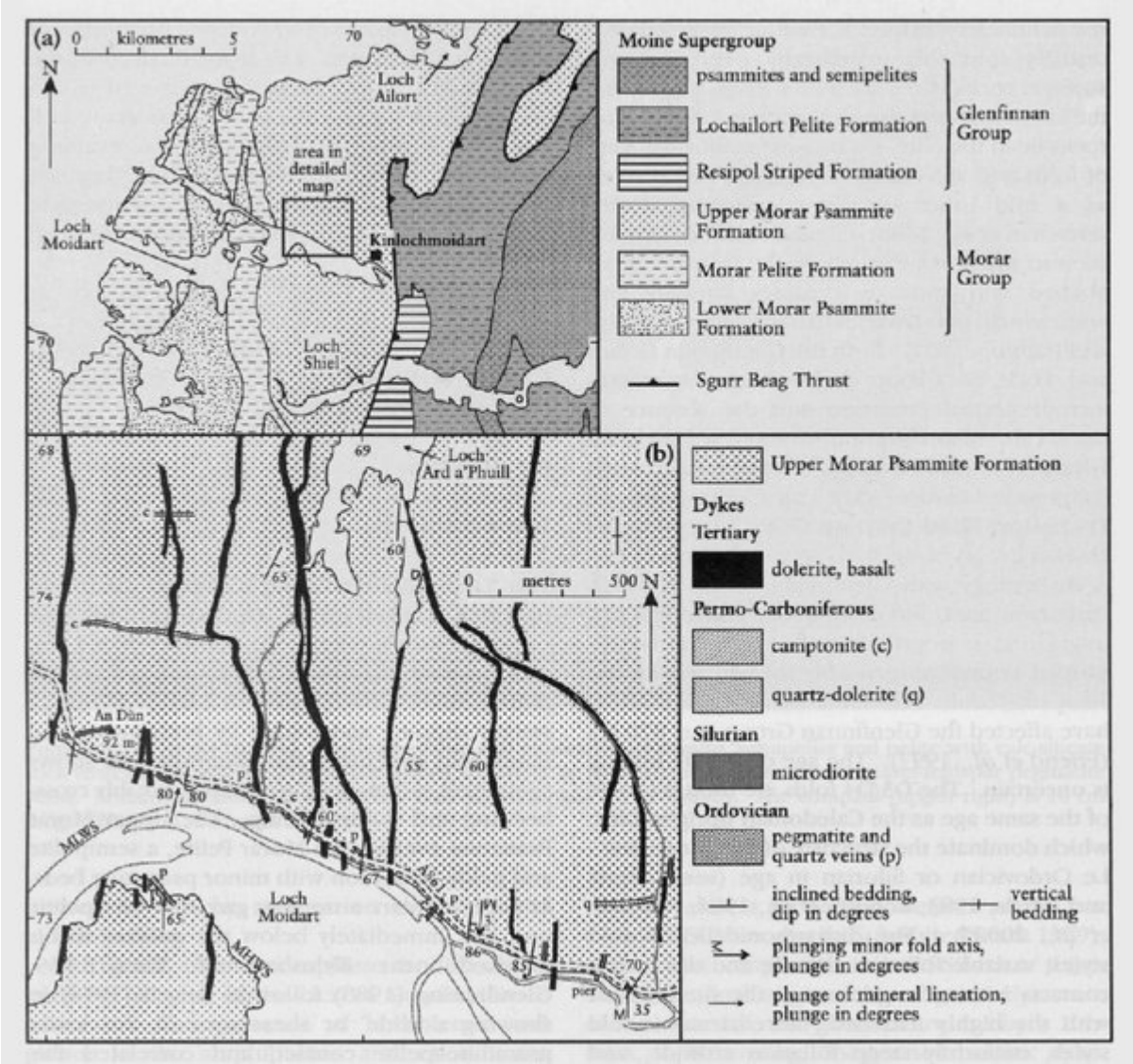
Grampian Event (Powell *et al.,* 1981; Tanner and Evans, 2003). Similar structural relationships are seen in the Loch Moidart section where there is a combination of D2 and D3 structures. In Moidart, Brown *et al.* (1970) assigned the NNW-trending folds that refold D2 structures east of Kinlochmoidart to D3, but Powell (1974) more correctly assigned them to D4.

MacQueen and Powell (1977) studied inclusion patterns within garnets in Skye, Knoydart, Morar and Moidart, and showed that garnet growth occurred in three distinct phases, albeit possibly all occurring during a single deformation phase. Their major conclusion was that D2 deformation and garnet growth were diachronous, with growth in the interior of the orogen pre-dating the main deformation in more-peripheral parts. Subsequent work and isotopic dating has shown that D2 probably occurred within the period 737–820 Ma (e.g. Tanner and Evans, 2003) and that the D3 event followed at *c.* 455 Ma (van Breemen *et al.,* 1974). The D3 event resulted in amphibolite-grade metamorphism in the east and greenschist-grade assemblages in Skye and western Morar. Howkins (1961) interpreted garnet profiles from Glen Uig, immediately east of Loch Moidart, as indicating two periods of metamorphism with the outer garnet zone related to later deformation and metamorphism. Vance *et al.* (1998) interpreted the garnet profiles from a sample from Polnish (3 km WNW of Lochailort) similarly. They obtained core-whole rock Sm-Nd isochron ages of *c.* 820 Ma and a rim-whole-rock isochron age of 788 ± 4 Ma. Tanner and Evans (2003) obtained a U-Pb TIMS age of 737 ± 5 Ma from titanite in Morar Pelite from the western end of Loch Eilt. They argued that this dated the peak metamorphism as Knoydartian with temperature conditions reaching *c.* 650° C and pressures of around 10 kbar. This would argue that the Neoproterozoic tectonothermal events are orogenic in character, rather than extensional (cf. Soper *et al.,* 1998; Dalziel and Soper, 2001). However, despite the evidence for both Knoydartian and Grampian orogenic events in the Morar-Moidart region, their relative intensity, accompanying metamorphic grade, and spatial extent still remain unclear.

