Newer Granites, Younger Caledonian igneous rocks, Northern Highlands of Scotland

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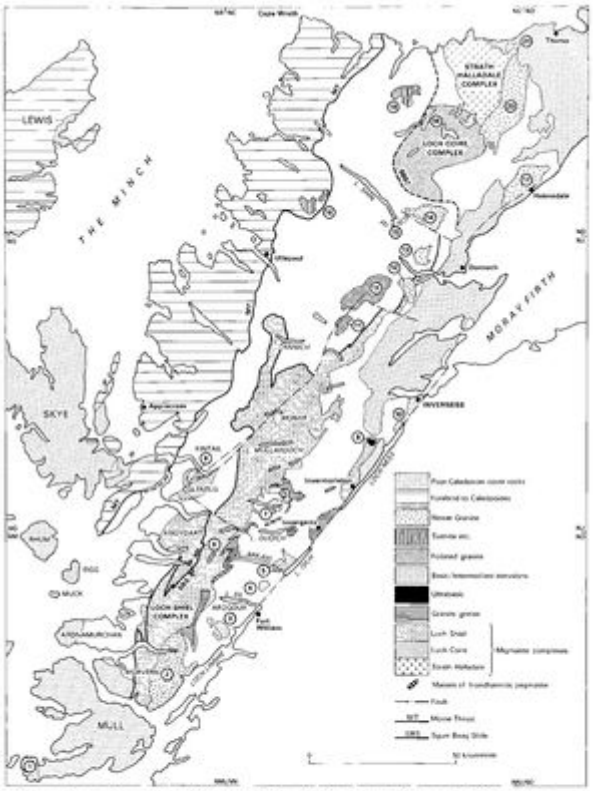
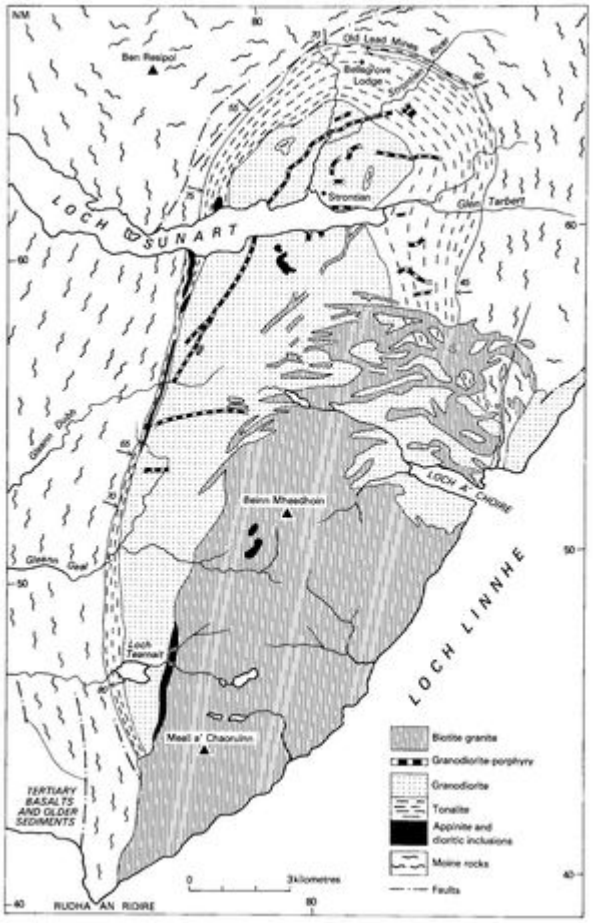
Newer Granites, introduction



Major intrusions, granite gneiss and migmatites within the Caledonides of the Northern Highlands. P915476.



Map of the Strontian Complex. P915482.

The Newer Granites of the Scottish Highlands (P915476) comprise a group of major plutons and some smaller masses, all intruded later than the main metamorphic recrystallisation and deformation of the surrounding schist, but earlier than the deposition of the Middle Old Red Sandstone. Most of the Northern Highland granites were emplaced during late Ordovician and Silurian times (c.440–400 Ma). Nearly all appear to belong to the class referred to by Read (1963) as 'Forceful Granites', which were emplaced by pushing aside their enclosing schists, although in some cases (e.g. the Ross of Mull Granite) this process may have been accompanied by magmatic stoping. Lack of metamorphic aureoles, the plastic deformation of their envelopes, and the metamorphosed state of the minor intrusions which cut them indicate that most of these masses were formed at a time when regional temperatures, although much declined from the metamorphic maximum, were still elevated (Watson, 1964; D. I. Smith, 1979). Although commonly referred to as 'granites' the rocks are usually mainly granodiorites, adamellites or even diorites, and comprise a calcalkaline suite ranging from appinite through basic diorite to granite; several of the larger intrusions contain the complete range of these compositions. The larger complexes show distension of the schist envelope and deformation of the outer, earlier, zones of the intrusion by continued growth of the inner components. The peripheral intrusion may show a foliation of its mineral constituents which parallels both the margin of the intrusion and the deflected strike of the surrounding schists. Where the rocks form intrusive complexes, the more basic intrusions are usually the older; however, the later rocks do not, in general, chill *Younger Caledonian igneous rocks* 107 against earlier ones. Only the major Newer Granite masses will be discussed below.

