Scourie Mor

[NC 144 450]–[NC 144 437]

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Introduction

The rocks on the peninsula of Scourie Mor, which lies south-west of Scourie Bay, form the northern part of the type area for the Central Region of the Lewisian Gneiss Complex (Sutton and Watson, 1951). An extensive array of granulite-facies felsic and mafic gneisses is particularly well displayed between Eilean a' Bhuic [NC 137 449] and Camas an Tairidh [NC 147 438] (Figure 3.4). The exposures are dominated by mafic tonalites that contain rafts and large lenses of mafic and ultramafic rocks up to about 400 m wide and as much as 1 km long (e.g. O'Hara, 1961a, 1965; Whitehouse, 1989). The mafic–ultramafic bodies are largely undeformed and provide some of the best examples seen in the Lewisian Gneiss Complex, contributing to the importance of the site. In places there are minor amounts of metasedimentary material, including calc-silicate lithologies (O'Hara, 1960). The gneiss complex has been subjected to deformation and granulite-facies metamorphism, during which a few discordant leucotonalite sheets were emplaced. Later, in the Palaeoproterozoic, the rocks were intruded by mafic dykes of the Scourie Dyke Suite (e.g. O'Hara, 1961b), although only relatively thin dykes (< 5 m wide) are seen in this area. Subsequently, all the elements were transected by hydrous shear-zones, which caused variable retrogression, an event associated with Laxfordian reworking (Beach, 1973). The complex lithological association is particularly significant as evidence of several important mineral reactions is preserved, demonstrating a major decompression event. Studies of these reactions have been used to elucidate the metamorphism of the region (e.g. O'Hara, 1965; Savage and Sills, 1980) and to derive a pressure–temperature (P–T) path for the crustal evolution of the gneisses (e.g. Barnicoat, 1987; Sills and Rollinson, 1987).

Description

The Scourie Mor GCR site encompasses the peninsula that lies west of the crofts of Scourie Mor, extending from Eilean a' Bhuic to the northwest to Camas an Tairidh to the south-east. The craggy indented coastline and rocky hills that reach 80 m above OD at Cnoc na Leacaig provide excellent clean exposures of the various elements of the Lewisian Gneiss Complex.

The dominant felsic gneisses are broadly tonalitic or dioritic in composition and are typically dark grey-brown in colour on fresh surfaces. They are commonly banded, with layers of felsic gneiss alternating with more-mafic gneiss. For the most part the lithological layering is parallel to a planar foliation, and locally a lineation is present. The layering and foliation generally dip to the north-west at 300–50°. Orthopyroxene, typically associated with garnet, is common throughout the gneisses, signifying granulite-facies metamorphic conditions. Original relationships between the different felsic lithologies have been obscured by the extensive recrystallization and high strain under granulite-facies conditions. The ductile nature of the deformation is indicated by the commonly lineated form of the orthopyroxene and the discontinuous quartz ribbons that partially define the banding and foliation. Low-strain areas are rare, although some localities do occur between Camas an Lochain [NC 140 446] and Camas nam Buth [NC 142 446].

Large bodies of mafic–ultramafic rocks are exposed between Camas nam Buth [NC 142 446] and Geodh' Eanruig [NC 142 442], although there is some debate as to the exact disposition of the units. Cohen *et al.* (1991) suggested that they are lensoid masses, but Sills *et al.* (1982) interpeted them as dismembered parts of a larger-scale body that has been folded. At some localities where overall strain appears to be low, for example on the north side of Camas nam Buth, sheets and sub-parallel masses of gneiss are interleaved with, and also clearly cross-cut, some of the layering in the ultramafic–mafic rocks. This relationship is consistent with similar exposures on the north side of Scourie Bay (Friend and Kinny, 1995).

The ultramafic–mafic rocks display a range of interlayered lithologies, which grade from pure dunite at one extreme through clinopyroxene-and/or orthopyroxene-rich varieties into spinel lherzolites and peridotites (e.g. Peach *et al.,* 1907; O'Hara, 1961a; Savage and Sills, 1980; Whitehouse, 1989). The mafic rocks are generally more homogeneous, commonly consisting of clinopyroxene + orthopyroxene + plagioclase + garnet with accessory spinel, sulphides and Fe-Ti oxides. Garnet porphyroblasts up to 5 cm in diameter are prominent in some layers and normally show plagioclase-rich symplectite coronas (Figure 3.5). Where the garnets are small, they may be completely replaced by plagioclase feldspar.

