

Glen Catacol

OS Grid Reference: NR905450

Highlights

The Northern Granite intrusions of Arran include a spectacular example of a diapir, uniquely well preserved in the British Tertiary Volcanic Province. The Dalradian country rocks have undergone extensive ductile deformation, with concentric folds formed around the granite. Excellent sharp intrusive contacts of the latter with the Dalradian are common within the site.

Introduction

The north-western part of the Northern Granite and adjoining updomed and metamorphosed Dalradian metasediments lie within this site, which includes the glacially eroded and deepened Glen Catacol and much of the higher ground of the Bheinn Bharrain-Meall nan Damh ridge. Two distinct biotite granites comprise the Northern Granite, a coarse-grained Outer Granite often in chilled, intrusive contact with the Dalradian, and a younger fine-grained Inner Granite which has sharp intrusive contacts towards the Outer Granite. The Outer Granite forms the spectacular mountainous scenery of northern Arran (Fig. 6.1), whereas the Inner Granite is less resistant to weathering and is characterized by lower, more rounded hills. Granite–granite and granite–metasediment contacts are generally steep, a feature well displayed within the site which has over 700 m of relief. Post- and pre-granite basaltic dykes and post-granite felsitic dykes also occur throughout the site.



Figure 6.1: The Northern Granite Mountains of north Arran. Cir Mhor, Arran. (Photo: C.H. Emeleus.)

Early investigations on the Northern Granite (MacCulloch, 1819; Ramsay, 1841; Zirkel, 1871; Smith, 1896) were succeeded by those of the Geological Survey with the publication by Gunn (1903) and Tyrrell (1928) of the standard works on the geology of Arran. The form of the Northern Granite was considered by Bailey (1926) and subsequent work by Flett (1942) detailed the nature of the contact between the coarse- and fine-grained granites. More recently, the structures associated with the intrusion of the granite have received detailed attention from Woodcock and Underhill (1987) who have produced a new model for the high-level emplacement of the pluton; this topic has been further pursued by England (1988a, 1990).

Description

The Outer Granite is a coarse-grained rock dominated by quartz and alkali feldspar accompanied by minor amounts of plagioclase and biotite. It is well exposed in the mountainous areas of the site and in the lower reaches of the River Catacol. Coarse granite, with characteristic rough weathering and widely spaced, subhorizontal and subvertical joint sets, is well-exposed on Meall nan Leac Sleamhuinn (NR 916 479), Madadh Lounie (NR 925 487) and Creag na h-Iolaire (NR 926 475) in close proximity to Dalradian country rocks (Fig. 6.4). The strong jointing, which often parallels the valley floors and sides, has been attributed to the unloading effects during the weathering of the granite. The Inner Granite has a similar mineralogy to the Outer Granite but is much finer grained and is frequently conspicuously drusy; the small cavities become especially numerous near the contacts with the earlier Outer Granite. The Inner Granite is occasionally granophyric, as at the confluence of the Allt nan Calman (NR 918 454). The intrusive relationship of the Inner Granite towards the Outer Granite has been well documented by Flett (1942). Intrusive contacts are exposed close to the confluence of the Diomhan and Catacol rivers (c. NR 923 469) on the south-east side of Meall nan Damh, in the col between that hill and Mheall Bhig, where thin sheets and veins of fine-grained granite cut the Outer Granite, and some 3 km south of Glas Choirein. The contacts are generally steeply dipping, with the Inner Granite passing under the Outer Granite.