Helmsdale Granite

This large intrusion (98 km^2) is apparently a steep-sided or stock-like mass in which coarse porphyritic adamellite (with phenocrysts up to about 35 mm across) forms an outer zone, with a pink fine-grained non-porphyritic variety of adamellite making up the central area (Read and others, 1925). The body is in part unconformably overlain by rocks of Lower Old Red Sandstone age, and the rocks above the unconformity are enriched in uranium-bearing minerals in places; these have provided a target for economic investigations (Gallagher and others, 1971).

Rogart Intrusion

This intrusion (70 km^2) has been described most recently by Soper (1963). It is a funnel-shaped granodioritic complex surrounded by a zone of contact migmatites, the generation of which is related to the formation of the complex itself. According to Soper's interpretation, a front of migmatitisation preceded the uprise of the granodiorite magma to a level where migmatite formation ceased, while the igneous magma continued to expand forcefully upwards, displacing its plastic envelope.

The granodiorite complex comprises three elements, an outer tonalite, a middle hornblende-biotite granodiorite and an inner adamellite and biotite granite. Foliation and lineation are prominent in the tonalite but decrease inward, although they are still sufficient to show the general concentric disposition of the intrusions and the funnel-shape of the complex. The last intrusion, the biotite granodiorite, cuts across the junctions of the earlier components. Large masses of appinite are found both in the granodiorite and the biotite granite, apparently as rafts of an earlier intrusion. These now form varying degrees of hybrid rocks similar to those of Ach'Uaine type (see p.114).

The migmatites of the complex (but not the granodiorite core) are unconformably overlain by sediments of Lower and Middle Old Red Sandstone age. The south-west margin of the complex is

limited by the Strath Fleet Fault, which, as it cuts across the various components, renders the present outcrop asymmetrical.

Cluanie Intrusion

The Cluanie Intrusion (18 km^2) also shows displacement of its envelope, with the strike and dip of the Moine rocks conforming to the attitude of the igneous contact (Leedlal, 1952). Only one rock type is present, a variably porphyritic hornblende- biotite granodiorite within which can be mapped several textural variants of the same rock type. The phenocrysts of oscillatory-zoned microcline-perthite are frequently megacrysts measuring up to 5 cm across and, by concentration of these, the rock in bulk can vary from tonalite to adamellite. In places, where the phenocrysts are abundant, their concentration defines a crude flow-structure.

The pluton is cut by many dykes of the Microdiorite Suite (p.113) while veins of Cluanie granodiorite cut a suite of felsic porphyrites which, although similar in character to the main swarm, must have been emplaced earlier. 108 *The Northern Highlands*

Ratagain Complex

The Ratagain Complex (18 km^2) is unusual for the Northern Highlands in several respects. Its rocks range from minor ultrabasics through major constituents of diorite, granodiorite and monzonite to adamellite. It is emplaced so near the outcrop of the Moine Thrust as to suggest that its base has been controlled by the Thrust; perhaps the intrusion was initiated along the thrust (Tuson *in* Beckinsale and Obradovich, 1973), or else it was transported *en masse* by the later movements along the thrust plane. In this respect it resembles the Ross of Mull granite (p.110) and the syenitic intrusions of Assynt (p.102). It also lies in contact with Lewisian gneisses, which themselves overlie the Moine Thrust.

The sequence of intrusion differs from that commonly found in Caledonian plutons in that the rocks of the main complex, including the more basic diorites, cut an early intrusion of granodiorite (Nicholls, 1951). Berridge (BGS, unpublished report) substantially confirmed Nicholls' work and noted granodiorite, diorite, monzonite and adamellite (emplaced in that order) showing a progressive migration of the intrusive centre to the north-east. None of contacts is chilled, and all four major rock types are, at least in part, modified by hybridisation with the preceding members. From observations of internal foliations Berridge inferred that the intrusion is not a laccolith, as Nicholls thought, but, at this level of exposure, is steep-walled. (Note, however, the inference concerning the base of the intrusion referred to above.) Berridge also considered that the 'appinitic', basic and ultrabasic xenoliths in the mass are probably altered inclusions of melanic hornblendic rocks of Lewisian origin.

South of Loch Duich (and probably under it) the Ratagain Complex is truncated by the Strathconon Fault. A granitic body in Glen Lichd on the other (SE) side of the fault may be a displaced part of the mass. The complex is apparently the centre of an intrusive swarm of dykes (see p.116).

