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# Cnoc Mor to Rubh' Ardalanish

[NM 367 186]–[NM 360 160]

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## Introduction

### The Ross of Mull pluton

The Ross of Mull pluton extends over an area of some 140 km<sup>2</sup>, much of which lies offshore, forming skerries along the eastern coast of Iona and the Torran Rocks (Cunningham-Craig *et al.*, 1911; Bailey and Anderson, 1925; Barber *et al.*, 1979). The pluton is mainly granitic, with a crudely concentric reverse zonation. Three discrete facies are identifiable within the land outcrop (on the basis of variations in biotite content), all with gradational internal contacts (Figure 8.10):

1. an outer non-porphyritic equigranular biotite granite, which is the most evolved part of the pluton; a xenolithic, two-mica contaminated variant forms small bodies along the pluton margin;
2. an inner pink K-feldspar-phyric biotite granite;
3. a heterogeneous hybridized variant of '2' that ranges from biotite granite to biotite granodiorite, and contains hybrid rocks and basic enclaves.

Little is known of the geology offshore, although the granites off eastern Iona and the Torran Rocks are similar to the outer facies.

The Ross of Mull granites have been quarried extensively in the past, particularly the outer non-porphyritic granite along the coast north of Fionnphort (Faithfull, 1995). The stone has been used for bridges, docks, lighthouses and other buildings throughout the world, as well as for ornamental stone. Notable examples include Ardnamurchan Lighthouse, Westminster Bridge, New York and Liverpool docks, Glasgow University, Manchester Town Hall and the Albert Memorial.

The granitic components are of high-K calc-alkaline affinity, and are mostly metaluminous to weakly peraluminous, with compositions in the range 67–78% SiO<sub>2</sub>. The rocks of the basic enclaves have SiO<sub>2</sub> contents of 45–55%, and have shoshonitic affinities. Halliday *et al.* (1979a) obtained a mineral/whole-rock Rb-Sr age of 414 ± 3 Ma from the outer biotite granite, that probably dates cooling rather than crystallization of the pluton.

The pluton is hosted mainly by metasedimentary rocks of the Moine Supergroup (Riley, 1966). These comprise the Assapol and Shiaba groups, thought to be lateral equivalents of the Glenfinnan and Morar groups of the mainland successions (Holdsworth *et al.*, 1987). Country rock xenoliths are present in all the facies and a relict stratigraphy is traceable through the pluton. To the west, the granite is in contact with low grade ?Upper Proterozoic metasedimentary rocks of the Iona Group. These overlie meta-igneous and metasedimentary rocks of the Archaean Lewisian Complex, with tectonically modified unconformity (Potts *et al.*, 1995).

The thermal overprint in the Moine rocks extends up to 3 km from the eastern margin of the pluton, but significant hornfelsing, marked by the incoming of andalusite, is found only within 500 m of the contact (Bailey and Anderson, 1925). Higher-grade assemblages containing fibrolite and sillimanite appear only at the pluton contact (Brearily, 1984). Regional metamorphic kyanite is metastable throughout much of the aureole (Bosworth, 1910; MacKenzie, 1949). Clough (in Bailey and Anderson, 1925) noted the occurrence of a small suite of hornfelsed microdioritic intrusions ('lamprophyres') close to the eastern margin, which pre-date granite emplacement. On Iona the aureole is generally less than 1 km wide.

Both the granite and the country rocks are cross-cut by a synplutonic suite of minor intrusions consisting of shoshonitic calc-alkaline lamprophyres (spessartite and kersantite) and porphyritic microgranodiorite. These intrusions are mostly sheets, with composite or multiple forms common. All are cut by, generally ESE-trending, camptonite and monchiquite dykes of Permian age (Beckinsale and Obradovich, 1973).

The Cnoc Mor to Rubh' Ardanish GCR site demonstrates the form and nature of the eastern contact of the Ross of Mull pluton. The site provides a traverse through the inner aureole and marginal contact zone of the pluton. Units that comprise the central part of the pluton are represented by the Knockvologan to Eilean a' Chalmain GCR site.

