Roineabhal, South Harris

[NG 045 865]–[NG 055 845]

J.R. Mendum

Introduction

Roineabhal is the most prominent hill of South Harris, forming an 'elephant-grey'-weathering, rocky bulwark, some 460 m high that overlooks the Minch and the Sound of Harris. It is composed largely of anorthosite and forms part of the Palaeoproterozoic South Harris Igneous Complex. The intrusion has been folded into a large-scale, tight, sideways-closing fold with a near-vertical axis, thus providing a natural cross-section from marginal layered gabbros through to pure-white anorthosite in its central part. The Roineabhal Intrusion is unique in being the largest gabbro–anorthosite body in the British Isles and one of only two such bodies in the Lewisian Gneiss Complex. In addition to its invaluable scientific importance, in the 1990s the intrusion was investigated as to the possible establishment of a superquarry, mainly as a source of white reflective roadstone.

The South Harris Igneous Complex (SHIC) comprises major gabbro, norite, anorthosite and diorite bodies that dominate the geology of the south-western part of South Harris. The bodies were metamorphosed under high-pressure granulite-facies conditions after their emplacement into metasedimentary rocks, although they were later partially retrogressed to lower amphibolite-facies assemblages. Note that the prefix 'meta-% which should be appended to all these igneous members of the SHIC, is omitted for clarity in this account. Although the igneous bodies now all show metamorphic mineralogies, they still retain an igneous appearance and exhibit unmodified geochemical trends where relatively undeformed and containing granulite-facies assemblages. Metamorphic studies and isotopic ages for the intrusions and surrounding metasedimentary rocks imply that the SHIC was emplaced into the base of an island arc or continental-margin arc during the Palaeoproterozoic at around 1880–1875 Ma (Baba, 1998; Friend and Kinny, 2001; Whitehouse and Bridgwater, 2001). The metasedimentary rocks that now form the carapace to the SHIC were themselves probably deposited in a trench and forearc environment at around 1890–1880 Ma and then rapidly subducted (Baba, 1999b; Friend and Kinny, 2001). They consist of psammites, semipelites, quartzites, graphitic and aluminous pelites, metalimestones, and mafic metavolcanic rocks that now form two NW-trending metasedimentary belts, the Leverburgh and Langavat belts (Figure 2.4) (see Na Buirgh GCR site report, this chapter).

The Roineabhal Intrusion is the most southeasterly exposed member of the SHIC and together with its marginal gabbros forms an elongate triangular outcrop some 6 km long by 0.75–2.5 km wide, surrounded by Leverburgh Belt metasedimentary rocks. Granulite-facies mineralogies are preserved in its central part, but the marginal zones are more strongly deformed and have amphibolite-facies mineralo-gies. Shear zones have developed along the margins, with mylonitic fabrics developed locally. The south-eastern part of the Roineabhal Intrusion has been mylonitized, brecciated and cataclased in the Outer Hebrides Fault Zone. A zone of greenschist-facies hydrous retrogression that has resulted in extensive saussuritization of the anorthosite overlaps the OHFZ and also extends farther to the north-west (Figure 2.7).

The Roineabhal Intrusion and related gabbros can be divided into four distinct zones:

- a marginal zone of quartz-gabbros, banded ultramafic rocks and gabbros;
- a Lower Zone of banded mafic gabbros, gabbros and anorthosites;
- a Middle Zone of banded anorthosites and gabbros;
- an Upper Zone of banded anorthosites and leucogabbros.

These zones form an overall layered sequence with the gabbros at the base and the anorthosite at the top of the original sheet-like intrusion. Only a few later intrusions cut this zonal sequence. Gabbros form net-veins in the anorthosite and rarely mafic dykes are present (Fettes *et al.,* 1992). Late-Laxfordian pegmatitic granite veins are also present and some Palaeogene dolerite dykes occur around Lingarabay and in Coire Roineabhail.

The anorthosite has attracted the attention of many geologists, starting with MacCulloch (1819) and Heddle (1878). Jehu and Craig (1927) made a detailed map of the intrusions of the SHIC, and Davidson (1943) carried out detailed petrographical work in the Roghadal–Roineabhal area, recognizing that the meta-igneous bodies form part of a single differentiated igneous complex. Dearnley (1959, 1963) produced a further detailed map of the SHIC and surrounding metasedimentary rocks, which has been largely substantiated by later work. He thought that the SHIC was coeval with the 'Younger Basic' Suite and that the two main metamorphic events recorded in the intrusions were Laxfordian in age. Witty (1975) carried out detailed mapping and geochemical studies of the anorthosite and adjacent gabbros, and Heyes (1978) did complementary metamorphic and structural studies. Fettes *et al.* (1992) summarized the geology and structure of the south-west part of South Harris, and compiled a 1:25 000-scale map. It was originally assumed that the belts of metasedimentary rocks and the SHIC were all of Archaean age (e.g. Watson and Lisle, 1973). However, recent geochronological studies by Cliff *et al.* (1983, 1998), Cliff and Rex (1989), Friend and Kinny (2001), Whitehouse and Bridgwater (2001) and Mason *et al.* (2004a) have shown that the deposition of the Leverburgh and Langavat sediments, the intrusion of the SHIC, and the granulite-facies metamorphism are all Palaeoproterozoic and bracketed within 10 to 20 million years between 1890–1870 Ma. Overall models for rapid arc formation, deep subduction, collision, and high-pressure metamorphism in South Harris by Baba (1998, 1999a,b) accord well with this isotopic data (see 'Interpretation', below, for details).

