Marsco and Mheall a' Mhaoil

OS Grid Reference: NG508252

Highlights

Segments of the narrow Marscoite Suite mixed-magma ring-dyke are excellently exposed on both sites. The Marsco site is the type site for the Marscoite Suite and provides key evidence from a variety of contacts for the relative ages of several of the superimposed granite intrusions forming the Western Red Hills centre.

Introduction

The Marsco and Mheall a' Mhaoil sites are dominated by various granite and felsite intrusions which belong to the Western Red Hills centre. The contact between the granitic intrusions and the Precambrian country rock is exposed in the Mheall a' Mhaoil site. However, both sites are of particular petrological importance because of the classic exposures of a composite, annular dyke-like intrusion within the granites containing ferrodiorite, felsite and hybrid rocks which are the product of magma mixing. These belong to the Marscoite Suite, the type locality for which is at Marsco. In addition, a gabbro forms the Marsco summit area.

Harker (1904) published the results of the first detailed survey of the central parts of Skye which included the Western Red Hills centre. He recognized the hybrid nature of some of the intrusions at Marsco, Glamaig and Mheall a' Mhaoil which he termed marscoites and glamaigites. Further detailed work in the area did not appear until that ofRichey *et al*. (1946) followed by Wager and Vincent (1962), Wager *et al*. (1965) and Thompson (1969). These studies led to the subdivision of the Western Red Hills centre into at least 12 separate acid intrusions and provided a detailed knowledge of the petrology of the Marscoite Suite. Further work by Bell (1983) and Vogel *et al*. (1984) confirmed the hybrid character of the suite. A recent synthesis covering the sites is contained in the Skye field guide ofBell and Harris (1986) and the 1:50 000 compilation map of the Skye intrusive centres (published by the Open University) is particularly useful.

The term epigranite was introduced by Wager *et al*. (1965) to distinguish the high-level granites of the British Tertiary Volcanic Province from other, deeper-level granites such as those of Caledonian age in Scotland. The granites are characteristically found as stocks and ring-dykes emplaced into brittle crust and their chemical compositions indicate equilibration at low-pressures, equivalent to one or two kilometres of cover. They are frequently drusy, or miarolitic, and the cavities indicate that a gas phase developed; they typically did not develop pegmatites. The rocks are, strictly speaking, alkali-feldspar granites, granites or alkali granites on Streckeisen's classification (1978). Although epigranite has been used widely in connection with the Skye granites, use of the term has not spread to the other centres in the Province and it is not used by Bell and Harris (1986). The term will not be used in this account.

Marsco

Granites and felsites form several distinct intrusions within the site (Fig.2.12; Wager *et al*., 1965; Thompson, 1969). These either have steep-sided, wall-like contacts or else their margins dip at low angles, suggesting roof-like relationships. The contacts are sometimes marked by zones of crushing and are frequently fine-grained and chilled (cf.Thompson, 1969, plate 17B). This, together with veining of one acid intrusion by another has enabled their relative ages to be established; the intrusive sequence within the Western Red Hills centre is summarized by J.D. Bell (1976) and by Bell and Harris (1986).

