

# Late- to post-tectonic minor intrusions, Caledonian magmatism, Grampian Highlands

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## Late- to post-tectonic minor intrusions

The Caledonian minor intrusions of the Grampian Highlands include plugs, sheets, and, more particularly, dykes. They can be divided into three geochemically distinct suites:

1. appinites and calc-alkaline lamprophyres—most abundant in Appin and Lorn, but extending through Lochaber to the East Grampians
1. microdiorites—widespread throughout the Grampian Highlands
1. felsites and quartz-feldspar-porphyrries.

Appinites from Garabal Hill, Arrochar and Rubha Mor (Appin) have yielded U/Pb zircon and sphene ages of 422–429 Ma (Rogers and Dunning, 1991), indicating a restricted Middle Silurian range, possibly related to major transcurrent faulting. The other minor intrusions can only be dated by their field relations with the major plutonic phases; they cut some of the early phases of the postorogenic granitoid intrusions but predate some of the later phases.

## Appinites and calc-alkaline lamprophyres

Many small intrusions of appinite and lamprophyre occur throughout the Grampian (and Northern) Highlands; they are respectively coarse-grained and fine-grained products of calc-alkaline magmatism. The presence of mafic hydrous phases, mainly hornblende and biotite, as euhedral phenocrysts indicates that the magma was volatile-rich (Rock, 1991). The lamprophyres occur as dykes and sheets, the appinites as plugs and irregular intrusions. The lamprophyres are mostly spessartites (hornblende phenocrysts with dominant plagioclase in the groundmass) with some vogesites (hornblende with orthoclase) and rare minettes (biotite with orthoclase).

The appinites typically comprise rocks with a fairly wide range of composition (the appinite suite); appinite itself is a kind of hornblende-melamonzonite. In the Ben Nevis district Bailey (1960) described appinite associated with augite-diorite, monzonite, kentallenite (olivine-monzonite) and

cortlandtite (olivine-augite-hornblendite). Appinites in the Glen Roy area, where they are up to a kilometre across, exhibit a similar composition range (Key et al., 1997). The rocks are characterised by extreme disequilibrium of mineral phases, with the mafic phases commonly showing reaction relationships, e.g. olivine mantled by pyroxene and pyroxene by amphibole or biotite.

Many of the appinite intrusions, notably those in the Appin and Glen Roy areas, are associated with pipes infilled with breccias composed of country rock fragments (Platten and Money, 1987). Several different lithologies, including many transitional types, may be present in a single mass of appinite, with the more acid members cutting the more basic; the lithological variation is ascribed to fractional crystallisation (Platten, 1991). A lamprophyre dyke associated with an appinite suite in the Loch Lomond area contains a varied suite of both cognate and upper crustal xenoliths (Dempster and Bluck, 1991).

## **Microdiorites**

The microdiorites form sheets and dykes of intermediate composition, ranging from quartz-microdiorite to microgranodiorite. Typically, the dyke rocks have a fine-grained groundmass of andesine or oligoclase, hornblende, biotite, minor K-feldspar and quartz. The small plagioclase phenocrysts are generally andesine, often showing oscillatory zoning. Phenocrysts of hornblende and, more rarely, augite and/or biotite, may also be present. The textural difference between the microdiorites and the appinites is ascribed to the much lower volatile content of the former, the texture of which shows a much closer approach to equilibrium crystallisation. Alteration of the groundmass and ferromagnesian phenocrysts, which led in the past to some microdiorites being wrongly identified as lamprophyres (vogesites or minettes), is widespread.

Several episodes of calc-alkaline microdiorite intrusion occurred during the late-Caledonian magmatic episode. The earliest members are foliated and recrystallised sheets and dykes which have been affected by late-tectonic shearing; they are probably approximately coeval with the late-tectonic granites. Non-foliated and/or weakly foliated microdiorites, which cannot be related specifically to individual granitic complexes, are widespread throughout the Grampian Highlands and are believed to be roughly coeval with the main phase of post-tectonic granite intrusion.

All of the post-tectonic granitic complexes of the Lorn and Lochaber districts are spatially associated with extensive, dense swarms of NE-trending dykes of intermediate to acid composition, ranging from andesite and microdiorite to felsite. The Etive swarm cuts the Lorn Plateau Lavas, Glencoe volcanic rocks and the Moor of Rannoch Granite. Successive members of the Etive Granite Complex are cut by dykes associated with later phases of the complex, except the Central Starav Granite which is free of dykes. Similarly, the outer components of the Ben Nevis Complex are cut by a consanguineous suite of intermediate to acid dykes, which in turn are cut by the central granite. The vast majority of the dykes of this episode trend NE-SW, but there are a few earlier NW-trending dykes in the Glencoe cauldron subsidence. In the Glencoe area, the crustal extension represented by the emplacement of the dyke swarms has been estimated at 2.5 to 4 km over a distance of 9 km (Roberts, 1974). Suites of microdiorite and quartz-porphry sheets and dykes are associated with the Glen Tilt Complex, particularly to the east of its main intrusive phases, and with the Foyers pluton.

## **Felsites and quartz-feldspar-porphyrries**

In the north-eastern Grampian Highlands, and extending as far west as Speyside and Glen Tilt, there is a prominent suite of felsite and quartz-feldspar-porphry dykes, whose trends vary from north-south to NE-SW, but are frequently arcuate. These cut the earlier post-tectonic diorites and granites, but the later pink biotite-granites, with the exception of the Mount Battock Granite and the

later phases of the Glen Gairn and Lochnagar granites, are not traversed by these dykes. A large sheet of particularly coarse-grained quartz-feldspar-porphyry, almost granitic in texture, occurs to the west of the Lochnagar Granite, and several irregular bodies of finer-grained felsitic rock are present nearby. In Strathnairn, stockworks of felsite sheets appear to be coeval with the Maol Chnoc vein complex, which predates the emplacement of the Foyers pluton.

## **Seven-fold division of the Caledonian Igneous Suite**

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