Druim Iosal

[NG 851 160]–[NG 861 162]

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Introduction

The Druim Iosal GCR site area, south-east of Glenelg, exposes a number of rare and unusual metasedimentary rock-types that form part of the Lewisianoid gneisses of the Eastern Unit of the Glenelg–Attadale Inlier. Within the felsic and mafic gneisses, which elsewhere constitute the bulk of the Eastern Unit, are layers of forsterite-bearing metadolostone and metalimestone ('marble'), calc-silicate rock, schistose graphitic pelite and gneissose garnetiferous kyanite-biotite pelite (Figure 7.24). The area includes one of the largest outcrops of kyanite-bearing rocks in the British Isles.

These Lewisianoid rocks were metamorphosed under high-pressure eclogite-facies conditions during the Grenvillian (*c.* 1080 Ma) orogenesis (Sanders *et al.,* 1984; Storey, 2002; Brewer *et at.,* 2003; Storey *et al.,* 2005), approximately coeval with the formation of eclogites (see Totaig GCR site report, this chapter). The encircling Moine metasedimentary rocks that surround the Eastern Unit were deposited after the Grenvillian Orogeny (see Friend *et al.,* 2003). The Lewisianoid rocks, together with Moine psammites, were later extensively deformed into large-scale fold interference patterns during the Caledonian and possibly Knoydartian orogenies. This folding is discussed in detail in the Beirut a' Chapuill GCR site report (this chapter).

Although eclogites (by definition of mafic composition) are relatively rare, their petrology has been very well studied (e.g. Carswell, 1989). Eclogite-facies rocks of felsic or pelitic composition, as found at Druim Iosal, are more varied and liable to retrogression and have generally been poorly studied (e.g. Koons and Thompson, 1985).

The area around Druim Iosal was mapped by C.T. Clough as part of the primary geological mapping of the Glenelg area (Geological Survey of Scotland, 1909; Peach *et al.,* 1910). Ramsay (1957b) subsequently remapped the area in detail. Little petrological work has been done at the Druim Iosal site, but Sanders' (1988, 1989) work at other localities in the Glenelg area is applicable to the rocks described here.

Description

Druim Iosal consists of two large rocky crags at the eastern end of Gleann Beag, with the steep NW-facing cliffs rising north-eastwards to a peat and heather-covered plateau, some 300 m high (Figure 7.25). The crags are composed of gneissose garnetiferous kyanite-biotite pelite, which outcrops over an area of about 1 km^2. The surrounding slopes have scattered exposures of forsterite 'marble' and felsic gneiss, and sparse exposures of schistose graphitic pelite and serpentinite.

The gneissose pelite is a coarse-grained foliated rock composed of black biotite, feldspar, small mauve garnets 1–2mm in size and small blue-grey or colourless laths of kyanite, alternating with layers of quartz or quartz-feldspar aggregates. White mica is rare or absent, except where the kyanite has been retrograded to shimmer aggregate. Coarser feldspar and quartz layers form boudins up to 20 cm thick. Layers rich in randomly orientated pale greenish-blue kyanite crystals, individually up to 2 cm long, are seen. Zones with abundant anhedral ruby-red garnets up to 1.5 cm across are also common.

Forsterite 'marble' occurs in Gleann Beag immediately west of Druim Iosal (Figure 7.24). The 'marble' weathers with a rough black surface with small projecting calc-silicate minerals, but when freshly broken the rock is white to pale green, with bright green spots. The meta-dolostone is layered, defined by the varying proportions of calc-silicate minerals. These include forsterite crystals 2–3mm in size, which may be partly or completely altered to serpentine, and diopside,

phlogopite and tremolite. Diopside commonly occurs as large nodules, up to 2 m across, composed of coarse randomly orientated crystals, enclosed by a rim of amphibole (see Peach *et al.,* 1910, plate III). Graphite flakes and large plates of phlogopite mica, up to 10 cm across, also occur within the marble.

West of Druim Iosal the forsterite 'marble' units converge to form a fold closure with the wide outcrop of gneissose pelite in its core. The geometry of the eastern part of the Druim Iosal outcrop and its relationship to the surrounding Moine rocks suggests that the gneissose pelite occupies the core of a kilometre-scale fold interference structure (Figure 7.24), more details of which are described in the Beinn a' Chapuill GCR site report (this chapter).

Interpretation

The significance of the gneissose pelites lies in their composition, origin and metamorphic evolution. Chemical analyses of the pelites (Clough in Peach *et al.,* 1910, p. 28; Rock *et al.,* 1986) suggest that their protolith was an aluminous mudstone. Their geochemistry is similar to kyanite-bearing gneissose pelites of South Harris, but quite different from pelitic rocks in the Moine and Dalradian sequences. The Glenelg gneissose pelites have higher than normal magnesium contents, more characteristic of evaporite sequences.

