

Pre-tectonic basic magmatism, Caledonian magmatism, Grampian Highlands

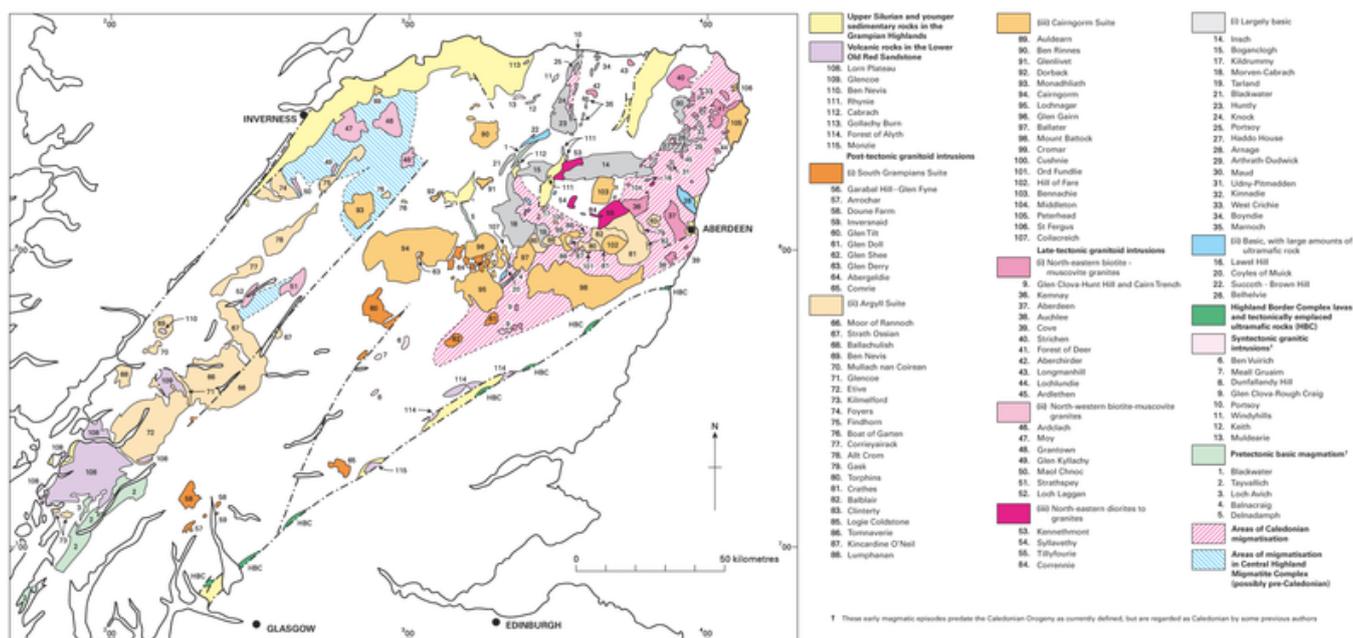
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Stephenson, D, and Gould, D. 1995. British regional geology: the Grampian Highlands. Fourth edition. Reprint 2007. Keyworth, Nottingham: British Geological Survey.

Pre-tectonic basic magmatism

The Central Highland Migmatite Complex contains partially amphibolitised two-pyroxene-gabbros in two zones, structurally underlying the boundary between the migmatite complex and the Grampian Group (Highton, 1992); they are small bodies not shown on [P915434](#). They were intruded after the local D₁ deformation and associated metamorphism and migmatitisation, but before D₂. They are preserved as concordant sheets and larger podiform masses up to 800 m by 200 m. Primary igneous textures are preserved in the largest masses. Cumulate textures are widely developed, and large pyroxene oikocrysts are prominent in the coarser lithologies. The primary igneous assemblages were clinopyroxene + plagioclase + brown hornblende + ilmenite ± orthopyroxene ± biotite.



Distribution of Caledonian igneous rocks in the Grampian Highlands. P915434.

Igneous activity during later deposition of the Dalradian Supergroup was closely linked with crustal instability, which resulted in the commencement of high-level rift faulting in Argyll Group times (Chapter 5). Increased crustal stretching, associated with the opening of the Iapetus Ocean to the south-east of the Dalradian depositional basin (Graham, 1976; Leake, 1982), led to the development of volcanism, particularly in the South-west Highlands.

The earliest recorded evidence of volcanic activity, widespread but minor and basic in character, is in the Argyll Group. Minor tuffs and pillow-lavas occur in the Muckle Fergie and Kymah burns (Tomintoul/Glenlivet area), in the lower part of the Islay Subgroup. A few thin cross-bedded tuffaceous beds occur at a similar stratigraphical level in the Loch Creran area (Litherland, 1980). To the north of the Dee and south of Tomintoul, the Easdale Subgroup contains the **Delnadamph**

Volcanic Member (5) lying within the local equivalent of the Ben Eagach Schist. Pillow lavas, fine-grained vesicular amphibolites, and coarse-grained actinolite-rich amphibolites are associated with pelitic to psammitic rocks. The Ardrishaig Phyllite (Easdale Subgroup) contains sporadic 'green beds' (Borradaile, 1973), while the equivalent Ben Lawers Schist contains minor basic lavas as well as some green beds.