## Description

The Cnoc Mor to Rubh' Ardanish GCR site encompasses the coastal outcrops along the Ardanish peninsula on the southern coast of the Ross of Mull. Of special interest is the interaction of the granitic rocks with the Assapol Group country rocks during emplacement. Magmatic processing and assimilation of included metasedimentary material has resulted in a locally developed marginal hybrid granite. Here, enclaves and screens of Moine metasedimentary rocks are seen in various stages of incorporation into the host granite. Other notable features of the site are the aureole and the syn-plutonic intrusions. Three principle units are recognized within the site (Figure 8.11):

1. country rocks
2. marginal granite, with locally developed contaminated variant
3. inner porphyritic biotite granite

### Country rocks

To the east of Port Mor, the eastern margin of the granitic pluton is in contact with country rocks of the Assapol Striped and Banded Formation. These comprise variably interlayered beds of semipelite, psammite and minor pelite, with concordant ribs of calc-silicate rock. Both the metasedimentary rocks and the microdiorite intrusions within the envelope are hornfelsed.

In the former, regional tectonic fabrics and mineral assemblages are barely recognizable. Knots of sillimanite (up to several centimetres long) and/or small porphyroblasts of andalusite are prominent in semipelitic and pelitic lithologies. Small dark crystals of cordierite are ubiquitous, and cordierite also replaces biotite in the more micaceous psammitic lithologies. Regional metamorphic muscovite is generally absent from the metasedimentary rocks of the inner aureole, although andalusite and/or fibrolite may be replaced by a late white mica. Within the microdiorite sheets recrystallization is extensive, with hornblende overgrown and replaced by a new red biotite.

### Marginal granite

Of principal interest in this site is the occurrence of a zone of contamination, up to 200 m wide, along the eastern margin of the pluton. This contaminated variant forms most of the outcrop of the marginal granite exposed along the eastern side of the peninsula between A' Bhualaidh and Eilean Faoileann a' Chlachanaich. The non-contaminated granite parent is seen only in exposures on Cnoc Mor, as a pale-pink, coarse-grained, equigranular biotite granite. The contaminated granite variant is marked by a decrease over several tens of metres in the pink colouration of the parent granite. Outcrops are commonly crowded with country rock xenoliths showing all stages of assimilation into the host. The contaminated granite is unusually quartz-rich and contains abundant mesocrysts of red-brown biotite, which contain inclusions of zircon and zoned dark-cored apatite. Muscovite is present but is not a primary mineral. Pods and small masses of granite pegmatite are locally common. A large sheet of coarsely crystalline pegmatite at [NM 3677 1760], presents a fine example of macroscopic microcline perthite.

The contact with Moine rocks is essentially a sub-horizontal sheeted complex of interdigitating granite and country rock. The envelope is gradational over a few tens of metres, from country rocks containing granite sheets concordant with the prominent foliation, into granite with screens of metasedimentary rocks. The marginal granite carries abundant rafts, up to 250 m long [NM 364 172] and slab-like xenolithic blocks (Figure 8.12). An outcrop (at [NM 3673 1804]) contains enclaves in varying states of assimilation from little altered angular slabs to rounded enclaves. The latter are enclosed by a reaction corona of leucocratic granodiorite. Locally the contaminated granite contains a nebulous mica fabric or schlieren of biotite-rich restite. These schlieren typically wrap around included blocks. K-feldspar megacrysts are common in many partially assimilated enclaves. These overgrow both the relict metamorphic fabrics in the enclaves and

the contacts with the granite host.

Sheets of porphyritic microgranodiorite, generally dipping NW at 15–40°, cut all facies of the granite and country rocks. These irregular sheets, display necking and side-stepping typical of synplutonic minor intrusions (Figure 8.12).

### **Inner porphyritic biotite granite**

Much of the site on the Ardanish peninsula comprises a K-feldspar-phyrlic biotite granite facies. This component is generally a pink, coarse-grained biotite monzogranite, with abundant megacrysts, up to 5 cm long, of pink perthitic microcline. This is well exposed in low rounded outcrops of the Rubh' Ardanish area. The boundary of the porphyritic biotite granite with the marginal granite is generally transitional over several tens of metres. Mica schlieren are, however, recognizable within the outer facies at some distance from the main outcrop of contaminated marginal variant [NM 359 162]. On Bhualaidh, the contact with the marginal granite is sharp.