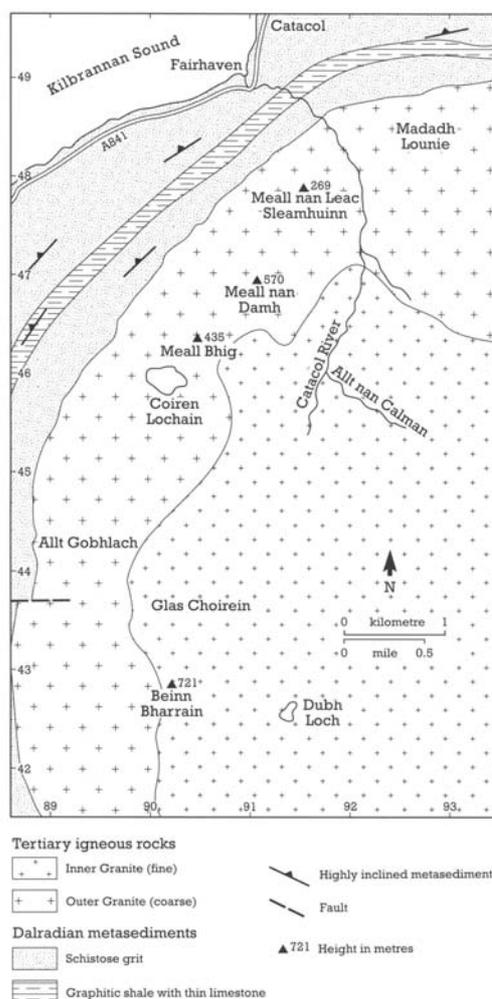


Figure 6.4: Geological map of the Glen Catacol site (adapted from the British Geological Survey 1:50 000 Special District Sheet, Arran)

Accessory minerals are fairly rare in both granites; they include magnetite, apatite, zircon and fluorite. However, both granites are noted for the variety of well-crystallized minerals lining the drusy cavities, which include feldspar, dark mica, quartz (clear, amethystine and Cairngorm varieties), pale blue to yellowish topaz and blue-green beryl.

Immediately to the north of Loch Tanna, fine-grained Inner Granite exposed in the river bed is slightly variable in grain size. Thin aplite veins and sheets are common in both granites and examples may be seen cutting the Outer Granite to the north-east of Meall nan Leac-Sleamhuinn (NR 915 478).

Dalradian metasediments crop out in the northern and western parts of the site in contact with the Outer Granite and provide important evidence that the granite was emplaced diapirically. The metasediments vary from coarse conglomerates to greenish-grey phyllites, arenaceous schists and dark slates. An impure schistose limestone associated with dark-grey graphitic slates is intermittently exposed between Pirnmill and Catacol. Details of the stratigraphy of these rocks are given by Anderson (1945), a summary of which appears in Macgregor (1965). The metasediments have been subdivided into:

- a. North Sannox Grits (6 subdivisions), and
- b. Loch Ranza Slates.

The Loch Ranza Slates occupy the core of the Loch Ranza Anticline, which is thought to be coincident with the Aberfoyle Anticline (also see Johnston, in Craig, 1965) and lies within the Barrovian chlorite zone. The Catacol synform to the north-east, on the other hand, has resulted from the deformation of the Dalradian rocks by the forcible emplacement of the granite and the steeply inclined Dalradian metasediments are frequently deflected into parallelism with the granite contacts.

Within 50–100 m of the granite, the Dalradian rocks become almost vertical in attitude and are often seen to have been considerably metamorphosed thermally, with resultant overprinting of their cleavage. At Fairhaven, Madadh Lounie, on the Allt Gobhlach and along the coast to the west of the site, the schists provide evidence for the updoming effects of the granite and dip north-westwards away from the granite, with minor folding parallel to strike of the contact. On the east side of Glen Catacol at Madadh Lounie, fine-grained Outer Granite is in sharp contact with schists in the prominent spurs along the cliff face. Dark schists are thermally altered in a zone of about 75 m at the contact and they take on a bluish hue. Occasionally, fine-grained veins and offshoots of granite penetrate the country rock and blocks of Dalradian, probably detached by stoping, are sometimes completely engulfed by granite (McKerrow and Atkins, 1985). In the Allt Gobhach (at NR 885 439) granite is in steep contact with indurated quartzose schists and the metasediments within a few metres of the granite have developed epidote, biotite, cordierite and andalusite. West of Glen Catacol, the contact of granite and schist is well exposed on the northern side of Meall nan Leac Sleamhuinn (NR 913 483) where the marginal granite contains several metasedimentary xenoliths.