Rocks of supposed metasedimentary origin are rare and occur either in association with the ultramafic–mafic rocks or as parallel bands in the tonalites (e.g. O'Hara, 1960; Burton *et al.,* 1994). They chiefly form thin, discontinuous bands and lenses, which can be difficult to differentiate from the host gneisses. Some bands or lenses contain sulphides, typically pyrite; as a result they are rusty-weathering and stand out more readily. A thin, bluish-grey layer of scapolite-bearing calc-silicate rock has been found east of the mafic body at Geodh' Eanruig (O'Hara, 1960; (Figure 3.4)).

The gneisses are cut by broadly WNW-trending mafic dykes of the Scourie Dyke Suite, similar to those in the adjacent Scourie Bay GCR site. The dykes are essentially undeformed with a micro-gabbroic texture, but are largely amphibolitized. The area is also cut by shear zones, many of which lie within the marginal parts of the dykes. As these shears and associated amphibolite-facies metamorphism affect the Scourie dykes they are presumed to be of Laxfordian age.

Interpretation

It is generally accepted that the mafic and ultramafic rocks in the Central Region of the Lewisian Gneiss Complex have undergone the same metamorphic history as the gneisses. However, there have been differing views as to the survival of any remnants of the primary igneous minerals (e.g. O'Hara, 1961a; Savage and Sills, 1980), and several different interpretations regarding the origin and disposition of the mafic-ultramafic masses. O'Hara (1961a, 1965) suggested that the mafic rocks formed by metasomatic reactions between ultramafic material and the host gneisses, whereas others suggested that they represent fragmented layered complexes (e.g. Bowes *et al.,* 1964; Davies, 1974). The latter view was corroborated by Sills *et al.* (1982), who carried out extensive geochemical analyses, particularly from the units at Camas nam Buth. They demonstrated the presence of cryptic layering and established a consistent way-up based on geochemical criteria, which could be traced over fold hinges. They concluded that the mafic-ultramafic lithologies represent the remains of fragmented layered complexes that have been intruded by the tonalitic gneisses and subsequently deformed and metamorphosed. This model is consistent with other Archaean terrains in the North Atlantic region (e.g. Greenland and Labrador). However, because of the chemical imbalance that exists between the ultramafic and felsic gneisses there are clear areas where limited metasomatic exchange, as proposed by O'Hara (1961a, 1965), can be observed. Whereas many of the relationships between the mafic-ultramafic units and the dominant felsic gneisses are equivocal, there are some low-strain areas that preserve cross-cutting relationships, showing that the protoliths of the felsic gneisses cross-cut the igneous layering in the mafic rocks.

The age of the ultramafic-mafic bodies has been equally controversial. Humphries and Cliff (1982) conducted Sm-Nd mineral studies of metamorphic minerals in these bodies and obtained an age of *c.* 2490 Ma. This was interpreted as representing the time at which the rocks passed through the Sm-Nd closure temperature, i.e. the cooling age following earlier granulite-facies metamorphic conditions. Combined with ages of *c.* 2700 Ma for the commencement of the Badcallian event (e.g. Pidgeon and Bowes, 1972), this evidence was taken to indicate that granulite-facies conditions lasted some 150 million years. However, more recently, evidence has been gathered for two metamorphic events in the area, at *c.* 2700 Ma and *c.* 2500 Ma (e.g. Corfu *et al.,* 1994; Friend and Kinny, 1995), so that the date obtained by Humphries and Cliff (1982) probably represents the time of metamorphic crystallization. Whitehouse (1989) obtained a Sm-Nd whole-rock isochron of 2670 ± 110 Ma for the Scourie Mor mafic-ultramafic bodies, and Cohen *et al.* (1991) used whole-rock U-Pb and Sm-Nd isotopic data to infer an emplacement age of 2707 ± 52 Ma.

