Cnoca Breac (Rubh' Aird-Mhicheil), South Uist

[NF 733 337]

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Introduction

The Cnoca Breac GCR site on the western coast of South Uist provides a section across one of the most spectacular examples of an Archaean layered or banded mafic–ultramafic meta-igneous body, part of the 'Older Basic' Suite (Fettes *et al.,* 1992). These bodies, which are among the oldest rock-types found in the Outer Hebrides, occur throughout the archipelago but are particularly common in the Uists. Although typically only a few tens of metres wide, they may be traceable through intermittent exposures for considerable distances along the strike of the regional foliation. They are commonly associated with metasedimentary rocks, and the two lithologies are believed to be the remnants of a supracrustal layered mafic–ultramafic sequence dating from at least *c.* 2900 Ma. These early-formed elements of the Lewisian Gneiss Complex were subsequently enveloped by granodioritic and tonalitic intrusions, the protoliths of the dominant quartzofeldspathic gneisses, at deep crustal levels during the Scourian (*c.* 2900–2750 Ma).

The banded mafic bodies characteristically exhibit mineralogical banding, commonly with repeated mafic–ultramafic cycles, mainly marked by variations in the ratio of hornblende to plagioclase. Felsic bands also occur but are less common. The banding is believed to have originated as a form of igneous layering, now modified and enhanced by metamorphic recrystallization. The mass at Cnoca Breac is one of the largest and best-exposed examples of these bodies, with a notably wide range of lithologies present. The well-developed layering occurs on several scales from tens of centimetres upwards and with an overall trend from ultramafic to felsic mineralogies across the width of the body.

The GCR site lies in the South Uist synformal zone (see 'Introduction', this chapter), a locus of very high Laxfordian reworking. However, despite its undoubted long tectonometamorphic history the essential elements of the layered intrusion are still readily identifiable. The rocks were mentioned but not described by Jehu and Craig (1925). Coward *et al.* (1969) were the first to recognize the significance of the banded 'Older Basic' bodies, but did not provide detailed information about this site. The first comprehensive description was included in Fettes *et al.* (1992). Although large 'Older Basic' bodies do occur in parts of Lewis and Harris (e.g. in the Gress and Coll river sections north of Stornaway), banded mafic–ultramafic bodies appear to be absent from the northern islands. The lithologically comparable banded metagabbros and meta-anorthosite in South Harris are now known to be Palaeoproterozoic in age and hence unrelated to the Archaean 'Older Basic' Suite. Nesbitt (1961) reported the only other possible Hebridean correlative to the occurrences in the Uists from North Rona, some 72 km NNE of the Butt of Lewis. Interestingly, Nesbitt (1961) records the presence of garnet-sillimanite pelitic gneiss adjacent to the banded basic rocks. However, similar banded mafic–ultramafic bodies have also been described more widely from the Scottish mainland, for example in the Scouriemore and Gorm Loch areas near Scourie (Davies, 1974), and from near Drumbeg and Achmelvich (Tarney, 1978).

Description

The GCR site lies immediately to the north of Rubh' Aird-mhicheil, on the western, generally sandy coast of South Uist. In fact the site locality and the banded mafic body have commonly been named after this promontory. Rock is exposed throughout the coastal section of the site on a low, dissected, wave-cut platform, which is partly intertidal. A notable shingle beach backs the site with flat machair behind.

The rocks in the general area from Rubh' Aird-mhicheil northwards to Eilean Bheirean (Verran Island) are characterized by a regular gneissose foliation that is generally subvertical and strikes NNW Very tight folds, up to several metres in amplitude, are common within the gneisses. In this part of South Uist the 'Younger Basic' dykes are conformable, pervasively recrystallized to amphibolite, and commonly strongly boudinaged. A concentration of mafic amphibolite

sheets and pods occurs on the south-western side of Rubh' Aird-mhicheil. It is unclear if these bodies relate to the banded mafic–ultramafic body on Cnoca Breac, or more probably that they are members of the 'Younger Basic' Suite. It is clear that this area is one of very high Laxfordian strain. The dominant lithology is the ubiquitous coarse-grained, biotitic and hornblende-bearing quartzofeldspathic gneiss containing a variety of mafic sheets and agmatitic lenses and patches. The spectacular development of banded mafic rocks dominates the GCR site and the main body is *c.* 250 m wide (Figure 2.22). Despite its size at Cnoca Breac, the body appears to be lenticular as it is not seen along strike to the north-west on Eilean Bheirean (Verran Island), nor to the south-east around Loch Olaidh an Iar (011ay).