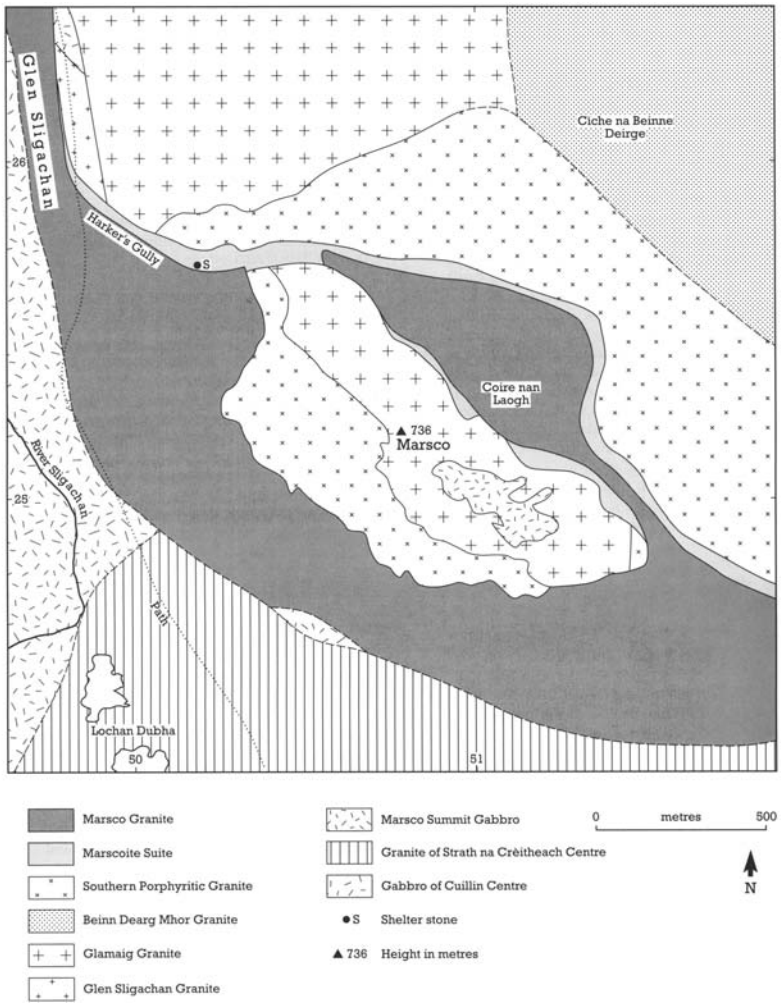

Figure 2.12: Geological map of the Marsco site (after Thompson, 1969, plate 18)

The sequence of intrusions within the site is as follows:

(Youngest) Marsco Granite
Marscoite Suite
Ferrodiorite core
Marscoite
Porphyritic Felsite (Southern Porphyritic Felsite)
Southern Porphyritic granite
Glamaig granite
Marsco Summit Gabbro

The intrusive sequence may be determined at various points on Marsco; the age relationships, and the varied types of igneous contacts present, are shown in cartoon form in Fig.2.13.

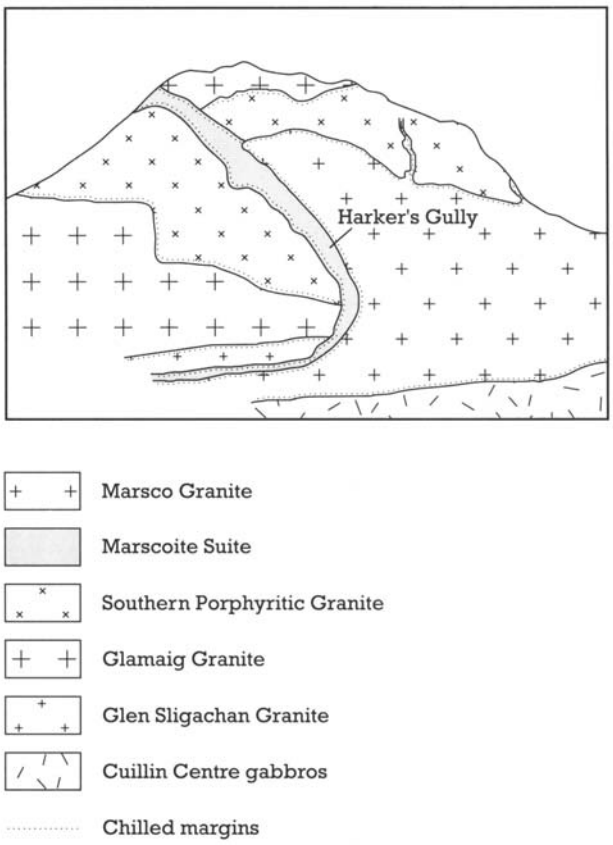

Figure 2.13: Sketch of the west side of Marsco, showing the relationships of the Marscoite Suite rocks to the granite intrusions (reproduced from Sutherland, 1982, fig. 29.5; after Brown, 1969, figure 13)

The Glamaig granite, which is exposed around the summit and northern slopes of Marsco, is the earliest of the acid intrusions in the Western Red Hills centre (Wager *et al.*, 1965). The rock is characteristically medium-grained, dull-grey in colour and contains both biotite and amphibole. A persistent feature is the presence of small (0.5–5 cm diameter), partly digested mafic inclusions which constitute about 5% of the rock. Less commonly, somewhat larger (up to 0.3 m diameter) rounded and lobate inclusions of felsitic rock also occur. About 1 km to the north-west of the site, this granite is in contact with crushed gabbros of the Cuillin centre. On Marsco it is capped by the Marsco Summit Gabbro, which is fine-grained where it comes into contact with the granite. The granite, however, also 'net veins' the gabbro and is contaminated for some distance away from the contact by partly digested xenoliths of gabbro. On the basis of these relationships, the Glamaig granite is considered to have been intruded before the Summit Gabbro was completely solidified. The Summit Gabbro is not cut by cone-sheets or dykes and is considered to be significantly younger than the Cuillin centre gabbros (Thompson, 1969).