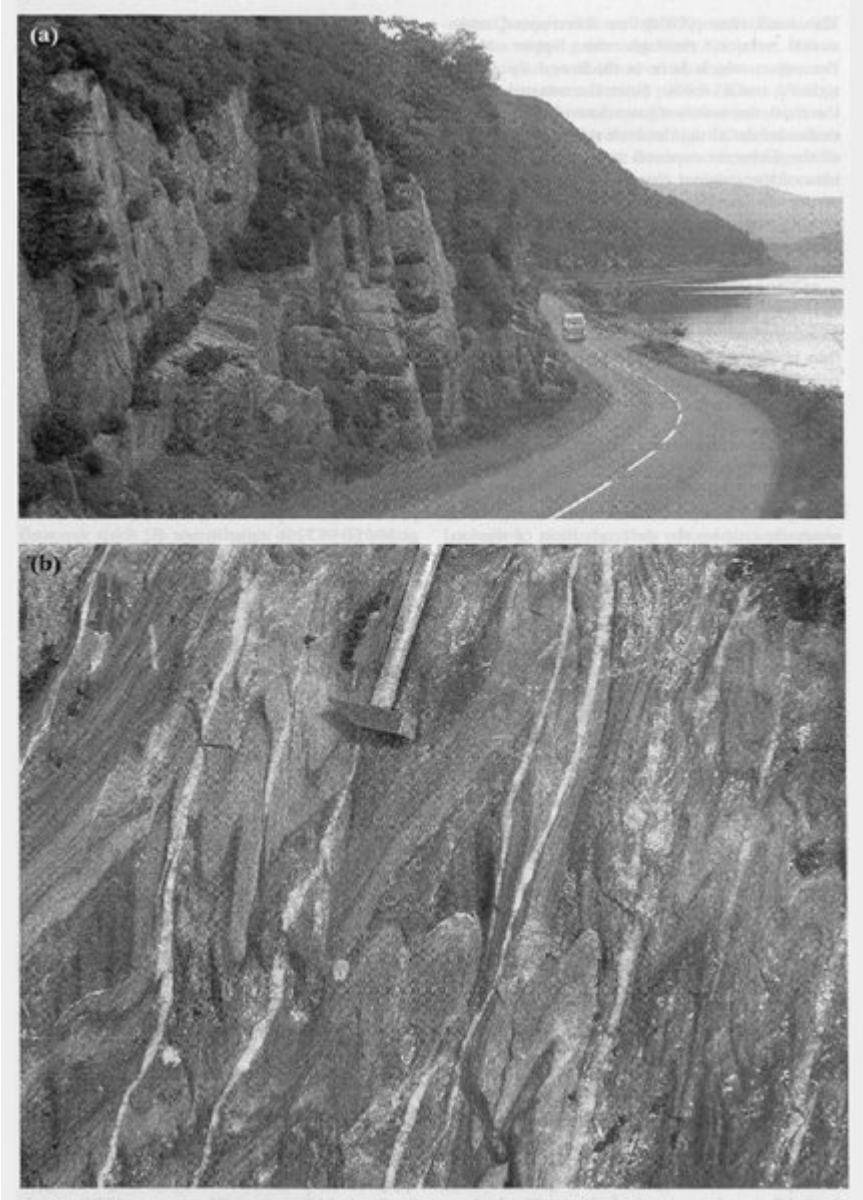
Conclusions

The Loch Moidart road section provides a cross-section through the Upper Morar Psammite Formation. This is the uppermost thick psammite unit in the Morar Group of the Moine succession and is noted for its good preservation of sedimentary structures, including cross-bedding and local grading. The formation regionally dips steeply east, but it is tectonically thickened by several large-scale folds, whose axes plunge gently to moderately north. Both minor and major F2 and F3 fold closures are seen. Mineral assemblages in pelitic units and calc-silicate pods show that metamorphic grade was higher in the eastern part of the section. Farther north, recent road cuts to the west of Lochailort provide larger and presently cleaner sections through the same unit. These show various types of cross-bedding (tabular, festoon), convolute bedding, and slump structures. The GCR site is important in that it provides a link between the metamorphic and structural features of the western seaboard and those associated with the Sgurr Beag Thrust. The site is important in that it is representative of the Upper Morar Psammite and provides a good cross-section for further study to enable the regional patterns of folding and metamorphism to be more fully understood.

References



(Figure 8.25) Map of Loch Moidart Road Cuttings, showing regional setting (a) and detailed geology (b).



(Figure 8.26) (a) View ESE along the northern shore of Loch Moidart showing the road cuts (A861) that expose the Upper Morar Psammite Formation, folded by F2 and F3 folds [NM 681 736]. (Photo: J.R. Mendum, British Geological Survey, reproduced with the permission of the Director, British Geological Survey, © NERC.) (b) Close to tight, moderately plunging F2 + F3 folds in striped psammites and semipelites of the Upper Morar Psammite Formation. The quartz and quartz-feldspar veins lie close to the penetrative S3 axial-planar cleavage. Rock face adjacent to the A861 at An Dùn on the northern side of Loch Moidart [NM 6815 7354]. The hammer head is 14 cm long. (Photo: J.R. Mendum, British Geological Survey, reproduced with the permission of the Director, British Geological Survey, © NERC.)