The body exhibits well-defined mineralogical layering, which is parallel to the regional foliation. The layering is defined by varying proportions of hornblende, garnet, plagioclase ± quartz, and occurs on a variety of scales (Figure 2.23). Individual layers, typically 10–20 cm wide, are defined either by a gradual increase in felsic minerals across their width or by the rapid alternation of more-uniform felsic and mafic units. Groups of layers also define units 1–2m thick, each unit ranging from ultramafic to felsic lithologies and grading in the same sense as the overall body. These units are dominated by mafic lithologies with individual layers defined by the relative abundance of garnet. Locally the garnets exhibit plagioclase rims, which have been partially flattened within the foliation. The garnets in the ultramafic layers are less susceptible to retrogression to plagioclase than those in the more-mafic layers. Overall the body becomes more felsic towards the north-east, with the easternmost 50 m being effectively a banded metagabbro–meta-anorthosite (Figure 2.24), implying that the body had an original top to the north-east. Screens of felsic gneiss, locally with abundant pyrite and pyrrhotite, occur within the body and these intercalations are more abundant in the eastern part of the body.

In thin section the textures and mineralogy are seen to be entirely metamorphic with no evidence of relict cumulate or ophitic igneous textures. The rocks are normally subequigranular, but in parts locally incipient planar fabrics are defined by aligned hornblende. Although clinopyroxene has not been recorded here, it is common in similar rocks elsewhere in the Outer Hebrides and on the Scottish mainland (Fettes *et al.,* 1992). No systematic geochemistry has been carried out on the Cnoca Breac body but similar, banded, mafic bodies elsewhere in the Outer Hebrides plot as quartz-normative tholeiites (Fettes *et al.,* 1992).

Within the regular, broadly parallel layering, tight minor folds are common locally; as in the surrounding gneiss. These folds have poorly developed axial fabrics in parts, and generally their axes plunge moderately to steeply to the north-east. Several factors confirm that this is an area of very high Laxfordian reworking, namely, the internal structures within the banded basic body and in the surrounding gneiss, the general parallelism of the mafic bodies with the local and regional gneiss foliation, and the pervasive amphibolite-facies mineralogies.

Small pseudotachylite veins are common on the northern side of the banded mafic body linked to minor offsets and brecciation. These veins are of late-Laxfordian or younger age, probably related to movements along the Outer Hebrides Fault Zone (see Cnoc an Fhithich GCR site report, this chapter).

The NW-trending dolerite dykes exposed at the northern end of the Cnoca Breac section (*c.* 1 m thick) and on the northern shore of Rubh' Aird-mhicheil (3 m thick) are members of the Palaeogene Mull Swarm (Figure 2.22).

Interpretation

Banded or layered mafic bodies are common in the Uists and Benbecula. Although not generally as spectacular as that at Cnoca Breac, these bodies are all characterized by well-developed mineralogical layering, commonly showing variations from ultramafic to mafic and felsic lithologies. The mineralogies and textures are now wholly metamorphic and recrystallized, but the banding clearly reflects original igneous compositional layering, and the intrusive igneous nature of the banded mafic bodies has not been seriously questioned. The bodies probably formed originally as lenticular gabbroic masses with layering akin to that now seen in younger less-deformed complexes, such as Bushveld, Skaergaard and the Cuillin on Skye.