The Southern Porphyritic granite is preserved as a steep intrusion on the northern slopes of Marsco whereas, in the Marsco summit area, it forms a flat-lying, wedge-shaped body below and chilled against the Glamaig granite; it overlies the younger Marsco granite which intrudes it. Both the upper and lower contacts of this body dip at low angles and are considered to be roof-like. The intrusion is a leucocratic granophyre carrying quartz and alkali-feldspar phenocrysts.

The rocks of the Marscoite Suite intrude the Glamaig and Southern Porphyritic granites as a discontinuous ring-dyke (Figs 2.12 and 2.13). In the site, the sheet is up to 50 m thick and is steeply inclined to the south. It normally consists of outer zones of porphyritic felsite (the Southern Porphyritic Felsite) and a core of ferrodiorite which are separated by zones of hybrid rock (marscoite). The Marscoite Suite rocks are distinctly younger than the Glamaig Granite with which they are in sharp, chilled contact in Glen Sligachan just north-west of the site. The contact with the Southern Porphyritic Granite, seen just north of Harker's Gully, is again sharp

but it is unchilled, suggesting that the marscoite is only slightly younger than the Southern Porphyritic Granite. The Marsco Granite intrudes the Marscoite Suite and breaks the symmetry of the latter in Harker's Gully, where it is in gradational contact with the ferrodiorite of the centre of the Marscoite Suite ring-dyke. The relationships of the several intrusions in and around Harker's Gully are shown diagrammatically in Fig. 2.13. Within the Marscoite Suite intrusion, near and above the Shelter Stone ("s' in Fig. 2.13), exposures on the east of the gully show marscoite in sharp, chilled contact with porphyritic felsite but the bulbous, crenulated contact indicates that the felsite was not consolidated when intruded by the marscoite as such a contact indicates liquid–liquid relationships. Inwards, over about 10 m, there is a complete gradation between the marscoite and the central ferrodiorite which was intruded and extensively mixed with marscoite before the former had consolidated.

The porphyritic felsite contains quartz and alkali-feldspar phenocrysts set in a fine-grained matrix; the phenocrysts are similar to those in the Southern Porphyritic Granite and the two intrusions are therefore considered to be related.

The marscoite is a fine-grained, grey rock containing xenocrysts of rounded andesine, orthoclase with embayed margins ("fingerprint' textures) and quartz rimmed by augite or amphibole. These minerals can be identified as phenocrysts in both the basic and acid rocks in the suite, suggesting that marscoite is a hybrid produced by the mingling of these contrasted types.

The ferrodiorite is variably porphyritic and non-porphyritic, having a fairly complex mineralogy consisting of andesine (as phenocrysts in the porphyritic variety), alkali-feldspar, quartz, hornblende, clinopyroxene (including inverted pigeonite), opaques, biotite and olivine (Wager and Vincent, 1962). Thompson (1969) noted the presence of quartz xenocrysts and concluded that the ferrodiorite, like marscoite, contains a component of felsite magma and that xenocrysts of alkali-feldspar have been dissolved during the slow cooling of the coarse ferrodiorite.

In the lower part of the Harker's Gully section, the later Marsco Granite has intruded along the southern margin of the ring-dyke and cut out the porphyritic felsite and marscoite members. However, the full symmetrical sequence is preserved above 500 m elevation. Within the ferrodiorites of the Marscoite Suite in Harker's gully, below the level of the Shelter Stone, there are blocks of banded quartz–oligoclase–biotite gneiss of possible Laxfordian age. Such occurrences are also found elsewhere, for example in Coire nam Bruadaran (NM 523 254), and are important in that they provide evidence as to the nature of the deep basement beneath central Skye.

The Marsco Granite is the youngest intrusion in the site. As mentioned, it has an unchilled, completely gradational contact with the ferrodiorite of the Marsoite Suite, but develops sharp, chilled roof-like contacts against the Southern Porphyritic Granite and Glamaig Granite (Thompson, 1969). The detailed mineralogy has been described by Thompson; of particular interest is the occurrence of fayalitic olivine and hedenbergite clinopyroxene as well as calciferous amphibole, indicating crystallization in an anhydrous magma with a high Fe/Mg ratio, at initially high-temperature.