Strontian Complex

This intrusion (200 km^2) is the largest of the Newer Granites of the Northern Highlands (P915476, P915482); it is truncated on its south-east margin by the Great Glen Fault. As its components resemble those of the Foyers Complex (100 km to the north-east on the other side of the Great Glen Fault), which is correspondingly truncated on its north-west side, it had seemed possible that the two complexes were displaced parts of the same intrusion (Kennedy, 1946). This correlation now

seems to be less likely (see p.175).

Like the Rogart Complex, the Strontian pluton is a composite body (MacGregor and Kennedy, 1932; Sabine, 1963) with an outer foliated tonalite grading inwards to a non-foliated porphyritic granodiorite. During emplacement the magma of the pluton compressed and displaced its envelope of schists, the foliation of which now follows the periphery of the complex round its semicircular outcrop. As at Rogart, the schists were evidently at temperatures which permitted this plastic deformation. The foliation in the outer tonalite likewise follows the contact of schists and pluton, and has been attributed (Munro, 1965) to compression of a partly crystalline outer intrusion during continued emplacement of an inner body. Both tonalite and granodiorite are cut by a later, passively intruded biotite granite (adamellite) which did not compress the earlier intrusions. The granite is apparently stock-like, but with a vein-complex in the north and east which penetrates both the earlier intrusions and the schist envelope.

Unlike the Rogart Complex, no extensive zone of contact migmatite is developed but, like it, the Strontian Complex has apparently expanded upwards into a rather hammer-headed shape, asymmetric by protrusion to the north (Munro, 1965). Because of this the present outcrop of the foliated tonalite is widest in the north and east.

Appinitic and dioritic rocks form large intrusions — up to 4 km long — within all components of the Strontian Complex, but they do not form hybrids to the same extent as at Rogart.

Ross of Mull Granite

The Ross of Mull intrusion (52 km^2) comprises a coarse-grained muscovitebiotite granite which contains small outcrops of an earlier quartz diorite in the southwestern sector. The granite is a handsome pink-coloured rock, in which the jointing is quite widely spaced in places. It has been quarried and extensively used as a building stone. The intrusion is described in Bailey and Anderson (1925), largely following the work of Bosworth (1910).

The intrusion is wedge-shaped, thickening to the west (Tuson, *in* Beckinsale and Obradovich, 1973), with its base dipping eastwards at c.30° from the east shore of Iona. Beckinsale and Obradovich produced a K-Ar age of about 420 Ma for the intrusion, and pointed out that this implied both that the Moine Thrust was formed prior to that data and that it has not moved since. The granite may have been intruded along the plane of the Moine Thrust, which is generally taken as running between the island of Iona (Lewisian and Torridonian rocks) and the Ross of Mull (Moine rocks). Although the granite is never seen actually in contact with the Torridonian of Iona, Torridonian outcrop are seen in skerries only a few tens of metres offshore, and both Torridonian and Lewisian rocks show effects of contact alteration by the intrusion.

The Moine rocks (psammites of presumed Morar Division and mixed schists of the Glenfinnan Division) adjoining the upper surface of the granite have a thermal aureole (in part a contact migmatite) about 500 m wide. Within the granite, again mainly in the south-west part of the outcrop, there are small rafts and xenoliths of hornfelsed schists, apparently little displaced from their normal structural position. The thermal aureole has provided a classic site for the study of aluminosilicate polymorphs where kyanite-bearing regionally migmatised schists enter within the zone of contact metamorphism (MacKenzie, 1949).

The Ross of Mull intrusion cuts, and is itself cut by, members of the Microdiorite Suite (see below). It is also cut by Permo-Carboniferous dykes, for which Beckinsale and Obradovich obtained an age of c.275 Ma.

Other granites

The granites of Migdale (near Bonar Bridge) and Fearn (just south of the Kyle of Sutherland) are fairly uniform adamellitic or monzonitic masses rather than complexes. They consist of granite, pegmatite and microgranite, and have extensive areas of contact migmatite. The Fearn Granite shows extensive deep weathering in places.

The Grudie Granite to the south of Loch Shin is a small adamellitic mass with some associated veining. It appears to have been the locus of fairly widespread base-metal sulphide mineralisation, and molybdenite is unusually common (Gallagher and others, 1974). The small Abriachan Granite (on the north-west side of Loch Ness) is affected by fenite-type metasomatism which Deans and others (1971) relate to a possible carbonatite developed in depth along the line of the Great Glen Fault. Secondary 'abriachanite' (blue crocidolite), aegirine and hematite have been deposited along joints in this granite, and elsewhere in the region between Loch Ness and the Beauly Firth.

Reay Intrusion

The small intrusion at Reay in Caithness varies in composition from quartz diorite to granodiorite (McCourt, 1980). It has a strong foliation parallel to the margin along its north-west boundary, but this decreases away from the contact. It cuts the foliation of the schists and also the white granite phase of the Strath Halladale migmatite (p.90). A small separate stock is cross-cut by veins related to the main Strath Halladale granite.

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