Coward *et al.* (1969) provided the first comprehensive account of banded mafic bodies in the Lewisian Gneiss Complex of the Outer Hebrides. These authors noted the areal coincidence of these mafic bodies with metasedimentary rocks, and that the metasedimentary rocks apparently pass laterally into the surrounding quartzofeldspathic gneisses. They

concluded that this transition resulted from the Scourian gneissification process and hence that the metasedimentary and banded mafic units were present prior to, or at an early stage of, the Scourian event. This conclusion is supported by the occurrence of unmigmatized 'Younger Basic' dykes cross-cutting the migmatitic foliation in the banded metabasic bodies (Fettes *et al.,* 1992, p. 35). Fettes *et al.* (1992) showed that the banded mafic bodies are a major component of the 'Older Basic' Suite. In the Outer Hebrides banded mafic bodies and metasedimentary lithologies commonly form discontinuous narrow linear belts concordant with the local and regional gneissose foliation. The belts are typically only a few tens of metres wide but may be traced along strike for up to 15 km. A notable example runs from north of Loch Druidibeg through the east end of Loch Bee and northwards through the centre of Benbecula, where it is folded and forms the hill of Rueval [NF 825 534].

As discussed in the Loch Sgioport GCR site report, Coward *et al.* (1969) postulated that the meta-igneous and metasedimentary units represented the exotic relics of an early supracrustal sequence, most of which had been migmatized and recrystallized to form the bulk of the quarrzofeldspathic gneisses. However, Moorbath *et al.* (1975) showed from U-Pb isotopic systematics that the quartzofeldspathic gneisses were derived from igneous protoliths, intruded prior to the main Scourian metamorphic events at 2700–2800 Ma. Also, the analogy with similar rock associations in Greenland, in particular the classic banded mafic–ultramafic and metasedimentary units of the Fiskeneaesset region (see Fettes and Mendum, 1987 for discussion), led later workers to decide that the banded 'Older Basic'–metasedimentary rock belts were xenolithic rafts or screens within the general tonalitic–granodioritic protolith of the quartzofeldspathic gneiss. These correlations date the meta-igneous–metasedimentary association at over 2900 Ma and thus define them as some of the oldest rocks exposed in the Outer Hebrides.

Although intrusions of the banded 'Older Basic' and 'Younger Basic' suites can be distinguished from each other in areas of low Laxfordian strain (see Gearraidh Siar and Baile a' Mhanaich GCR site report, this chapter) this is not the case in areas of high strain. Thus, it is not possible to attribute the amphibolitic mafic bodies immediately south-west of the Cnoca Breac body to either the older or younger suite. However, the close spatial connection between this concentration of mafic sheets and the banded mafic body might imply that they are all part of the same assemblage.

Coward *et al.* (1970) ascribed the major folds of South Uist to the Laxfordian $D3_L$ event. These antiforms and synforms plunge steeply to the north-west and have NW-trending axial planes.

On the regional scale they have a cuspate form with broad antiformal crests, marked by low Laxfordian strain, and narrow pinched-in synforms, typically with very high Laxfordian strains. The Cnoca Breac GCR site and its associated high degrees of reworking are consistent with its position in the complex axial zone of the South Uist Synformal Zone (Coward *et* at, 1970, fig. 2; see also Fettes *et al.,* 1992, pp. 124 and 131; and the accompanying 1:100 000-scale structure map (Uist and Barra (south); Institute of Geological Sciences, 1983)).

Conclusions

The Cnoca Breac GCR site exposes one of the best examples of banded or layered mafic–ultramafic rocks of the 'Older Basic' Suite rocks found in the Outer Hebrides. The readily identifiable, dark-green to black, grey, and white banding is defined by alternations of ultramafic, mafic and felsic layers on scales ranging from a centimetre up to several metres thick. This banding is interpreted as representing original igneous layering, albeit now highly deformed and pervasively recrystallized during the Scourian and Laxfordian events. However, the rocks still preserve the essential character of the body and the integrity of its layering. Indeed, in places metamorphism has effectively enhanced the layering, for example where there is an abundance of dark-red metamorphic garnet in the mafic layers.