The first major outbreak of volcanic activity is recorded close to the top of the Easdale Subgroup, in which metavolcanic rocks extend discontinuously for 120 km along strike. Several eruptive centres are indicated. The Beinn Challum Quartzite and Sron Bheag Schist, occurring between Tyndrum and the Loch Tay Fault, show a north-eastward increase in the proportion of volcanic material, with lavas and tuffaceous 'green beds' being intercalated within a metasedimentary succession. From the Loch Tay Fault to Glen Shee, the Farragon Beds (Goodman and Winchester, 1993) show an increased proportion of metavolcanic material, reaching 400 m in thickness in the Ben Vrackie area. Here, fine-grained, foliated metabasalts and tuffaceous metasedimentary rocks occur together with rubbly meta-agglomerates (Graham and Bradbury, 1981). The Farragon Beds thin to 40 m in Gleann Fearnach, and are separated by a 20 km gap from the metabasite at Meall Dubh in Glen Girnock. Slightly higher in the succession, the metabasite at **Balnacraig** (4) lies within the lower part of the Queen's Hill Gneiss Formation (Crinan Subgroup) in Glen Muick. It consists of fine-grained hornblende-schist intercalated with layers of psammite and calc-silicate rock. Basaltic pillow lavas together with fragmental ultramafic rocks of possible volcanic origin also occur in the Blackwater Formation of the Argyll Group (possibly Easdale Subgroup in part) between Upper Donside and Dufftown (1; MacGregor and Roberts, 1963; Fettes et al., 1991).

A lenticular zone of tuffs occurs within the Crinan Grit at Craignish, and a 50 m-thick band of green schists enriched in Mg, Cr, Cu and Ni at the base of the Ben Lui Schist between Tyndrum and Glen Lyon was probably derived by the erosion of local ultramafic rocks (Fortey and Smith, 1986). A major phase of sill injection took place, centred on the Knapdale-Tayvallich area, commencing roughly contemporaneously with the deposition of the Ardrishaig Phyllite and continuing until the extrusion of the Tayvallich Volcanic Formation (Wilson and Leake, 1982; Graham, 1976).

The main centre of extrusive activity in late Argyll-early Southern Highland group times was located in the **Tayvallich-Loch Awe** area of the South-west Highlands, where there are 2000 m of low-K basaltic pillow lavas and tuffs, with a few interbedded pyroclastic layers (2; Borradaile, 1973; Graham, 1976). The volcanic pile thins rapidly to the north-east and contains in its upper part indications of subaerial extrusion. Keratophyre, from a small laccolith cogenetic with the Tayvallich Volcanic Formation, has been dated at 595 ± 4 Ma (Halliday et al., 1989). The overlying turbiditic Loch Avich Grit is succeeded by the 300 to 500 m-thick **Loch Avich Lavas** (3), preserved only in the centre of the Loch Awe Syncline. The volcanoclastic Green Beds, which form a mappable unit within the Southern Highland Group from Kintyre to Glen Clova, may represent reworked debris from lateral equivalents of the Loch Avich Lavas. The metamorphosed basaltic dykes of northern Jura (Graham and Borradaile, 1984) are considered to represent feeders to the sills and lavas of mid-Argyll. These factors indicate that the Loch Awe-North Knapdale area was probably a centre of crustal instability from Easdale Subgroup times until early Southern Highland Group times.

The petrochemistry of the metamorphosed sills and lavas in mid-Argyll has been studied by Graham (1976) and Graham and Bradbury (1981). The original ophitic textures of the dolerites are commonly preserved, as are some primary skeletal ilmenite crystals, despite the recrystallisation of the rocks to typical greenschist and epidote-amphibolite facies assemblages. Patches of pegmatitic metadolerite within the sills commonly develop interstitial quartz and alkali feldspar, indicating the tholeiitic character of the dolerites, and there is evidence of a degree of cumulate settling in the thicker sills. Some of the basic rocks suffered hydrothermal spilitisation (albitisation of the plagioclase) shortly after extrusion.

The non-spilitised lavas and sills have an evolved tholeiitic basalt chemistry, showing a differentiation trend marked by considerable enrichment in Fe, Ti, Zr and P. The lavas of the Tayvallich Volcanic Formation are more differentiated than the Loch Avich lavas. The rocks are chemically similar to modern basalts produced during continental rifting, representing the first stage of oceanic spreading.

Amphibolite sills and sheets are widely developed in the upper Argyll Group from Perthshire to Deeside. In Perthshire, Pantin (1956) recognised a metamorphosed contact aureole around the Ben Vrackie sill complex, which intrudes the Ben Lawers and Ben Lui schists. The BGS resurvey during the 1980s of the area from Donside to the Banffshire coast has shown that many of the amphibolites, hornblende-schists and serpentinites previously regarded as pre-tectonic intrusives are actually sheared members of the syntectonic basic suite. However, the many smaller conformable bodies of amphibolite to the east of this line are probably metamorphosed sills intruded prior to the regional metamorphism.

Seven-fold division of the Caledonian Igneous Suite

Pre-tectonic basic magmatism

[Syntectonic granitic intrusions](#)

[Syn- to late-tectonic basic and ultramafic intrusions](#)

[Late-tectonic granitoid intrusions](#)

[Post-tectonic granitoid intrusions](#)

[Late- to post-tectonic minor intrusions](#)

[Lower Old Red Sandstone volcanism](#)

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