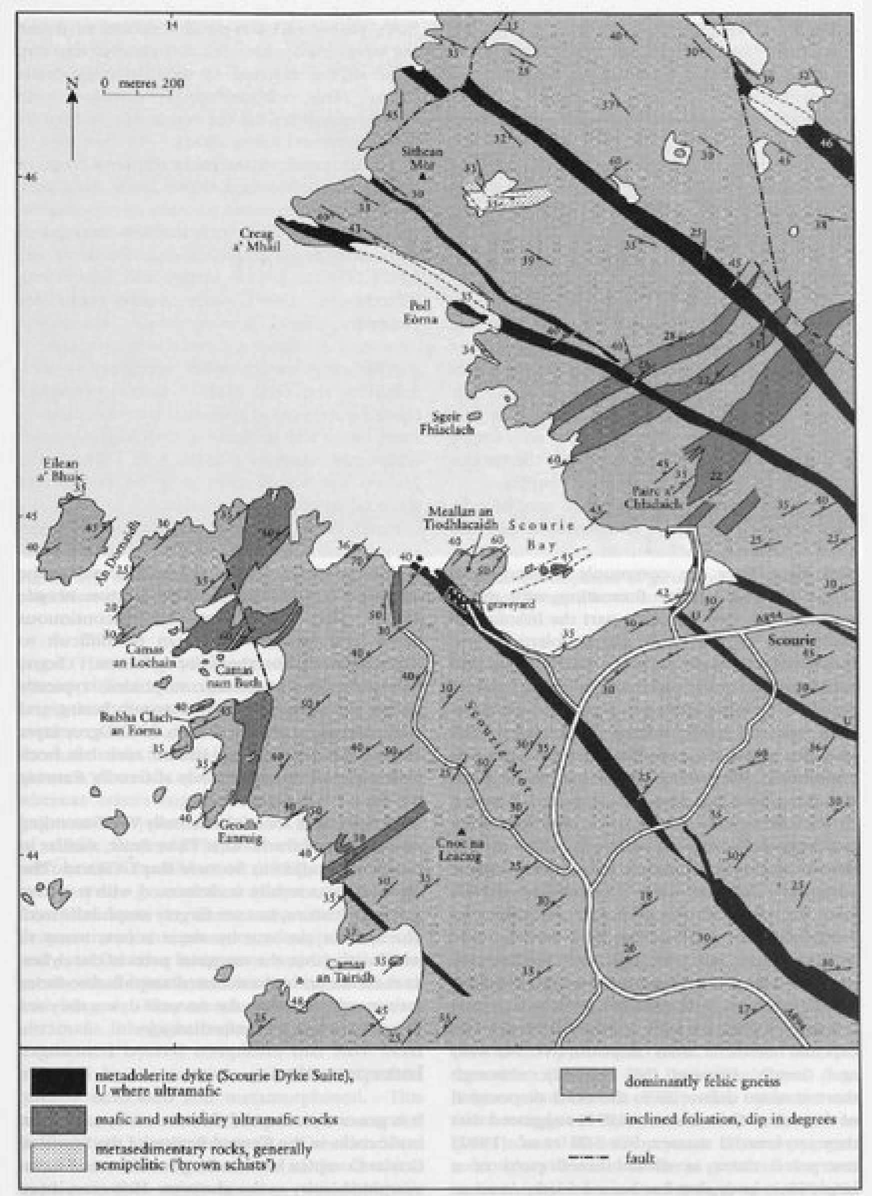
U-Pb isotope studies of single zircons in granulite-facies tonalitic gneisses from the Scourie Bay area have given protolith ages of *c.* 2960 Ma (Friend and Kinny, 1995; Kinny and Friend, 1997). One of these samples came from a granulite-facies leucotonalite sheet that crosscuts an ultramafic body at First Inlet, on the north side of Scourie Bay. This data provides supporting evidence for the hypothesis of Sills *et al.* (1982), that at least some of the mafic and ultramafic rocks are older than the gneisses. On the basis of these dates, it appears that either some of the mafic-ultramafic bodies may be genuinely younger than the tonalitic gneisses or, more probably, that the younger whole-rock and mineral ages represent metamorphic disturbance of the isotope systems. However, the opposing view has been re-iterated by Burton *et al.* (2000), who have used Re-Os data to obtain a date of 2687 ± 15 Ma for the ultramafic body at First Inlet, and who suggested that the crosscutting leucotonalite sheet may have assimilated zircons from the surrounding gneisses during emplacement.