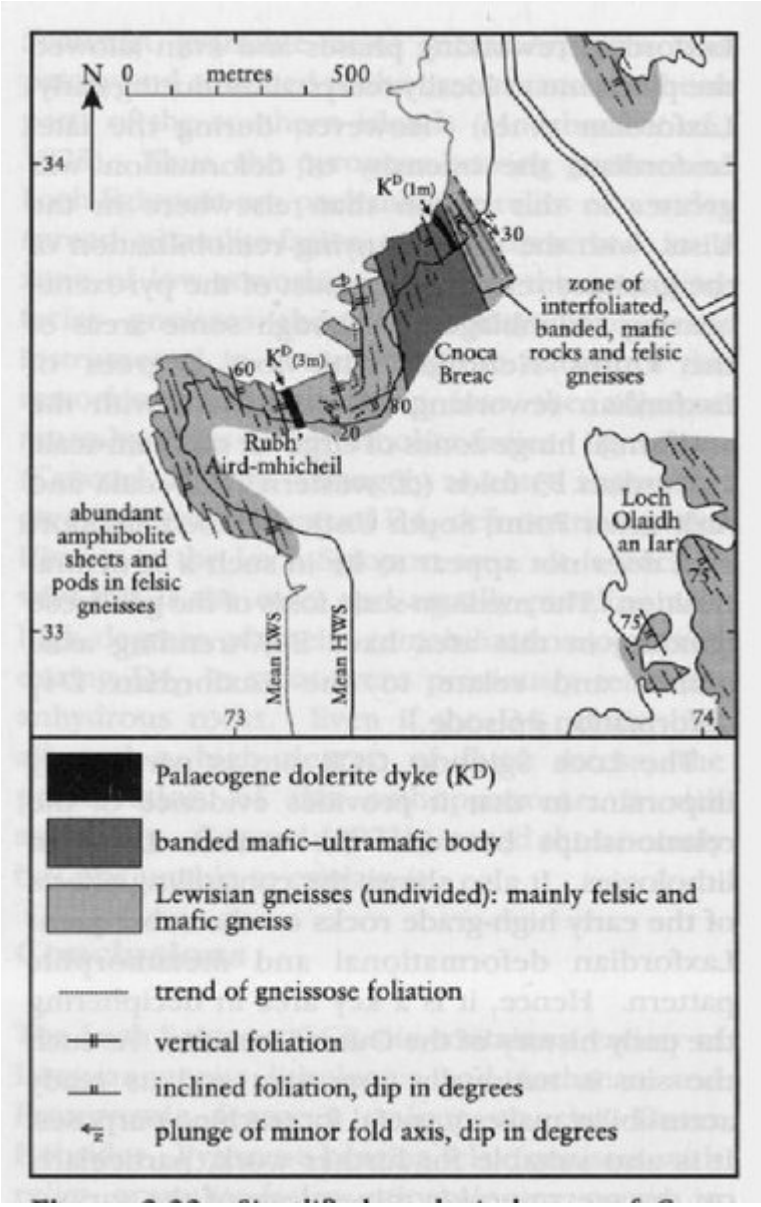
The intrusion is of Archaean age and lies within dominantly planar, mainly felsic gneisses that have been strongly reworked during the Palaeoproterozoic Laxfordian event. Regionally, the Cnoca Breac GCR site lies in the pinched-in, cuspate, axial part of the South Uist Synformal Zone, a major Laxfordian structure whose steep axial plane trends north-west. This synformal zone is marked by a very high degree of Laxfordian strain and reworking. The foliation and banding in the layered basic–ultrabasic body and the felsic gneisses are concordant and strike NNW and are typically subvertical. Tight to isoclinal folding is present in parts of the layered body, and the rocks have been recrystallized under middle amphibolite-facies conditions.

In the Uists and Benbecula, the Archaean mafic–ultramafic bodies of the 'Older Basic' Suite, such as that at Cnoca Breac, mainly occur as discrete lensoid masses only a few tens of metres wide and up to several hundred metres long.