Mheall a' Mhaoil

Within this site both early and late intrusions belonging to the Western Red Hills Centre are exposed (Fig. 2.14). These granophyres and felsites have arcuate outcrops with steep, outward dipping contacts and may be presumed to be ring-dyke in form. The principal intrusions within the site are:

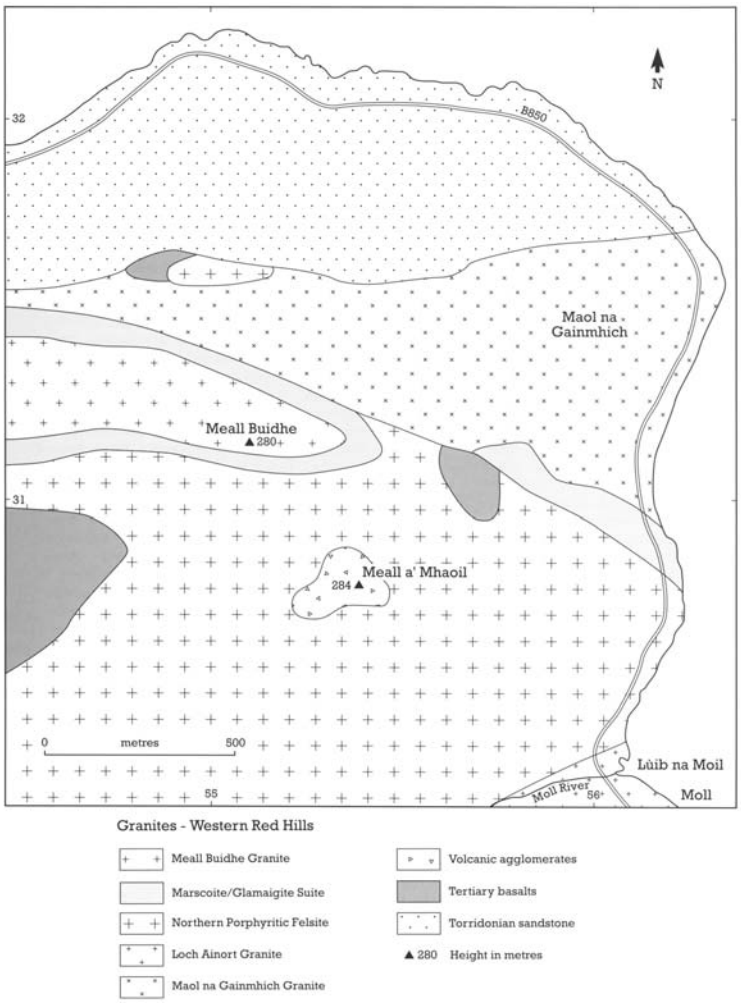

Figure 2.14: Geological map of the Mheall a' Mhaoil site (after Gass and Thorpe, 1976, fig. 6).

(Late) Meall Buidhe Granite
Northern Porphyritic Felsite
Marscoite – Glamaigite Hybrid Suite
Loch Ainort Granite
(Early) Maol na Gainmhich Granite

These intrusions are closely related to those of the Marsco site in the southern part of the Western Red Hills centre but differ in petrographic detail. In addition, subsidiary masses of vent agglomerate, crushed gabbro and basaltic lavas are preserved as screens within and between members of the complex.

The earliest Maol na Gainmhich Granite intrusion is in contact with Torridonian sandstones at Maol na Gainmhich and farther to the west. The contact is sharp and irregular in detail; a number of xenolithic masses of sandstone can be seen in granite exposures on the shore below the road. This is a coarse-grained, alkali granite containing arfvedsonite and a potassium-rich feldspar. It was formed early on in the evolution of the Western Red Hills centre although there is no direct evidence for its age relative to the early Glamaig Granite in the Marsco site. To the south, the granite is intruded by the later Northern Porphyritic Felsite, Meall Buidhe Granite and the Marsco–Glamaigite Hybrid Suite.

The intrusion of the large Loch Ainort Granite succeeded the Maol na Gainmhich Granite. In hand specimen, the Loch Ainort Granite is coarse grained with a blue-green to pink weathered surface. Its conspicuous, zoned, sodic feldspar phenocrysts are fringed by granophyric

intergrowths; the principal mafic phases, fayalite and ferro-hedenbergite, serve to distinguish it from the similar Beinn Dearg Mhor Granite exposed to the west. A crushed contact zone between the granites is exposed near Moll, and along the valley of the Moll River between Druim na Cleochd and Leathad Chrithinn to the south of the site.

