Beinn na Seilg–Beinn nan Ord

OS Grid Reference: NM450627

Highlights

The site contains major arcuate gabbroic and doleritic intrusions of Centre 2, including the Hypersthene Gabbro, part of a layered intrusion, which has severely metamorphosed adjoining country rocks. The later, granophyric Quartz Dolerite of Sgurr nam Meann contains superbly exposed evidence for the former coexistence of basic and acid magmas.

Introduction

This extensive site provides a valuable traverse through the arcuate intrusions of Centre 2 of the Ardnamurchan complex. It is of special importance in demonstrating the contact relationships between the complex and the country rocks surrounding it. The arcuate masses include the outer Hypersthene Gabbro which dominates the geology of the site, the granophyric Quartz Dolerite and quartz gabbros and eucrites. The inner set of cone-sheets associated with Centre 2 is also well represented.

The Beinn na Seilg–Beinn nan Ord area was first investigated in detail by Richey and Thomas (1930), following field surveys between 1920 and 1923. There has been no comprehensive account of the area since, but investigations describing the form, field relations and petrology of the Granophyric Quartz Gabbro have been published by Wells (1954a), and the field characteristics of this intrusion have been excellently described by Skelhorn and Elwell (1966). In addition, the structure and petrology of the Hypersthene Gabbro has been studied by Wells (1954b) who also investigated its xenoliths (Wells, 1951). A recent study by Day (1989) details much new information about the Hypersthene Gabbro and its contact effects.

Description

At Dubh Chreag (NM 452 633), 2 km west of Ormsaigbeg (Figure 4.6), the outer contact of the Hypersthene Gabbro is exposed against Lower Lias shales and limestones. This is the outermost major intrusion of Centre 2, the contacts of which dips southwards at angles of 45°–60°. Further to the east, around Lochan Ghleann Locha, the Hypersthene Gabbro intrudes Palaeocene basalt lavas overlying Middle Jurassic (Bajocian) sandstones and limestones; these rocks form a narrow strip parallel to the contact (1.5 km long and with a maximum width of 150 m) and are bounded to the south by a fault which downthrows them against Lower Lias. The sediments are intruded by numerous thin cone-sheets belonging to the outer set of Centre 2 inclined to the north at angles of between 35° and 40°. These are beautifully exposed, standing out in stark contrast against the cream-coloured sandstones and pale limestones of the Lias; they were first noted in the coastal cliffs by MacCulloch (1819) and later by Geikie (1897).