Minor intrusions, widely scattered throughout the site, include basic dykes which were intruded before and after the emplacement of the Northern Granite. A good example of a pre-granite dyke is seen near to the granite contact in the stream issuing from Lochan a'Mhill (NR 916 486). It has been substantially baked and the original clinopyroxene has been replaced by hornblende and accessory biotite (Gunn, 1903). Basaltic dykes intrusive into both varieties of granite trend NW–SE and can be observed in the Catacol River, some of its tributaries and along the better-exposed parts of Beinn Bharrain (NR 898 423). Felsitic dykes are less common but do intrude both granites, and examples occur near to the basic dyke at Lochan a'Mhill (NR 916 486) and within the granite of Glen Catacol. A small pitchstone sheet cuts the Inner Granite 500 m north-west of Loch Dubh (NR 908 428). It appears that the majority of acid dykes within the granite are younger than the basic dykes.

Interpretation

The Northern Granite is the most spectacular pre-central complex granite pluton in the British Tertiary Volcanic Province and is thus a very significant feature in the geology of Arran. The site is chosen in preference to the more scenically spectacular eastern part of the mass because both granites, numerous minor intrusions and granite contacts with upturned Dalradian metasediments, are exposed to advantage here. The area around Catacol provides a clear demonstration of the local tectonics associated with the diapiric emplacement of the pluton, such as the pronounced updoming of the Dalradian country rock and accompanying

annular Catacol synform. The intrusion has a cylindrical, plug-like form with outwardly dipping steep margins. Its margins have unusual characteristics for an intrusion of this size (McKerrow and Atkins, 1985): features such as the limited, sometimes very narrow thermal aureole, the poorly developed or absent chilled margin, a general absence of veins of late-stage residua in the country rock and the total lack of mineralization in the country rock. These features and the presence of many faults on the eastern side of the intrusion which downthrow away from it, suggest that the final emplacement of the diapir occurred when the granite was nearly solid. The diapir therefore caused brittle and ductile deformation in the country rock and was too cool and too 'dry' to effect substantial thermal metamorphism and mineralization in the country rock. However, the contacts in the Catacol area differ from this overall interpretation in that the junction is highly irregular and the veining of the country rock, together with evidence for stoping, suggest that here at least the granite was still at, or near to, liquidus temperatures when it was emplaced. An alternative model for the emplacement of the pluton has been suggested by Woodcock and Underhill (1987), based on detailed investigations of the deformation of the country rock. A two-stage ballooning model is suggested, following the arrest of the uprising pluton at the Dalradian–New Red Sandstone unconformity (exposed on the eastern side of the pluton). Initially the arrested pluton steadily inflated, causing radial stretching and normal faulting. This was followed by continued ballooning of the pluton, resulting in updoming of the country rocks, with further upwards and outwards movement following the intrusion of the Inner Granite. This model, however, does not explain the unusual contact features discussed above, in particular the irregular veining of the Dalradian rocks and the evidence for stoping. England (1990) contends that the Outer Granite has most of the characteristics of a diapir and some of a ballooning pluton.