Description

The Roineabhal GCR site covers the summit areas of Roineabhal (460 m) and Beinn na h-Aire (378 m), Coire Roineabhail, and the south-east slope of the mountain down to the Roghadal (Rodel)–Fionnsabhagh (Finsbay) road and the Lingreabhagh (Lingarabay) Quarry (Figure 2.8)a. The summit area is exposed bedrock and block-field and the south-east flank consists of nearly 100% exposed, glacially scoured, pale-grey-weathered bedrock with numerous gullies and small crags.

Rock types

The Leverburgh Belt metasedimentary rocks that surround the anorthosite consist mainly of quartzites and psammites. Only a thin sliver, 20–100 m wide, is present on the north-east side of the intrusion, in which the metasedimentary rocks are interbanded with pods and lenticular bands of amphibolite. On the south-west side a thicker succession of metasedimentary rocks is present. Around Sgriosan [NG 034 857] the psammites are conspicuously garnetiferous, but here too, mafic pods, dykes and lenses are abundant (Fettes *et al.,* 1992).

The oldest intrusive rocks are the gabbros and ultramafic rocks that effectively form a basal unit at the margin of the Roineabhal Intrusion. Subsequent deformation and metamorphism has resulted in their now discontinuous, foliated and amphibolitized appearance. Quartz-gabbros form the main part of the mafic rim rocks, with lenses of banded ultramafic rock and melagabbro, and abundant lenses of gneissose garnet-biotite-bearing psammite and semipelite up to 270 m long and 18 m wide (Witty, 1975). Banded ultramafic-rock-melagabbro units are best developed on Hà-cleit [NG 032 873], and above the Abhainn Easean Chais (around [NG 029 866]). Here, large- and small-scale rhythmic banding was recorded by Witty (1975) in lithologies ranging from garnet-hornblendite to garnet-clinopyroxenite and melagabbro. Although plagioclase feldspar is present, ranging from An_{85} (bytownite) to An_{50} (labradorite/andesine), the granulite-facies metamorphism has resulted in its reaction with pyroxene to form amphibole and garnet, giving the rocks a more-mafic appearance. In contrast the quartz-gabbros are a product of assimilation of metasedimentary material and consist of plagioclase feldspar, clinopyroxene, hornblende, quartz, minor biotite and even microcline feldspar. The plagioclase ranges from An_{30} (andesine) to An_{14} (oligoclase) and forms between 15% and 50% of the rock (see Fettes *et al.,* 1992).

The main fold of the Roineabhal Intrusion has thin, strongly attenuated limbs but exhibits a wide low-strain hinge zone. Hence, the Lower Zone is *c.* 70 m wide on the attenuated fold limbs but *c.* 600 m wide in the hinge area, some 2 km north-west of Roineabhal summit. It is made up of 14 gravity-stratified units, which range from melagabbro to gabbro and leuco-gabbro with minor anorthosite 'tops'. Note that leucogabbro was previously termed 'gabbro-anorthosite' by most authors — see Fettes *et al.* (1992). Hornblende and garnet are the common mafic minerals with clinopyroxene only found in gabbroic units in the upper part. Plagioclase compositions range from An_{37} (andesine) in the melagabbros to An_{68} (labradorite) in the anorthosite. In much of the Roineabhal GCR site area the Lower Zone rocks have been pervasively deformed and recrystallized under middle amphibolite-facies conditions, with breakdown of garnet to orthopyroxene + plagioclase symplectite and of clinopyroxene to hornblende. Scapolite is abundant in parts, and clinozoisite, zoisite, chlorite, biotite and calcite are developed locally in the more highly sheared zones.

The Middle Zone consists of banded anorthosite, leucogabbro and gabbro, with eight major gabbro bands (0.5–1.2 m thick) and numerous smaller ones (< 30 cm thick) recorded by Witty (1975). These rocks crop out over most of the summit area and on the north-west flank of Roineabhal, in Coire Roineabhail, and on Beinn na h-Aire. Clinopyroxene is abundant in the gabbros in this zone and plagioclase compositions mainly lie in the labradorite field (An_{70} to An_{50}). The gabbros have patchy garnetiferous zones, and circular to oval clots of gabbro up to 30 cm across are present in some anorthosite bands. On the fold limbs the Middle Zone rocks are attenuated and extensively recrystallized, but the degree of deformation is less strong than in the Lower Zone rocks or marginal gabbros.