The geochemistry of forsterite 'marbles' collected from the Glenelg Inlier (Rock, 1985; Rock *et al.,* 1986) shows major variations in the proportion of silicate impurities in the 'marbles', but all samples are magnesium-rich. The Mg and Ca contents are very close to those of pure dolomite, showing the 'marbles' were formed by the metamorphism of dolostones or dolomitized limestones (May *et al.,* 1993). The large diopside nodules may represent original chert nodules, which reacted with the surrounding dolomitic limestone during metamorphism. The Glenelg 'marbles' are again geochemically similar to those of South Harris. The assemblage of dolostones with chert nodules, and Mg-rich aluminous pelites, is characteristic of evaporitic sabkha environments (Chowns and Elkins, 1974).

The occurrence of forsterite 'marbles', gneissose pelites and schistose graphitic pelites clearly demonstrates a sedimentary origin of some of the rocks of the Eastern Unit. However, other rocks such as the mafic rocks (amphibolite and eclogite) and most of the felsic gneisses are of undoubted igneous origin. Thus, the Eastern Unit is a mix of orthogneisses and paragneisses. It is unclear whether the orthogneisses intruded into an older sedimentary sequence, or whether the sediments were deposited unconformably on an already existing orthogneiss basement and hence may be younger.

In gneissose pelite samples from other outcrops of the Eastern Unit in the Glenelg area, the association of kyanite and orthoclase feldspar, plus the occurrence of omphacite, indicate that the rocks have been metamorphosed under eclogite-facies conditions (Sanders, 1989). Using various geothermometers and geobarometers on a range of rock types of the Eastern Unit, Sanders (1989) estimated peak metamorphic temperatures in the range of 700°–740° C and pressures of 15–16.5 kbar. More recently Storey *et al.* (2005) calculated that peak conditions attained 750°–780° C and *c.* 20 kbar. These values show that the Eastern Unit was metamorphosed under eclogite-facies conditions, characteristic of crustal depths of the order of 50–60 km. Sm-Nd and U-Pb dating of eclogites from the Totaig area showed that eclogite-facies metamorphism occurred around 1080 Ma and was related to the Grenvillian Orogeny (Sanders *et al.,* 1984; Brewer *et al.,* 2003; see also Totaig GCR site report, this chapter). Brewer *et al.* (2003) showed that exhumation and retrogression of these rocks occurred at *c.* 995 Ma. Moine metasedimentary rocks were deposited on the exhumed Lewisianoid gneisses, and their deposition took place after 950 Ma (e.g. Friend *et al.,* 2003; see also Chapter 1). Hence, the current age data allow for uplift rates of < 0.3 km/Ma and cooling rates of < 1.25° C/Ma, signifying relatively slow exhumation rates by comparison with other eclogitic terrains. However, these are minimum values and further work is needed to constrain the Grenvillian tectonic events and their aftermath in the Glenelg–Attadale Inlier.

The Lewisianoid basement and the overlying sedimentary cover of Moine rocks were later involved in the possibly Knoydartian and certainly Caledonian orogenic events. Basement and cover were folded (D1) into tight isoclinal folds to form the alternating 'slices' of Lewisianoid and Moine rocks seen in the inner. These 'slices' were in turn folded by two further phases of folding, as described in detail in the Beim a' Chapuill GCR site report (this chapter). Refolding of F1 folds by the Beinn a' Chapuill Fold was responsible for the interference pattern represented by the outcrop of the gneissose pelites around Druim Iosal. Metamorphism and partial recrystallization under amphibolite-facies conditions

accompanied the deformation and folding. This metamorphism resulted in retrograde mineralogies in the high-grade metamorphic mineral assemblages in the Eastern Unit, but in prograde mineralogies linked to generation of the main foliation and linear structures in the surrounding Moine sequence.