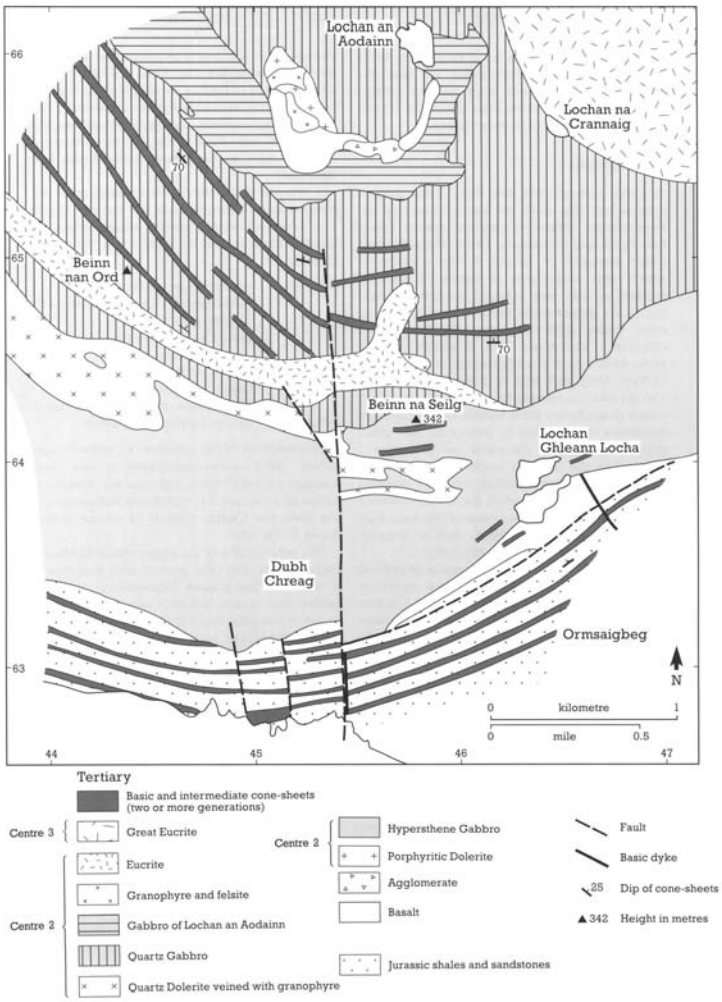

Figure 4.6: Geological map of the Beinn na Seilg-Beinn nan Ord site (after Gribble et al., 1976)

The thermal effects of the Hypersthene Gabbro are widespread, but intense thermal metamorphism occurs only within a few hundred metres of the contact. At Dubh Chreag, the Lias shales have been altered to hard, fissile hypersthene–biotite–magnetite–feldspar hornfels with possible cordierite. The impure limestones are now clinopyroxene–sphene–garnet–anorthite–hornblende hornfels, while the purer, Middle Jurassic limestones are now calc-silicate assemblages of recrystallized calcite, garnet, diopside and tremolite. Within the thermal aureole, the lavas and early cone-sheets also show considerable alteration and have become flinty and more massive. Closer to the contact, they are granular clinopyroxene–olivine–plagioclase–magnetite hornfelses often with orthopyroxene. Thoroughly hornfelsed country-rock xenoliths of igneous origin occur at various points along the contact of the gabbro. Day (1989) has demonstrated that extreme thermal metamorphism produced distinctive rheomorphic melts from the varied country-rock lithologies.

Among the main intrusions of Centre 2, a kilometre to the south of Sonachan, a strip of intensely altered volcanic rocks lies between the Older Gabbro of Lochan an Aodainn and younger quartz gabbros. Although severely metamorphosed to granular hornfelses, the agglomerates can still be matched with those of the ‘Northern Vents' of Centre 1, and the basalts have retained their flow structure.

A traverse from the southern margins of the Hypersthene Gabbro towards the focus of Centre 2 at Sonachan crosses several arcuate intrusions identified and named by Richey and Thomas as follows:

(oldest) Hypersthene Gabbro
(Granophyric) Quartz Dolerite of Sgurr nam Meann
Quartz Gabbros of Loch Caorach and Beinn na Seilg
Eucrite of Beinn nan Ord
Quartz Gabbro of Garbh-dhail
Old Gabbro of Lochan an Aodainn
(youngest) Quartz Gabbro of Aodainn

Representatives of the inner set of Centre 3 cone-sheets, small felsite/granophyre masses near Aodainn (NM 457 658) and near the summit of Beinn na Seilg and the westwards termination of the Faskadale Quartz Gabbro of Centre 3 also occur in the site.

The petrography of the Hypersthene Gabbro is extremely variable. The predominant rock type is a relatively fine-grained hypersthene – olivine gabbro but quartz dolerite and quartz gabbro occur as marginal facies at Dubh Chreag and east of Lochan Ghleann Locha. Masses of troctolitic or allivalitic gabbro grading into peridotite, coarse-grained augite-rich gabbro and gabbro pegmatite are also found in the intrusion; these often have intrusive contacts and quartz–feldspar veins occur towards the outer margins of the mass. One of the most interesting features of the gabbro is the sporadic development of layering produced by a combination of textural variation and variations in the modal mineralogy. Layers rich in pyroxene, magnetite and olivine occur at the base of some of the structures which vary from 10 mm to over 1 m in thickness. A degree of rhythmic layering of feldspar-rich and pyroxene-rich layers is apparent. Intra-layer slump structures and erosional surfaces are also noteworthy features, being comparable with those on Rum (Askival–Hallival). The layering dips inwards and increases from about 5° at the outer margin to over 60° at the inner contacts.