### **Interpretation**

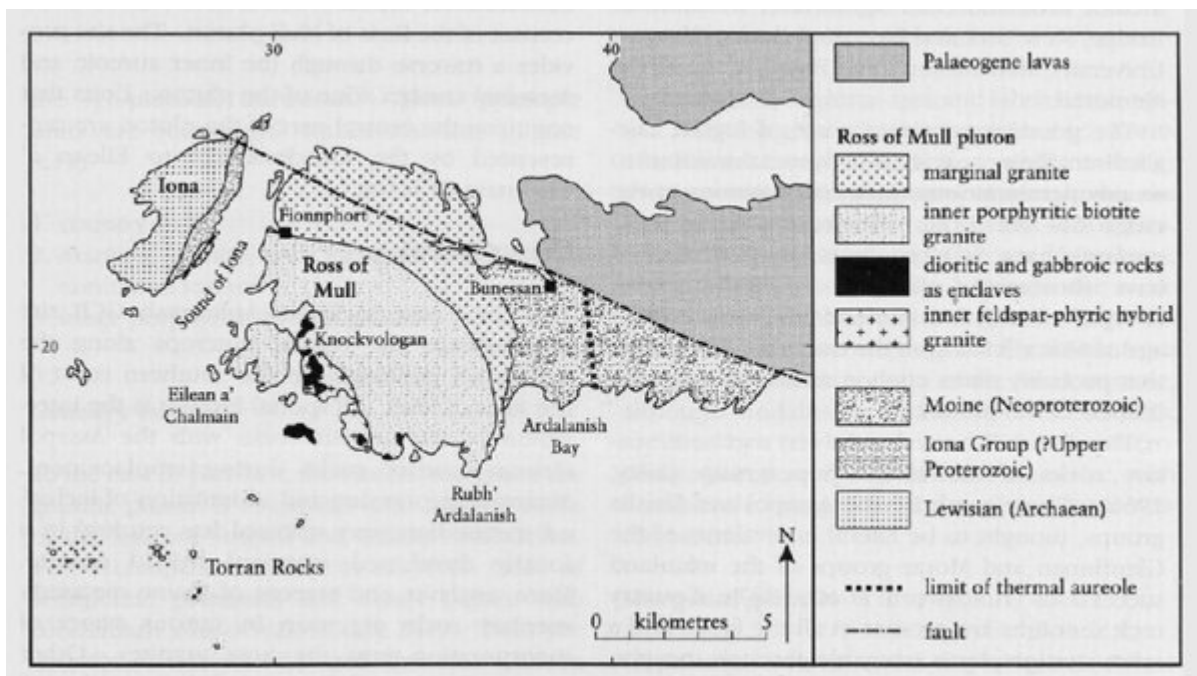
This eastern margin of the Ross of Mull pluton shows features typical of the transition zone between roof and wall in mid to upper crustal granite intrusions (Fowler *et al.*, 1995), which helps to explain the relatively wide thermal aureole. In section, the contact is low to moderately inclined to the east, and is irregular with brittle-looking metre-scale angular steps. Pre-existing regional deformational structures in the envelope do not appear to control the overall form of the contact, and are truncated mostly at a high angle. However, low-angled sheets have exploited foliation planes along much of the margin. Here country rock blocks are typically angular slabs with minimal rotation from their original orientation in the envelope. Away from this sheeted margin, included blocks of country rock are commonly separated by granite with locally prominent biotite-rich schlieren and banding. A tectonic origin for this mica fabric is unlikely. Evidence of strain-induced recrystallization or ductile thinning of beds within included material is absent. Further, the synplutonic minor intrusions cut across internal structures in the pluton, but close to the margin take on a stepped form similar to that of the contact. Thus, the schlieren more likely derive from incomplete processing and incorporation of envelope material during intrusion, resulting in a biotite-rich restite fabric within a hybrid. Hence the areas of contaminated hybrid granite preserve clues to part of the pluton emplacement mechanism.