Conclusions

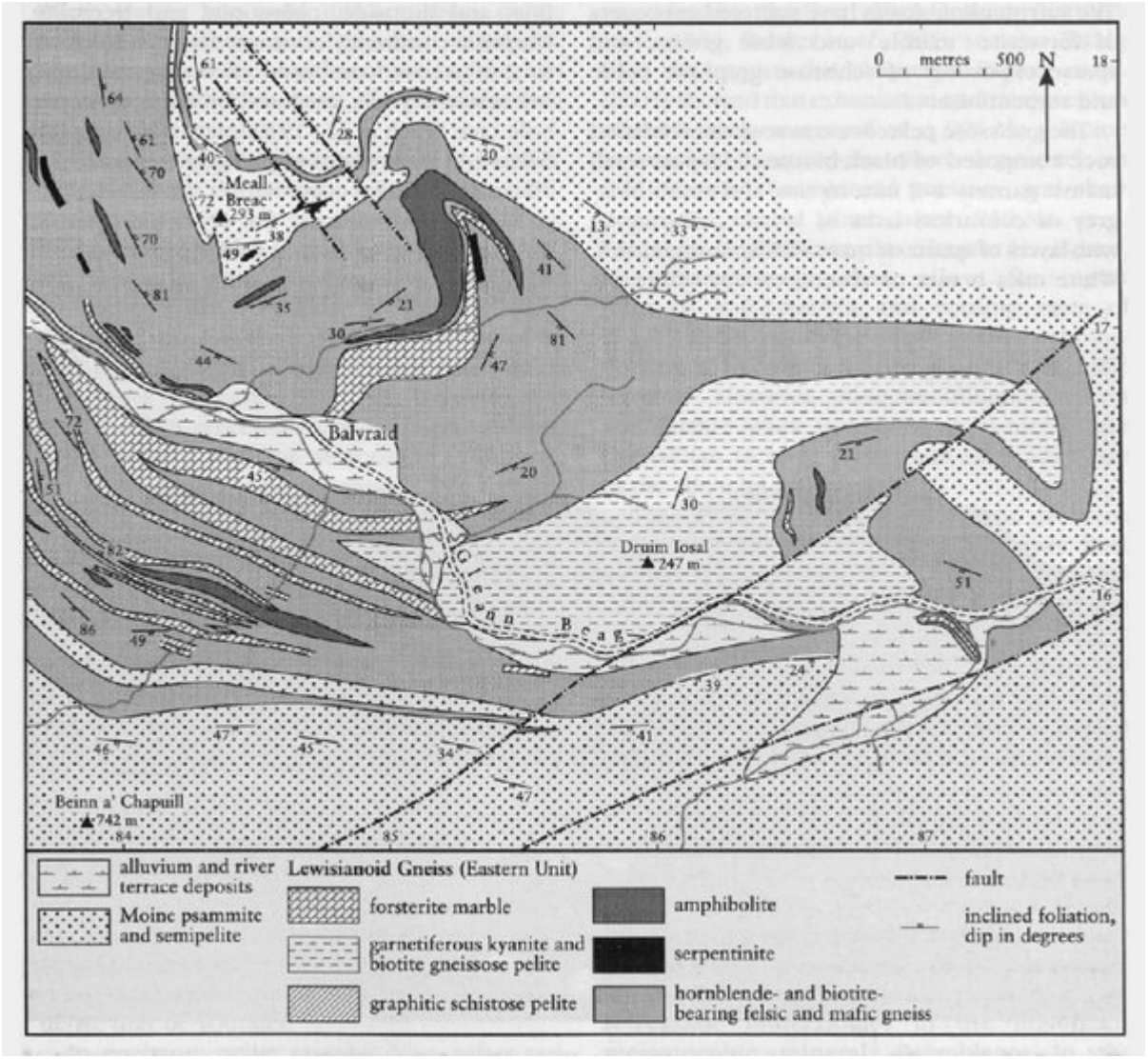
The gneissose garnetiferous kyanite-bearing pelites at Druim Iosal, east of Glenelg, represent one of the largest and best-exposed outcrops of kyanite-bearing rock in the British Isles. Their chemical composition and association with forsterite 'marble', suggests they were originally deposited in a sabkha-like environment as a sequence of magnesian aluminium-rich mud-stones and dolomite and dolomitic limestone units. They form part of the Eastern Unit of the Glenelg–Attadale Lewisianoid Inlier, which is composed of rocks of both sedimentary and igneous origin.

Mineral assemblages in the gneissose pelites, the forsterite 'marbles' and the associated eclogitic rocks, provide evidence that the rocks were metamorphosed and deformed under eclogite-facies conditions, which occur when rocks are subducted to at least 50 km depth in the Earth's crust. Sm-Nd and U-Pb isotopic dating has shown that this high-pressure metamorphism was related to the Grenvillian Orogeny and occurred at *c.* 1080 Ma.

The Glenelg–Attadale Lewisianoid Inlier is made up of two separate segments of continental basement; a Western Unit, mainly composed of orthogneisses of probable Archaean age, similar to the Lewisian Gneiss Complex of the foreland; and an Eastern Unit, comprising orthogneisses and paragneisses which may have had an earlier Archaean or possibly Proterozoic history but which were strongly reworked during the Grenvillian Orogeny. There is little or no evidence for structures relating to the Grenvillian orogenesis in the Western Unit of the Glenelg–Attadale Inlier (see Eilean Chlamail–Camas nan Ceann GCR site report, this chapter), and only tentative indications of its presence in other parts of Scotland. Hence, the Grenville 'orogenic front' appears to be marked only by the highly sheared Moine outcrop, which separates the two Lewisianoid segments.

The Druim Iosal GCR site is of national importance in that it displays a variety of metasedimentary rock-types of the Eastern Unit of the Glenelg–Attadale Inlier that have an unusual geochemistry and origin. The rocks have also undergone eclogite-facies metamorphism, dated as Grenvillian in age. The site is comple mentary to the Totaig and Dornie–Inverinate Road Section GCR sites which also describe parts of the Eastern Unit.

References



(Figure 7.24) Map of the Druim Iosal GCR site. After Ramsay (1957b).

(Figure 7.25) View of Druim Iosal from Dun Grugaig, Gleann Beag. The crags in the centre are composed of garnetiferous kyanite-biotite gneiss. (Photo: A.J. Barber.)