The Northern Porphyritic Felsite crops out to the south of Meall Buidhe. It contains phenocrysts of quartz and potash feldspar with rarer pyroxene and iron oxide. Apart from the significantly greater volume of phenocrysts, this felsite is mineralogically very similar to the Southern Porphyritic Felsite in the Marsco site. Inclusions of fine-grained basalt lavas and vent agglomerate are found in the felsite to the west and north-east of Mheall a' Mhaoil. The basalts are undoubtedly derived from the earlier lavas, while the agglomerates may be remnants of early vents between and around which the granite was emplaced.

Following these granitic intrusions and before the emplacement of the Meall Buidhe Granite, the Marscoite–Glamaigite Suite of hybrid rocks was emplaced as a discontinuous, inclined sheet in the form of an incomplete ring-dyke. These composite hybrid intrusions are essentially the same as the Marscoite Suite rocks described from the Marsco type locality (Talisker), although there are some differences: instead of the ferrodiorite central member present at Marsco, the marscoite passes inwards into a rock with streaky, light-coloured areas in a darker matrix, or else shows acid net-veining of the darker component. These variants give way to a rock described as xenolithic granophyre by Harker (1904) but which Wager *et al*. (1965) termed glamaigite. Glamaigite consists of rounded, sometimes globular dark dioritic areas up to one centimetre in diameter set in a medium-grained microgranitic or granophyric matrix. The centre of the intrusion is a more homogeneous rock termed dioritic glamaigite (Wager *et al*., 1965). Three intrusions of the Marscoite–Glamaigite Suite were described by Wager *et al*. (1965); two of these areas of hybrid suite rocks are within the site, on the coast at Moll and on Meall Buidhe (Fig. 2.14).

The Meall Buidhe hybrid rocks are exposed on Meall Buidhe (NM 551 312) and extend to Abhainn Torra-mhichaig west of the A850 Portree–Broadford road to the west of the site. The Moll Shore intrusion is a small, steeply inclined dyke-like mass on the coast and is well exposed in the road cuttings to the south of Maol na Gainmich, where the contact with the Northern Porphyritic Felsite shows signs of crushing.

Some of the hybrid rocks in the Mheall a' Mhaoil site are very similar to the marscoites at the Marsco site and they contain xenocrysts of quartz, sodic plagioclase and alkali feldspar. However, in this site they are lighter coloured and coarser grained, and grade into a net-veined, heterogeneous mottled rock termed glamaigite. Glamaigite is chemically similar to, and contains xenoliths of, marscoite. The characteristic mottled appearance is enhanced by weathering. Both the typically rounded dark patches and the lighter-coloured matrix in which they lie contain identical xenocrysts of andesine, quartz and orthoclase and both components are marscoitic hybrid rocks with similar chemical characteristics. Rounded xenoliths and inclusions of hawaiitic affinity are also found within the glamaigites.

Detailed traverses across the hybrid bodies at Meall Buidhe and Moll are described by Wager *et al*. (1965). The Meall Buidhe traverse, however, is interrupted centrally by the intrusion of a later epigranite called the Meall Buidhe Granite. Its north-eastern and south-eastern contacts with glamaigite are gradational where contamination of the granite with basic material is observed. Contamination has resulted in the presence of plagioclase phenocrysts mantled by alkali feldspar. The matrix contains pyroxene and interstitial hornblende in a microgranitic, rather than a granophyric groundmass. The granite, in fact, bears a striking resemblance to the Marsco Granite, but analyses by Wager *et al*. show it to be more basic than either the Marsco Granite or any of the other granites in the Western Red Hills centre.

Wager *et al*. (1965) have recorded the following traverse across the summit of Meall Buidhe through a steep composite dyke containing the Marscoite–Glamaigite Suite.

North

1. Maol na Gainmhich Granite
2. Chilled marscoite
3. Glamaigite (streaky and net-veined in the north but more patchy in the south)
4. Transitional zone between glamaigite and Meall Buidhe Granite
5. Meall Buidhe Granite – basic in places
6. Gradational Meall Buidhe Granite – glamaigite boundary
7. Glamaigite (on Meall Buidhe summit)
8. Marscoite
9. Chilled marscoite
10. Northern Porphyritic Felsite

South

The contacts between the intrusive members appear to be very steep or vertical, in contrast to the composite hybrid intrusion on Marsco where the contacts are inclined outwards relative to the centre of the ring-shaped intrusion. This may signify a deeper level of erosion of the marscoite ring-dyke at this site when compared with Marsco.