The Upper Zone rocks are best seen on the south-east slopes of Roineabhal and consist of 65–70% leucogabbro with some pure white anorthosite bands. The zone contains abundant diffuse to well-defined spherical to ovoid gabbro schlieren, typically 20–30 cm across, and garnetiferous anorthosite in patchy zones up to 100 m across (Fettes *et al.,* 1992) (Figure 2.8)b.

At the base of the Lower Zone, along its southwestern contact with the marginal quartz-gabbros, lenticular masses of anorthosite-ultramafic breccia up to 50 m wide occur (e.g. around [NG 043 855] and [NG 0338 8644]) (Witty, 1975). They consist of disorientated, angular, foliated and banded anorthosite blocks separated by thin veins consisting of pale-green clinopyroxene (augite), scapolite and plagioclase-hornblende symplectite. Garnet occurs as diffuse patches, streaks and locally abundant nodules. The breccias are commonly associated with small ultramafic intrusions. Melagabbro dykes and sheets, typically 1–2m wide, but up to 7 m across, are common throughout the Roineabhal Intrusion. They form generally concordant bodies in the lower units but discordant dykes and sheets in the upper units, and locally occur as net-veins. The typical mineral assemblage is clinopyroxene-amphibole-plagioclase feldspar-ilmenite, with garnet locally present. Quartz is a common accessory mineral. The dykes are compositionally and chemically indistinguishable from the Lower Zone mela-gabbros, but also from the 'Younger Basic' intrusions. Leucogabbro dykes up to 25 cm wide also cut the marginal gabbros and ultramafic rocks and some of the Lower Zone units.

Late-Laxfordian pegmatitic granites occur as thick E-trending veins and pods in the Roineabhal Intrusion and the marginal gabbros with prominent examples at the south-east end of the GCR site. They consist of microcline, plagioclase feldspar (oligoclase-albite), quartz, biotite and magnetite with abundant minor components including zircon, monazite, garnet, and thorium-and uranium-bearing minerals. The Sletteval Pegmatite, which consists of two veins, 20 m and 6 m thick, joined by an irregular vein at their north-west end, lies immediately adjacent to the Roineabhal Intrusion and cross-cuts the metagabbros and the adjacent diorite (Figure 2.7).

The south-eastern parts of the intrusion that occur east of the Roghadal-Fionnsbhagh road, effectively the Middle Zone and Upper Zone rocks, are saussuritized, with plagioclase feldspar altered to zoisite, sericite, paragonite and quartz and the mafic minerals to epidote, clinozoisite, chlorite and locally tremolite. The rocks become more highly fractured and pervasively saussuritized to the south-east, and above the main thrust plane in the OHFZ they are wholly brecciated, granulated, mylonitic and invariably strongly retrogressed.

Structure and metamorphism

Aeromagnetic data suggest that the intrusive bodies of the SHIC only extend downwards to 5–7km, and are lenticular, both along strike and down-dip (Westbrook, 1974; Fettes *et al.,* 1992). The Roineabhal Intrusion is unusual in that it lies in the core of a large sideward-closing fold, normally termed an antiform (e.g. Dearnley, 1963; Witty 1975). Limb dips generally range from *c.* 30° to *c.* 60° to both the north-east and south-west, but are commonly steeper and even subvertical (Figure 2.7). The fold has a subvertical to very steeply NW-plunging axis, and closes sideways and faces to the south-east. Dips in the hinge zone are variable, ranging from 30° to the north-west to subvertical. An early foliation ($S1_L$) is developed sub-parallel to the compositional banding in areas with upper amphibolite-facies metamorphic assemblages. Associated with foliation development are migmatization, quartz-feldspar segregations, small-scale tight folding, boudinage, and formation of small shear-zones. This deformation overlapped with the emplacement of the ultramafic rock–anorthosite breccias and intrusion of the melagabbro dykes and sheets. The relationship of folding and metamorphic grade suggests that this $D1_L$ deformation was accompanied by granulite- to upper-amphibolite-facies metamorphism. The granulite-facies areas show virtually no early deformation features. The assemblage garnet-dinopyroxene-plagioclase feldspar (An_{44})-(quartz)-(hornblende) is common in the gabbros and orthopyroxene occurs rarely. Clinopyroxene composition varies from calcic augite–salite in the Middle Zone units to diopside–salite in the Upper Zone. These mineralogies are indicative of hornblende granulite-facies conditions (see O'Brien and Rotzler, 2003).