The granophyric Quartz Dolerite of Sgurr nan Meann truncates the Hypersthene Gabbro on the north and east. Along most of its inner contact, it adjoins the Quartz Gabbro of Loch Caorach but its southern extremity lies entirely within the Hypersthene Gabbro, and along a short length in the north, its inner contact lies against the Beinn nan Ord Eucrite. The mass is younger than the Hypersthene Gabbro and the contact between the two is complex, with sill-like apophyses penetrating the older rock for distances of up to a kilometre. In contrast, the inner contact is simple and near vertical. The lithology of the Quartz Gabbro intrusion is its most outstanding feature. It comprises an association of feldspar-phyric and aphyric dolerite and gabbro xenoliths, often of great size, which are locally penetrated by an anastomosing plexus of acid net-veining associated with dykes and sheets of felsite/granophyre. A full petrological account of this intrusion has been published bySkelhorn and Elwell (1966); the detailed petrography is therefore not described here. The thicker sheets and dyke-like bodies of granophyre with aphyric dolerite inclusions penetrate the porphyritic dolerite and, in some exposures, the margins of the porphyritic dolerite appear to be chilled and phenocryst free; in others, the phenocrysts are abruptly truncated by the sheets or dykes and the grain size of the dolerite does not decrease towards the contact. Thus, there is conflicting evidence for the relative ages of the two dolerites. However, evidence that the porphyritic dolerite is the earlier is drawn from its inclusion as xenolithic blocks within the aphyric dolerite, with granophyre generally intervening between the two.

The Quartz Gabbros of Loch Coarach (NM 433 656) and Beinn na Seilg were considered by Richey and Thomas (1930) to be parts of a single ring-dyke, although they differ petrologically. The most basic type is an olivine gabbro consisting of olivine, augite, labradorite and accessory ore. On this original assemblage changes have been superimposed, changes caused by ‘acid material of late consolidation' (Richey and Thomas, 1930) such as schillerization of feldspars, de-schillerization of pyroxene, development of hypersthene and locally abundant acid mesostasis which has crystallized as alkali feldspar and quartz. To the west and south-west, the Quartz Gabbros are bounded by the Quartz Dolerite (and the Hypersthene Gabbro in the case of the Beinn na Seilg mass). The contact is poorly exposed and is difficult to interpret. These gabbros are not cut by the inner cone-sheets of Centre 2, but they do inject some of the components of the Granophyric Quartz Dolerite which is therefore probably the older intrusion.

Along their inner contacts, where the quartz gabbros adjoin the Eucrite of Beinn nan Ord, both rocks are brecciated at exposed junctions. At a few localities sharp contacts show the Quartz Gabbro cutting and chilled against the Eucrite.

The Eucrite of Beinn nan Ord lies to the north and east of the Quartz Gabbros and can be traced from Beinn na Seilg northwards and westwards across Beinn nan Ord to Sanna Bay. It is a moderately coarse-grained rock with abundant olivine, ophitic augite associated with large magnetite crystals and plagioclase (labradorite–bytownite). The olivine is usually associated with biotite and hypersthene where it is unaltered. Variants rich in olivine, pyroxene or plagioclase also occur and acidification and granulitization are widespread. The form of the Eucrite is unusual in possessing two arms projecting inwards to the focus of Centre 2 cutting across the earlier Quartz Gabbro of Garbh-dhail. The rock is resistant to weathering and generally well exposed in conspicuous glaciated crags. Over much of its extent, the rock has been microbrecciated possibly due to explosive shattering by an acid magma (Richey and Thomas, 1930). The outer contact against the Quartz Gabbros of Beinn na Seilg and Loch Caorach has been described above. The inner contact is against an earlier gabbro, the Quartz Gabbro of Garbh-dhail, which is cut by cone-sheets and linear crush lines, both of which are absent in the Eucrite. Both contacts of the Eucrite appear to be steep.

The Quartz Gabbro of Garbh-dhail forms much of the north-eastern part of the Beinn nan Ord and Beinn na Seilg area and, like the other quartz gabbros of Ardnamurchan, displays great variation in composition and texture. More basic and finer-grained varieties prevail in the exterior part of the mass, while the interior is more silicic and internal intrusive contacts suggest a composite nature, an initial injection of basaltic magma being followed by a relatively silicic magma. Flow-banding, dipping at high angles towards the focus of Centre 2, is locally present. The gabbro is chilled against the Hypersthene Gabbro on Beinn na Seilg and against the Old Gabbro of Lochan an Aodainn. Cone-sheets from the inner set of Centre 2 cut this Quartz Gabbro and both are baked against the Eucrite of Beinn nan Ord.