The emplacement process along this eastern margin was probably initiated by wall rock assimilation, but gave way to penetration and stoping of the envelope. Deflection of the schlieren fabric around included blocks points to foundering of blocks from the roof into a partially crystalline granite hybrid. The transitional boundary into the porphyritic biotite granite points to relative homogenization in the main part of the magma body. Preservation of the contaminated marginal rocks may well be fortuitous, reflecting local ponding within an irregularity in the roof or wall.

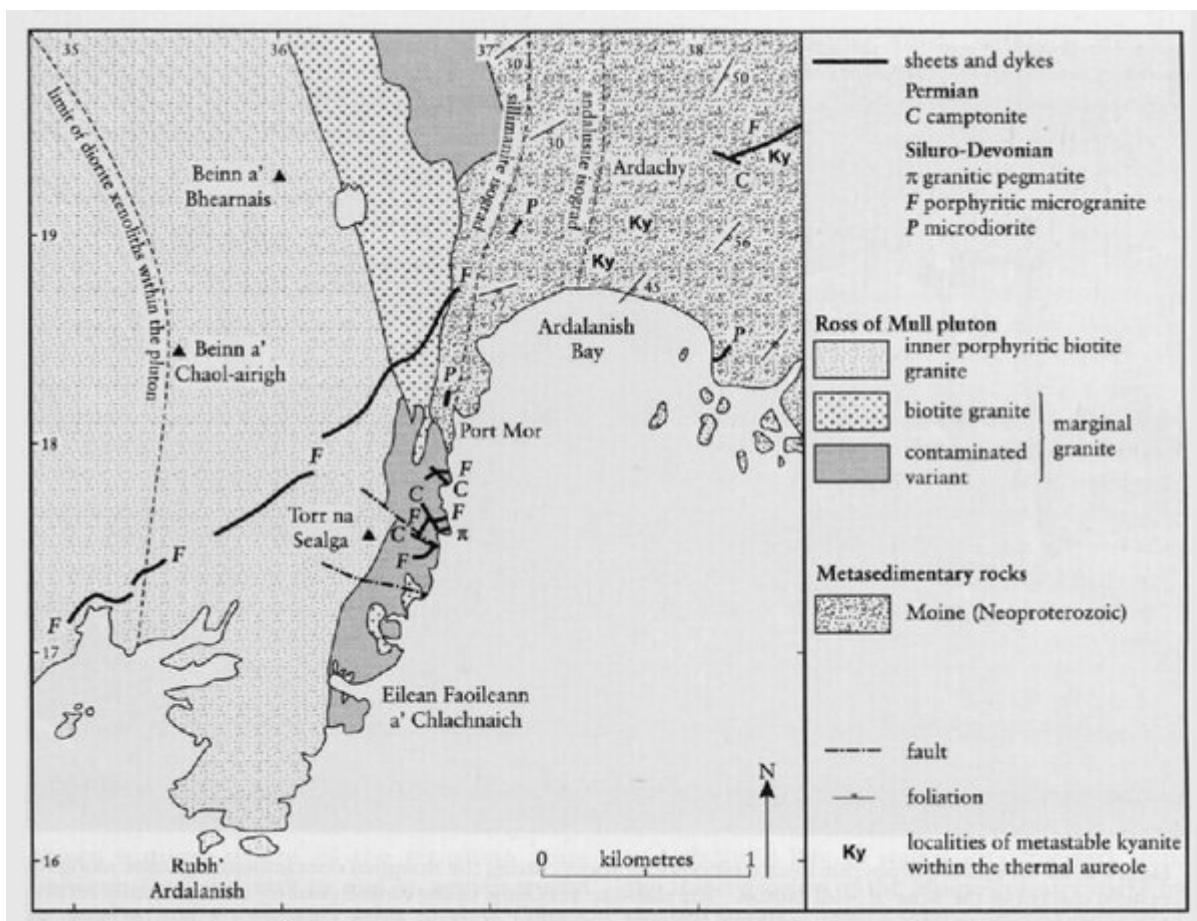
### **Conclusions**

This GCR site is of national importance as a representative of the Ross of Mull pluton, which provides one of the most definitive examples of passive emplacement with assimilation of country rock in the Caledonian plutonic suites. Within the coastal outcrops on the western side of Ardanish Bay, all stages are preserved, from the impregnation of the Moine country rocks by granite sheets, to the spalling off and sinking of slabs and blocks of country rock into the granite magma (stopping). Assimilation of metasedimentary material into the marginal granite resulted in the development of a contaminated hybrid granite, present at the pluton–country rock contact throughout most of the site. Localized ponding of fluids in the magma led to the crystallization of pegmatite. The complex sub-horizontal sheeted margin is unlikely to reflect the pluton form, but lies within the transition between the roof and wall of the intrusion.