The main penetrative deformation, $D2_L$, has folded the banded anorthosite into the large-scale 'antiform'. Attenuation and extensive shear-zone formation on the limbs of the main fold are focused along the margin of the Roineabhal Intrusion and in the adjacent gabbros. A strong biotite fabric has developed related to the shear zones but it is weak in the main fold hinge zone where spindle-shaped mafic clusters define a steeply plunging lineation. $D2_L$ deformation was accompanied by middle amphibolite-facies metamorphism (m3), best recorded in gneissose pelites of the Leverburgh Belt where cordierite + orthopyroxene have developed from garnet + quartz (Baba, 1998). Coronas or symplectites of orthopyroxene + plagioclase have formed between garnet and quartz in the more-psammitic rocks, and between garnet and clinopyroxene in the mafic rocks.

$D3_L$ represents a later phase of compression and pervasive shearing in the intrusion and adjacent gabbros. The main fold was undoubtedly tightened, and steep NNW-trending, dextral shear-zones up to 22 m wide and 500 m long were formed (Witty, 1975). Shearing was again focused in the marginal parts of the intrusion and it is difficult to separate $D3_L$ effects from earlier-formed fabrics. Deformation was accompanied by lower amphibolite-facies metamorphism (m4) with sillimanite, biotite and muscovite developed in the gneissose pelites and psammites, and hornblende and biotite in the mafic rocks (Baba, 1998).

Subsequently there were several further discrete Laxfordian deformation phases that resulted in localized shear-zone formation. The most significant phase resulted in the formation of E-trending, subvertical, sinistral shear-zones in the Roineabhal Intrusion. Lateral displacements of up to 140 m have been recorded (Witty, 1975). A later set of NE- to ENE-trending minor shear-zones cross-cuts the earlier structures and although they form prominent lineaments, visible on aerial photographs, they show only minor sinistral and dextral displacements. Some of the late-Laxfordian pegmatites show peripheral granulation suggesting that movements continued to the very end of the Laxfordian event. These later deformation episodes were accompanied by greenschist-facies metamorphism, although retrograde effects are only patchy in the Roineabhal Intrusion. The deformation and associated pervasive low-grade hydrous retrogression linked to the Outer Hebrides Fault Zone, probably occurred during the Silurian-age Scandian Event, as noted above.

Interpretation

The SHIC has long been recognized as a major element of the geology of the Outer Hebrides, and hence its origin, age and deformational and metamorphic history are particularly important to the overall understanding of the Lewisian Gneiss Complex. The gabbros and anorthosite of the Roineabhal Intrusion are the earliest intrusions in the SHIC, but the whole complex is compatible with differentiation from one or more tholeiitic basaltic magmas (see Fettes *et al.*, 1992). Igneous trends have been well documented in the granulite-facies parts of the anorthosite, gabbro and diorite intrusions, implying no re-distribution of elements during the granulite-facies metamorphism (Witty, 1975; Horsley, 1978). Such patterns are not preserved in the amphibolite-facies parts of these bodies. The SHIC shows an overall change from tholeiitic to calc-alkaline to alkaline magmatism with time, compatible with island-arc volcanism. The SHIC was interpreted as having been intruded at crustal levels of 25–30 km with the granulite-facies metamorphism reflecting its equilibration at these deep levels.

The correlation and absolute ages of main structural phases within the SHIC, the metasedimentary belts, and the gneisses farther afield, is not simple. The intrusive igneous bodies have acted as relatively competent elements of the geology particularly where they have retained their granulite-facies mineralogy. Witty (1975) suggested that the main 'antiform' in the anorthosite was partly a $D1_L$ structure, tightened and accentuated during the later $D2_L$ deformation and shearing. He also attributed some of the early boudinage and shearing of the gabbros and Lower Zone rocks to $D1_L$. The main $D1_L$ deformation and coeval granulite-facies metamorphism (ml and m2) appear to overlap with intrusion of the SHIC. This interpretation fits well with the metamorphic evidence from adjacent parts of the Leverburgh Belt (see below). In the SHIC the $D2_L$ and $D3_L$ deformation events are confined mainly to shear zones and were accompanied by amphibolite-facies metamorphism (m3 and m4 respectively). In the Leverburgh and Langavat belts the deformation phases are better developed and are represented by fold phases and related fabrics. The Leverburgh Belt rocks lie in a steeply plunging synform that can be paired with the Roineabhal Antiform. The deformation events are labelled here as Laxfordian (e.g. $D1_L$), but recent isotopic age data suggests that the events may be partly local in extent and that they cannot necessarily be regionally correlated with the structural phases in the Laxfordianized Archaean gneisses of the Uists and North Harris (Coward *et al.,* 1970; Fettes *et al.,* 1992; Kinny and Friend, 1997; Mason *et al.,* 2004a).