Interpretation

Richey's classic model for the emplacement of high-level granites involved subsidence of a central block of country rock bounded by steep, outward-dipping, arcuate fractures, terminated upwards by a cross-fracture (Richey, 1928, Fig. 7). The model proposed that magma subsequently moved both up the arcuate fractures to form ring-dyke intrusions with steep, wall-like contacts, and across the bounding cross-fracture to produce a roof-like contact with the country rock. The Marsco site demonstrates both wall- and roof-like contacts (Fig.2.13). The former are well developed on either side of the Marscoite Suite which is a classic, if thin, example of a ring-dyke. Roof-like contacts are extremely well developed on the south-west face of Marsco above and below the Southern Porphyritic Granite. Richey's model involved the foundering of a detached block several kilometres in diameter, rather than piecemeal stoping. In this respect, it is significant that the contacts show remarkably few xenoliths either of country rock sediments (Mheall a' Mhaoill site) or earlier granite (Marsco site). Thus, the sites provide evidence strongly supportive of Richey's model, although this evidence does not prove that individual intrusions, with the exception of the Marscoite Suite, are true ring-dykes rather than a suite of nested granite stocks which become younger towards the centre of the complex.

Throughout the British Tertiary Volcanic Province there is compelling evidence that acid and basic magmas:

1. coexisted during much of the life of the central complexes and

2. that they were frequently intruded more or less contemporaneously.

The Marscoite Suite of Marsco and the Marscoite–Glamaigite Suite of Maol na Gainmhich furnish excellent examples of both magma mixing and hybridization, and of the nearly contemporaneous intrusion of contrasting acid and more basic magmas. At Marsco, the Southern Porphyritic Felsite, which contains distinctive quartz and alkali-feldspar phenocrysts, was intruded first and the ferrodiorite, with its equally distinctive plagioclase phenocrysts, came last to form the core of the Marscoite Suite ring-dyke. Between these two contrasted rocks there is the marscoite which contains as xenocrysts the same minerals that form the phenocrysts in its neighbours and, furthermore, chemical analysis shows that the bulk composition of the marscoite is intermediate between the compositions of the adjoining rocks.

Thus, the petrographic and chemical evidence shows that the marscoite is a mixed, hybrid rock (Wager *et al.*, 1965; Vogel *et al.*, 1984) and Bell (1983) has demonstrated that it consists of ferrodiorite and porphyritic felsite mixed in the proportions 74:26. Further evidence for mixing is provided in hand specimen by the emulsion-textured glamaigite of Mheall a' Mhaoil.

The contact relationships seen within the Marscoite Suite, and between these rocks and both the Southern Porphyritic Granite and the Marsco Granite, suggest that all were intruded in close succession: the Southern Porphyritic Felsite is in sharp but unchilled contact with the Southern Porphyritic Granite; within the Marscoite Suite the bulbous, crenulated contact between the Southern Porphyritic Felsite and the marscoite is interpreted to show that both were liquid at the same time; and the marscoite is completely gradational towards the ferrodiorite. On the ring-dyke inner contact, a similar gradation from ferrodiorite towards the Marsco Granite means that the granite intruded shortly after the Marscoite Suite. It is also evident (Fig. 2.13) that the granite exploited the ring-dyke structure during emplacement.

The Marscoite Suite thus abounds with igneous intrusive contacts showing a spectrum from those which are sharp and chilled to others which are completely gradational. From careful consideration of the contacts, it appears that the Marsco Summit Gabbro and the Glamaig Granite form an early group of intrusions and that the Southern Porphyritic Granite, the Marscoite Suite and the Marsco Granite are a later suite. Sufficient time must have elapsed between the emplacement of the Southern Porphyritic Granite and the Marsco Granite for the latter to develop a chilled contact.

Conclusions

The field relationships of the granites, Marscoite Suite intrusions and country rocks provide evidence which supports the classic ring-fracture, block subsidence model for granite emplacement proposed by Richey (1928). The sites also contain classic examples of rocks formed by magma mixing; the marscoite member of the Marscoite Suite resulted from an approximate 3:1 mixing between porphyritic magmas of ferrodioritic and granitic compositions. In the ferrodiorite end-member there is subtle evidence for the incorporation of a small amount of porphyritic acid material, and the common occurrence of small, basic inclusions in the early Glamaig Granite suggests that some basic magma was mixed in with acid magma prior to emplacement of this intrusion.

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