Walker (1975) considered that the emplacement of granite diapirs preceded the development of all of the BTVP central complexes, that of Arran being the only one which is fully exposed for study. He envisaged a sequence of events, starting with emplacement of hot, basaltic magma into the base of the crust. This gave rise to low-density acid magma which rose as a diapir, closely followed by basalt channelled into a magma trap below the diapir. The diapir was augmented by new magma formed by fractionation of the basalt, by partial melting of crustal rocks or, most probably, a combination of the two (see 'Introduction', Chapter 1). In the brittle, upper crust, the country rocks were deformed by folding and faulting and later events included the formation of cone-sheet swarms and 'confluent cone-sheet type' bodies of gabbro beneath the diapirs (Walker, 1975, figs 5 and 6). Basalt eventually broke through the diapir to form ring-dykes of gabbro which may be so numerous as to obliterate much of the evidence for the original diapir (for example, Mull, Skye). In north Arran the later stages did not develop, and in this area there are relatively few basaltic intrusions which post-date the granites, although the gravity data suggest that there is underlying, dense (gabbroic) rock (Tuson, 1959).

The sharp, steep contacts of the Inner Granite with completely undeformed coarse Outer Granite suggest that the later Inner Granite was emplaced in a permissive manner by ring-faulting and block subsidence.

Conclusions

The Outer Granite of the Northern Granite of Arran is the most spectacular diapiric intrusion of granite in the British Tertiary Volcanic Province. Intrusion of the Outer Granite has deformed the country rocks, causing them to develop steep, radial dips off the intrusions and also to become folded parallel to the granite contact. The granite probably moved upwards as a nearly solid body in the final stages, although some mobile granite magma did remain and formed veins in the country rocks. The Inner Granite was intruded without any deformation of the earlier, coarse-grained, Outer Granite.

Reference list

- Anderson, J.G.C. (1945) The Dalradian rocks of Arran. *Transactions of the Geological Society of Glasgow*, **20**, 264–86.
Bailey, E.B. (1926) Domes in Scotland and South Africa: Arran and Vredefort. *Geological Magazine*, **63**, 481–95.

- Craig, G.Y. (1965) *The Geology of Scotland*, 1st edn, Oliver and Boyd, Edinburgh, 556 pp.
- England, R.W. (1988) The ascent and emplacement of granitic magmas: the Northern Arran Granite. Unpublished Ph.D. Thesis, University of Durham.
- England, R.W. (1990) The identification of granite diapirs. *Journal of the Geological Society of London*, **147**, 931–4.
- Flett, W.R. (1942) The contact between the granites of North Arran. *Transactions of the Geological Society of Glasgow*, **20**, 180–204.
- Gunn, W. (1903) *The Geology of North Arran, South Bute and the Cumbraes, with Parts of Ayrshire and Kintyre*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.
- MacCulloch, J. (1819) *A Description of the Western Islands of Scotland including the Isle of Man. Comprising an account of their Geological Structure, with Remarks on their Agriculture, Scene y, and Antiquities*. 3 vols, Hurst Robinson, London.
- Macgregor, M. (1965) *Excursion Guide to the Geology of Arran*. Geological Society of Glasgow, Glasgow, 192 pp.
- McKerrow, W.S. and Atkins, F.B. (1985) *Isle of Arran: a Field Guide for Students of Geology*. Geologists' Association guide, 96 pp.
- Ramsay, A.C. (1841) *The Geology of the Island of Arran from Original Survey*. Glasgow, 78 pp.
- Smith, J. (1896) A new view of the Arran granite mountains. *Transactions of the Geological Society of Glasgow*, **10**, 216–56.
- Tuson, J. (1959) A geophysical investigation of the Tertiary volcanic districts of western Scotland. Unpublished Ph.D. Thesis, University of Durham.
- Tyrrell, G.W. (1928) *The Geology of Arran*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.
- Walker, G.P.L. (1975) A new concept of the evolution of the British Tertiary intrusive centres. *Journal of the Geological Society of London*, **131**, 121–41,
- Woodcock, N.H. and Underhill, J.R. (1987) Emplacement-related fault patterns around the Northern Granite, Arran, Scotland. *Geological Society of America Bulletin*, 515–27.
- Zirkel, F. (1871) Geologische Skizzen von der Westküste Schottlands. *Zeitskrifte Deutsches Geologisches Gesellschaft*, **23**, 1–124.