Geochronological work on the anorthosite and in other parts of the SHIC and the meta- sedimentary belts has been used to constrain the time frame for the intrusive, deformational and metamorphic events. The early Sm-Nd work of Cliff *et al.* (1983) showed that the SHIC is Palaeoproterozoic in age rather than Archaean as had been assumed previously. They interpreted the age of intrusion of the SHIC as *c.* 2000 Ma, with the granulite-facies metamorphism in the anorthosite dated at 1870 ± 40 Ma. Subsequently, Cliff *et al.* (1998) obtained a Sm-Nd age of 1827 ± 16 Ma from the net-veined gabbros in the Roinabhal Intrusion, again interpreted as dating the granulite-facies metamorphic event. Whitehouse and Bridgwater (2001) recently revised this age to 1876 ± 5 Ma, based on more-precise ion-microprobe U-Pb zircon dating. They also obtained a U-Pb zircon age of 1876 ± 5 Ma from a small tonalite body that intrudes the diorite at Bagh Steinigidh. On the basis of the zircon morphologies and zoning, they interpreted the date as representing the age of intrusion. This tonalite is taken to be the youngest member of the SHIC, except for the minor shoshonite dykes (see Na Buirgh GCR site report, this chapter; and Fettes *et al.,* 1992). Friend and Kinny (2001) showed that zircon overgrowths in adjacent aluminous pelitic rocks of the Leverburgh Belt have concordant SHRIMP U-Pb ages of 1874 ± 29 Ma, which they interpreted as the age of metamorphism. Mason *et al.* (2004a) obtained U-Pb TIMS data from zircons from a gabbro in the anorthosite body at [NG 0275 8740]. The data are discordant but give an upper intercept of 2491 ± 30 Ma, interpreted as the age of emplacement, and a lower intercept of 1877 ± 50 Ma, interpreted as the date of metamorphism. U-Pb zircon ages from the diorite and norite bodies gave ages of 1888 ± 2 Ma and 1883 ± 3 Ma respectively, both interpreted as emplacement ages. Thus, Mason *et al.* (2004a) argue that the anorthosite is some 600 million years older than the other elements of the SHIC.

The metasedimentary rocks of the adjacent Leverburgh and Langavat belts have also been shown to be of Palaeoproterozoic age by Friend and Kinny (2001). They obtained a spread of ages between 2780 Ma and 1880 Ma on detrital zircon cores from two metasedimentary samples, implying that their deposition pre-dated intrusion of the SHIC and granulite-facies metamorphism by only a few million years.

Baba (1997, 1998, 1999a,b) carried out detailed field, petrological and geochemical studies of the metasedimentary rocks, focused in the Roghadal-Leverburgh area. He showed that the Leverburgh Belt sedimentary protoliths were compatible with deposition in a trench environment linked to an island arc or continental-margin arc. He also reported sapphirine, orthopyroxene-kyanite, and orthopyroxene-sillimanite assemblages in pelitic and semipelitic rocks. These mineral assemblages are indicative of ultra high-temperature, high-pressure granulite-facies peak metamorphic conditions with temperatures of *c.* 9300–950° C and pressures of > 12 kbar (see O'Brien and Rotzler, 2003). Baba (1999a,b) pointed out that the main deformation and peak metamorphism in the anorthosite could not be explained merely by intrusion of SHIC into lower crustal levels (i.e. 25–30 km; see above) at the base of an arc, but required a subsequent definite pressure increase. He postulated that subduction must have continued downwards for a further 10–15 km following intrusion of the SHIC, possibly as a result of continental collision. Hence, two separate granulite-facies events were recognized (ml and m2), followed by a static development of corona textures under middle amphibolite-facies conditions (Baba, 1998; see also Dickinson and Watson, 1976). Fettes *et al.* (1992) noted that this last 'm_{2a}' metamorphic event reflects a pressure decrease of 4 kbar, relating to rapid uplift. The D3 and later deformation and metamorphic features were considered to be compatible with localized strain and punctuated uplift during the Laxfordian, as documented previously by Dickinson and Watson (1976). Ar-Ar studies by Cliff *et al.* (1998) and Rb-Sr biotite ages obtained by Cliff and Rex (1989) document the later uplift history of the SHIC and metasedimentary belts of South Harris relative to the migmatitic Archaean gneisses and later granites in the adjacent terrain to the north-east.

Thus, the current interpretation is that the metasedimentary rocks of South Harris were deposited in a trench environment adjacent to an active island-arc or possible continental arc. They were subducted beneath the arc to crustal depths of *c.* 27 km where the SHIC was intruded. Then both elements were further subducted to 35–45 km depth, and were folded and metamorphosed under upper granulite-facies conditions (Baba, 1999b). Temperatures of 800° C to over 900° C and pressures of > 12 kbar were attained during the peak metamorphism (Baba, 1999a). All these events are currently interpreted to have occurred between 1890 Ma and 1870 Ma (Friend and Kinny, 2001), except by Mason *et al.* (2004a) who postulated that intrusion of the Roineabhal Intrusion occurred much earlier at *c.* 2490 Ma. It is significant that similar localized arc activity is recorded in other parts of the Laurentian and Fennoscandian shield at about 1850–1900 Ma (Park, 1994; Whitehouse and Bridgwater, 2001).