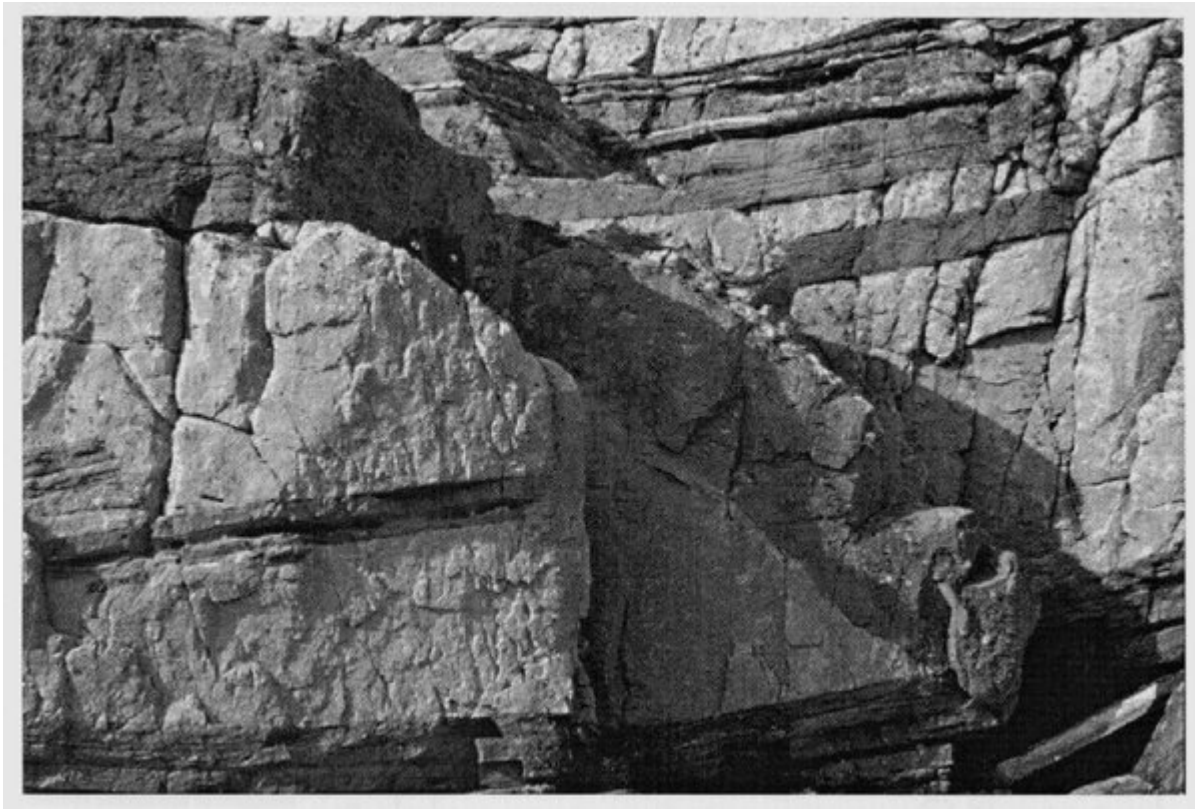
### **References**



(Figure 8.10) Map of the Ross of Mull pluton.



(Figure 8.11) Map of the area around the Cnoc Mor to Rubh' Ardalanish GCR site, Ross of Mull pluton, adapted from BGS 1:50 000 Sheet 43 and unpublished work, University of Liverpool.



*(Figure 8.12) Irregular porphyritic microgranodiorite sheet cutting the marginal contaminated granite along the eastern margin of the Ross of Mull pluton. The slab-like xenoliths of the Moine country rock generally retain a pre-emplacment attitude in this marginal sheeted complex. Carraig Mhor [NM 3678 1762]. (Photo: A.J. Highton.)*