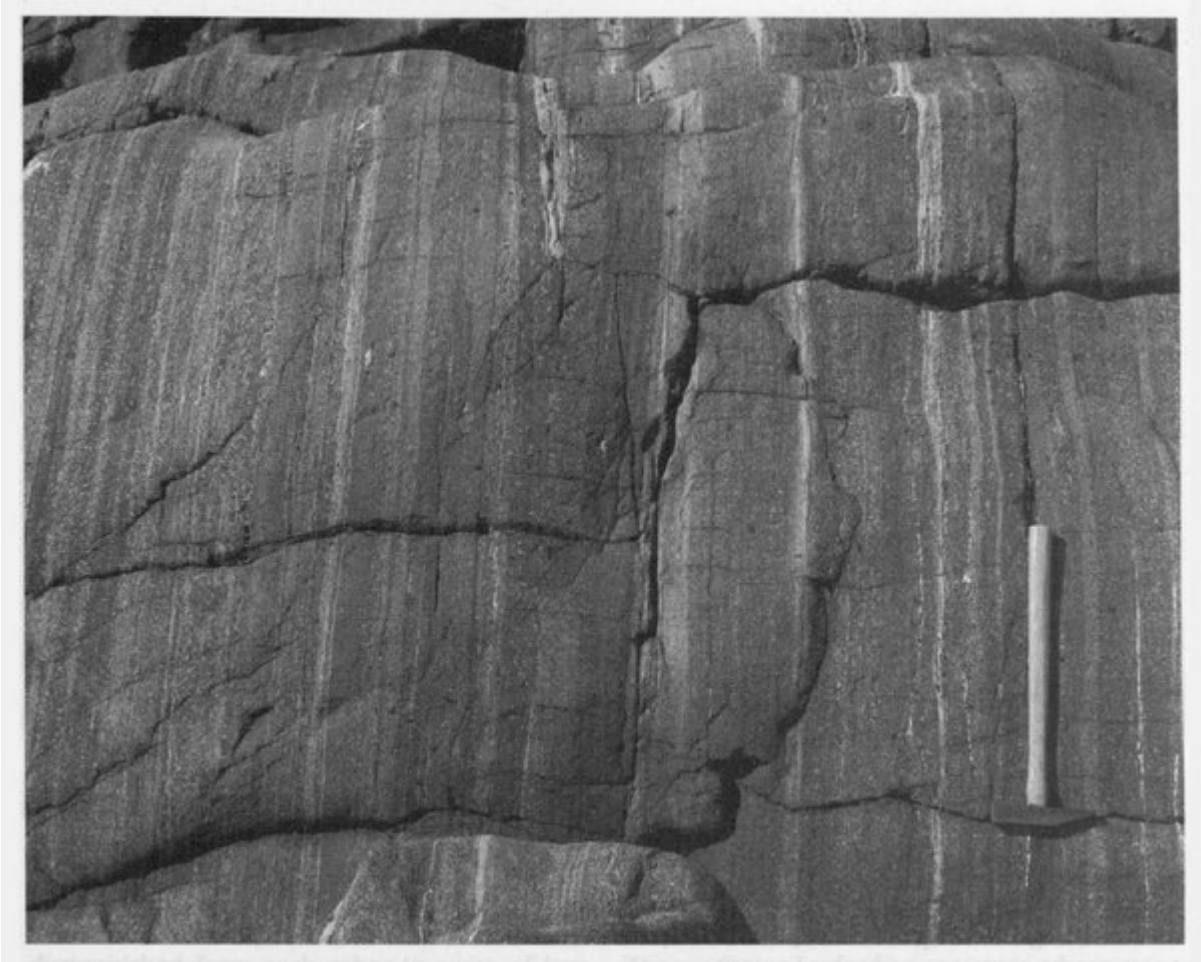
However, they are commonly clustered into linear belts, traceable for up to 15 km, which are also marked by a relative abundance of metasedimentary units. This banded meta-igneous–metasedimentary rock association is thought to include the oldest rocks present in the Outer Hebrides, probably having formed at least 2950 Ma. This sequence was subsequently intruded by numerous granitoid intrusions, the igneous protoliths of the present quartzofeldspathic gneisses, at the beginning of the Scourian (mainly around 2850 Ma). The meta-igneous–metasedimentary units were preserved as refractory rafts or screens within these major granitoid intrusions.

This GCR site is of national importance because it displays one of the geologically most varied and spectacular examples of a layered mafic–ultramafic igneous intrusion in the Lewisian Gneiss Complex. Such bodies are readily correlated with larger and better-exposed banded basic meta-igneous bodies in West Greenland. As such the Cnoca Breac GCR site is a possible locality for future work as well as being valuable for the teaching of Hebridean and Lewisian geology.