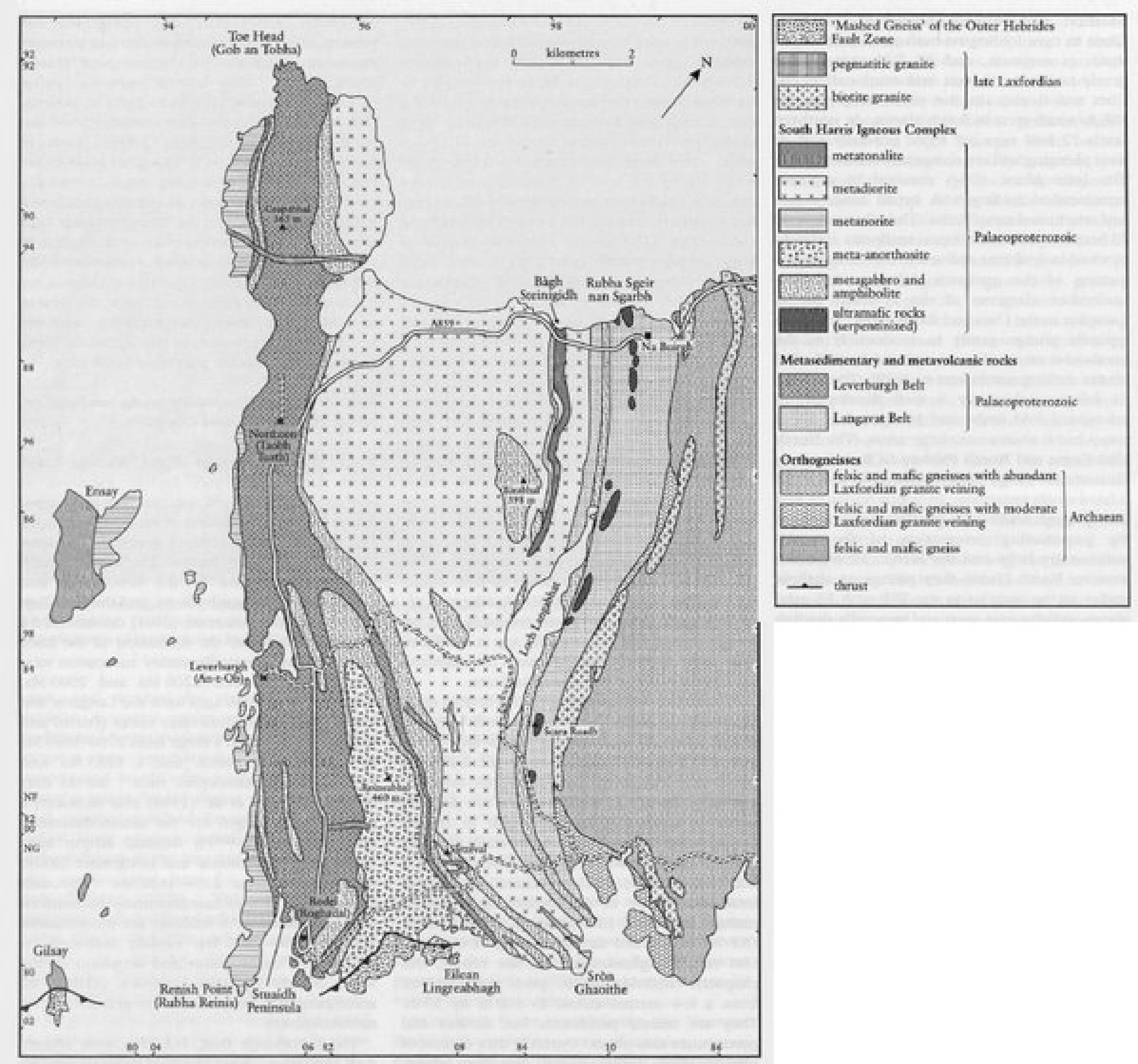
Conclusions

The Roineabhal GCR site covers a major part of the largest gabbro-anorthosite body found in the UK. The anorthosite (a white, almost pure plagioclase feldspar rock) occurs in the upper parts of the Roineabhal Intrusion, part of the Palaeoproterozoic-age South Harris Igneous Complex (SHIC) that comprises various metamorphosed intrusions of anorthosite, gabbro, norite, diorite and tonalite. The Roineabhal Intrusion contains distinct igneous la!;ering on both large- and small-scales and can be readily divided into Lower, Middle and Upper zones that become younger to the south-east. It is tightly folded into a large-scale antiform with a subvertical to steeply NW-plunging fold axis. Anorthosite-ultramafic rock breccias occur in lenticular zones along its south-west margin, and late-stage melagabbro dykes and net-veins cut the compositional banding. The SHIC intrusions show geochemical trends typical of calc-alkaline rocks derived from differentiation of basaltic magma at deep crustal levels.