The Old Gabbro of Lochan an Aodainn outcrops in an arc between Lochan an Aodainn and Achosnish and is considered to be a very early intrusive member of Centre 2. It is now very altered but it was originally a variable fine- to coarse-grained olivine-bearing dolerite with olivine-free, olivine-rich, allivalitic and fine-grained augite-rich varieties. The Gabbro has a distinctive dull, matt, dark-grey appearance caused by numerous opaque inclusions in the feldspar and alteration of the mafic minerals. Crushing and shattering are widespread, with segregation and migration of acid material locally producing a rock resembling an augite granophyre. The Old Gabbro is in contact with a small mass of basalt lavas and agglomerates along its north-eastern margin, but elsewhere its margins are entirely determined by later intrusions.

North of the Old Gabbro, the Quartz Gabbro of Aodainn crops out and is heterogeneous both in texture and in the proportion of acid mesotasis. It is generally a moderately fine-grained rock bearing both orthopyroxene and clinopyroxene and a little interstitial alkali feldspar and quartz. Coarser areas appear to be xenolithic towards the porphyritic finer-grained rocks. Internal contacts are both sharp and gradational, and other textural variations indicate the possibility of a composite origin for the intrusion. The Aodainn mass clearly veins and intrudes the Old Gabbro, with chilling and some hybridization occurring along this contact. North-east of Lochan an Aodainn, a strip of dark-grey rock containing phenocrysts of plagioclase, augite and olivine intervenes between these masses; this has been interpreted as a remnant of a still older intrusion. The Quartz Gabbro is truncated to the north by the Great Eucrite of Centre 3 which caused the thermal metamorphism noted in the earlier intrusions.

The Quartz Gabbro of Faskadale, the outermost intrusion of Centre 3, enters the eastern margin of the Beinn nan Ord–Beinn na Seilg area and appears to underlie many of the Centre 2 arcuate intrusions indicating a subsurface, north-westerly extension to Centre 3 (see Glas Bheinn above for a description of the Faskadale intrusion).

Small, roughly circular masses of granophyre or felsite, unrelated to the major intrusions, occur in at least two localities with the site. A small mass of dark-grey, non-porphyritic felsite forms a rocky hill south of Aodainn and, on Beinn na Seilg, a shattered outcrop of pink granophyre is found between the Beinn nan Ord and Garbh-dhail quartz gabbros. Dykes do not

commonly cut the Centre 2 intrusions but several basic and a few acid examples are known. A thick (1.0–1.5 m) dyke of greenish, flow-banded spherulitic pitchstone outcrops on the shore at Ormsaigbeg and can be traced northwards for about 2 km, cutting the Hypersthene Gabbro, but terminating short of the quartz gabbros.

Interpretation

The sequence of arcuate intrusions and their intricate contact relationships in this area provide a valuable record of the development of Ardnamurchan, Centre 2. The results obtained by Richey and Thomas (1930), from their survey of the area, attracted international attention and rapidly became of outstanding importance as a demonstration of a ‘typical' ring-dyke complex. Parts of the area have been reinvestigated by later workers in the light of newly developed concepts in igneous petrology and, while solving some problems, have encountered more. For most of the area, however, no published later work has superseded that of Richey and Thomas and the majority of the problems that they recognized, but perforce had to leave unsolved, have not received the attention that they deserve. The research potential of the area must rank among the highest in Britain and this greatly augments the international value of the area as a ‘type locality' for a ring-dyke complex.

Two of the dominant intrusions in the site, the Hypersthene Gabbro and granophyric Quartz Dolerite of Sgurr nam Meann, have been reinvestigated more recently; the conclusions from some of these studies are discussed below.