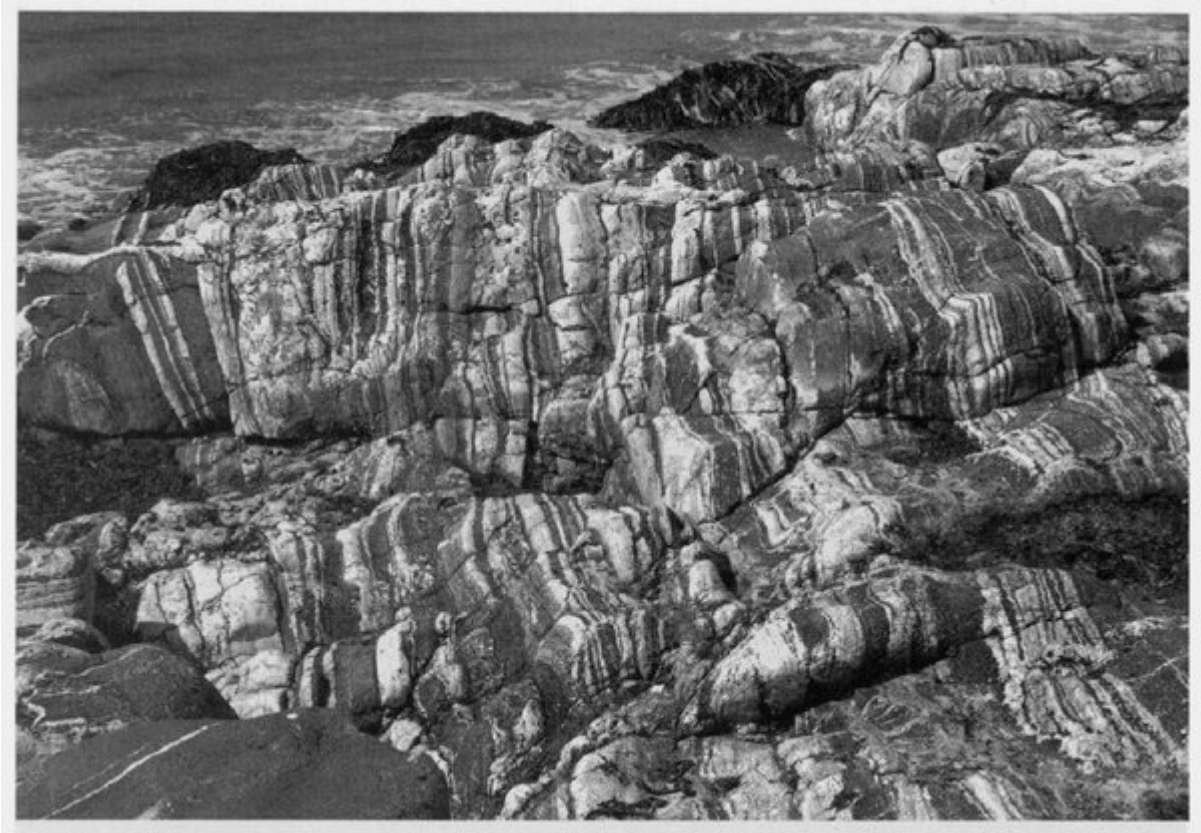
References



(Figure 2.22) Simplified geological map of Cnoca Breac, South Uist.



(Figure 2.23) 'Older Basic' body at Cnoca Breac [NF 7338 3385], showing attenuated and metamorphosed mafic, ultramafic and felsic igneous layering. The hammer is 42 cm long. (Photo: British Geological Survey, No. P008306, reproduced with the permission of the Director, British Geological Survey, © NERC.)



(Figure 2.24) Deformed and metamorphosed mafic and felsic (anorthositic) banding in the north-east part of the 'Older Basic' body at Cnoca Breac [NF 7347 3390]. The banding reflects the original igneous compositional layering. (Photo: British Geological Survey, No. P008309, reproduced with the permission of the Director, British Geological Survey, © NERC.)