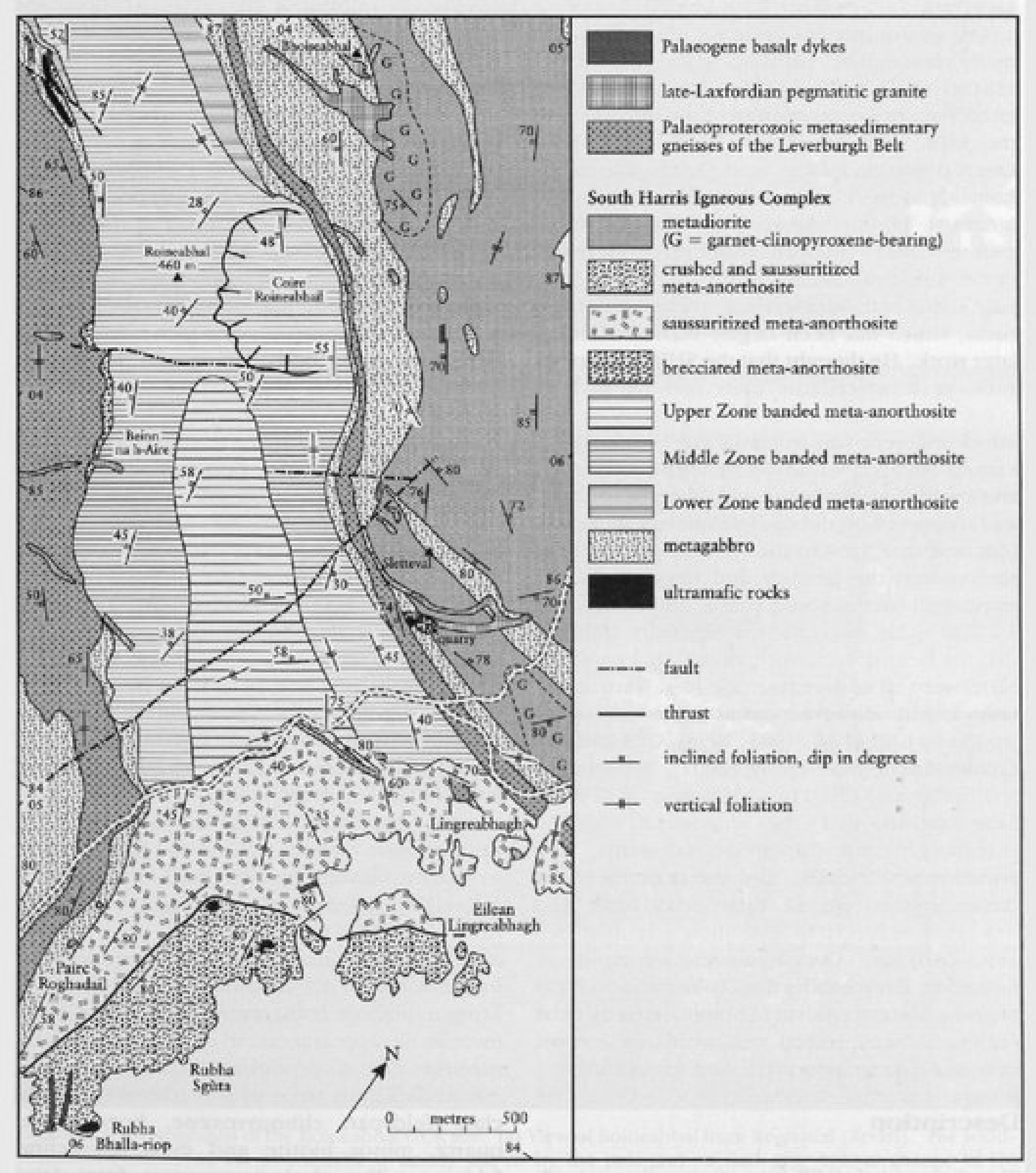
These igneous rocks were intruded into metasedimentary rocks of the adjacent Leverburgh and Langavat belts. Geochronological work suggests that both the metasedimentary rocks and the intrusions were formed between about 1890 Ma and 1870 Ma. The metasedimentary rocks are compatible with deposition in a trench environment adjacent to an island arc and must have been subducted to lower crustal levels where the SHIC intrusions were emplaced. The earliest deformation and metamorphism were coeval with emplacement of the intrusions. Subduction continued until the SHIC and metasedimentary rocks reached crustal depths of *c.* 35–45 km where the rocks were metamorphosed further under high-pressure granulite-facies conditions. Rapid uplift followed, with renewed metamorphism under lower-pressure amphibolite-facies and finally under greenschist-facies conditions. Deformation during this phase was mainly confined to generation and reworking of shear zones marginal to the anorthosite. The main deformation and metamorphism spanned the period of Laxfordian reworking and progressive uplift between *c.* 1875 Ma and *c.* 1500 Ma. However, the south-east part of the anorthosite was later affected by considerably hydrous retrogression and associated shearing and cataclasis, linked to movements on the Outer Hebrides Fault Zone, probably during the Silurian-age Scandian Event.