The Hypersthene Gabbro is the earliest intrusion of Centre 2 and was initially considered to be a ring-dyke by Richey and Thomas (1930). Subsequent work by Wells (1954a) and Skelhorn and Elwell (1971) has shown that, although the contact between the gabbro and the country rocks is mostly outwardly dipping at moderate angles, in places it is demonstrably steep or flat-lying, or complicated by large xenoliths and stoped blocks of the host rock.Wells (1954a) considered the original overall shape to be an upwardly flaring cone with a domed roof, while Skelhorn and Elwell (1971) suggested a more boss-like form. Wells (1954a) concluded that the form of the intrusion, particularly its considerable width, bears little resemblance to a ring-dyke and was probably forcefully intruded. The layered structures in the Hypersthene Gabbro dip inwards and have a conical shape and, according to Wells, gravity accumulation of crystals in the lower part of the intrusion, which had a conical form, played a significant role. The steepening of the layering at the inner contacts of the intrusion was suggested bySkelhorn and Elwell (1971) to have resulted from the deformation of the roughly circular mass by ring faulting or gradual subsidence of a central block. Palaeomagnetic evidence supplied byWells and McRae (1969) suggests that if this hypothesis is accepted, then the deformation must have occurred before the rocks had cooled below their Curie temperature.Wells (1954a) also suggested that a quartz gabbro marginal facies to this intrusion crystallized from preHypersthene Gabbro magma which was driven towards the upper surface during the forceful intrusion of the Hypersthene Gabbro. The recent study of this intrusion byDay (1989) contains much new factual information and interpretations.

The Quartz Dolerite was recognized by Richey and Thomas (1930) as a ring-dyke, although they were aware of the extensive apophyses projecting from the main mass.Wells (1954b) described the mass as a "ring-dyke/sill intrusion'. Skelhorn and Elwell (1966) regarded Wells's hypothesis as one possibility but also presented three others: a sill connected to a ring-dyke or plug which is now replaced by a later intrusion; a ring-dyke with stepped contacts, the present erosion surface coinciding with a shallow step; or a marginal remnant of a ring-dyke cap formed above the block which subsided to allow the intrusion of the ring-dyke.Walker (1975) suggested that the mass may have been formed by successive laterally directed injections of magma into a ‘curved flange' fracture caused by the differential subsidence of the rocks adjoining the magma chamber. The form of the mass clearly requires further investigation as was pointed out by Black (in discussion, Skelhorn and Elwell, 1971) who noted in addition that the maps produced by the Survey, Wells (1954b) and Skelhorn and Elwell (1966) differ significantly owing to the use of differing criteria to identify the Quartz Dolerite. Earlier, Black (pers. comm.) demonstrated his view that the so-called ‘Quartz Dolerite' was in fact an igneous mélange of blocks of gabbro (shown on the maps of other workers), intrusions of various types of dolerite, and felsite emplaced along a partial ring-fracture which also served as a channel for gas fluxing.

The Granophyric Quartz Dolerite of Sgurr nam Meann demonstrates clearly the association of acid and basic magmas in the intrusions of Centre 2 and in the Ardnamurchan complex as a whole (Blake *et al*., 1965). Vogel (1982) has published a detailed petrological study of the acid–basic net-veined intrusion. It was observed that the basic aphyric and porphyritic components occur as pillow-like xenoliths, with cuspate and crenulate margins within the silicic rock and with chilling at many contacts indicative of 'liquid–liquid' relationships. Whole-rock chemistry indicates that magma mixing between basaltic and silicic liquids was a dominant process along with limited crystal fractionation. Vogel (1982) suggested that this net-veined complex presents a rare example of the interaction at a high level between mafic and silicic melts in the Ardnamurchan magma chamber before the silicic magma was lost to surface volcanism. It is a clear example showing that basic and acid magmas coexisted in a single intrusive body.

Conclusions

The Beinn na Seilg–Beinn nan Ord site is a classic key locality in the Ardnamurchan complex, showing the succession of arcuate intrusions associated with Centre 2. Although arcuate in overall outcrop, the various major intrusions do not all conform to the classic ring-dyke model and some show features unique within the Tertiary Province. Evidence for the coexistence of acid and basic melts and for magma mixing within the high-level Ardnamurchan magma chamber as well as crystal accumulation and fractionation processes is afforded by many of the intrusions, almost all of which are composite in nature.

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