Conclusions

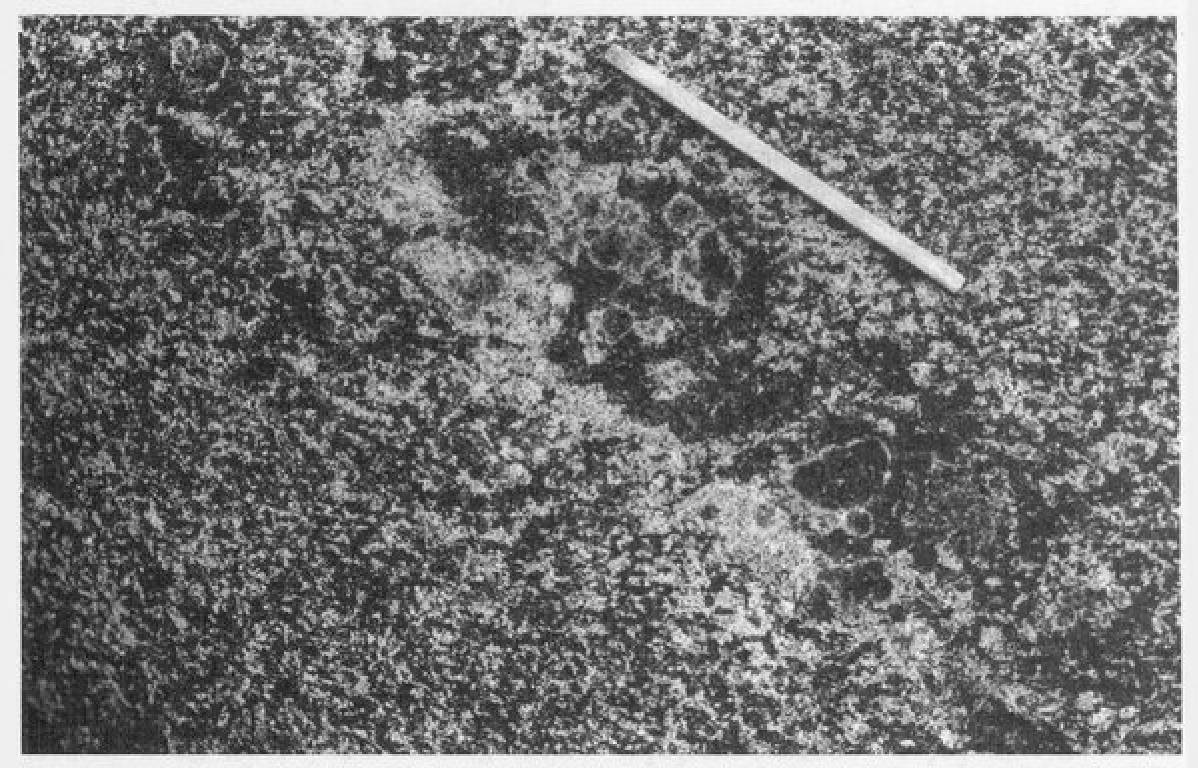
The Scourie Mor GCR site provides some of the best examples in the Lewisian Gneiss Complex of Archaean tonalitic felsic gneisses and mafic-ultramafic bodies. Sm-Nd and U-Pb isotopic age dating has shown that the protolith igneous bodies were formed at *c.* 2950 Ma and were metamorphosed under granulite-facies conditions at *c.* 2700 Ma. The rocks form part of the oldest gneiss complex found in Britain and preserve some of their original igneous textures and structural relationships. The rocks also provide evidence of the minerals and textures formed during high-grade metamorphism and the subsequent uplift with consequent release of pressure. These delicate textures survive owing to the general lack of later, hydrous deformation that affected many of the granulite-facies gneisses elsewhere. Late metasomatic modification by hot fluids can be demonstrated locally, but these relatively minor reactions are mainly focused along the margins of the ultramafic bodies.

The site includes several 'low-strain' areas that have undergone very little deformation at all, and the original lithological and geochemical layering is well preserved within some of the mafic-ultramafic rocks. Within these low-strain areas, the host felsic gneisses show good crosscutting relationships, which demonstrate that the mafic and ultramafic bodies are older than the tonalitic felsic gneisses. In other areas such relationships are unclear or contradictory and research is ongoing as to their relative and absolute ages. The site remains one of the best places to study the early history of the Lewisian Gneiss Complex and as such is of international importance.

References



(Figure 3.4) Map of the Scourie area, including the areas covered by the Scourie Mor, Scourie Bay and Sìthean Mòr GCR sites. Based on the Geological Survey 1:10 560 sheets Sutherland 30 (1913), 39 (1912), and O'Hara (1961a).



(Figure 3.5) Mafic rocks at Camas nam Buth, showing the typical development of garnet porphyroblasts with plagioclase-rich decompression coronas. The matchstick is 4.4 cm long. (Photo: C.R.L. Friend.)