The Roineabhal Intrusion is unique in the Lewisian Gneiss Complex and provides compelling evidence of Palaeoproterozoic igneous and tectonic events. It has been the subject of innumerable geological studies and is likely to remain a prime research and teaching locality. It is undoubtedly of international importance.

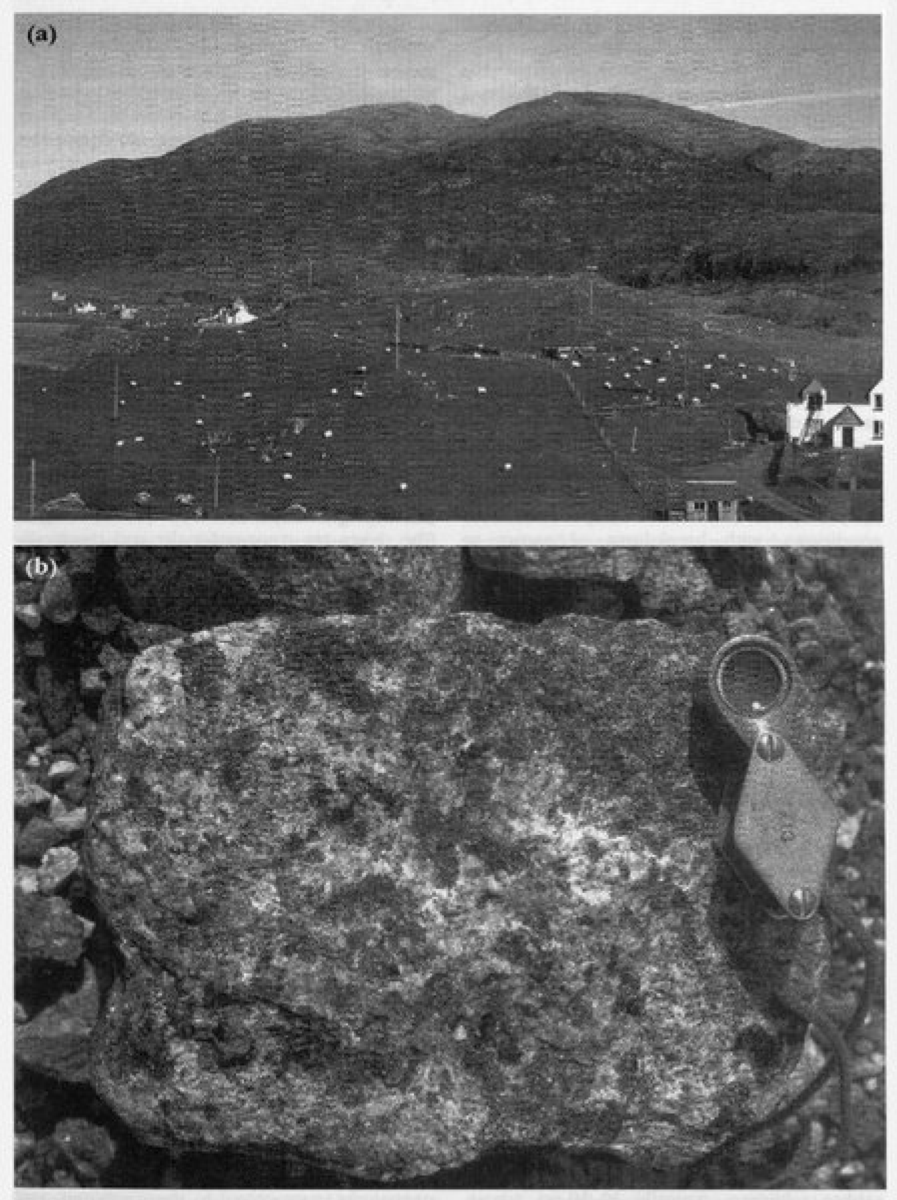
[References](#)



(Figure 2.4) Simplified geological map of South Harris. After Fettes et al. (1992).



(Figure 2.7) Simplified geological map of Roineabhal, South Harris. After Fettes et al. (1992).



(Figure 2.8) Photographs of the Roineabhal GCR site. (a) View of Roineabhal from Roghadal (Rodel). The southwestern boundary of the anorthosite is clearly shown by the pale-grey to dark-grey colour change of the bedrock. (b) Garnetiferous leucogabbro from the Upper Zone of the Roineabhal Intrusion. The hand lens is 6 cm long. (Photos: J.R. Mendum.)