Post-Caledonian igneous activity, Northern Highlands of Scotland

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Johnstone, G S and Mykura, W. 1989. British regional geology: Northern Highlands of Scotland. Fourth edition. Keyworth, Nottingham: British Geological Survey.
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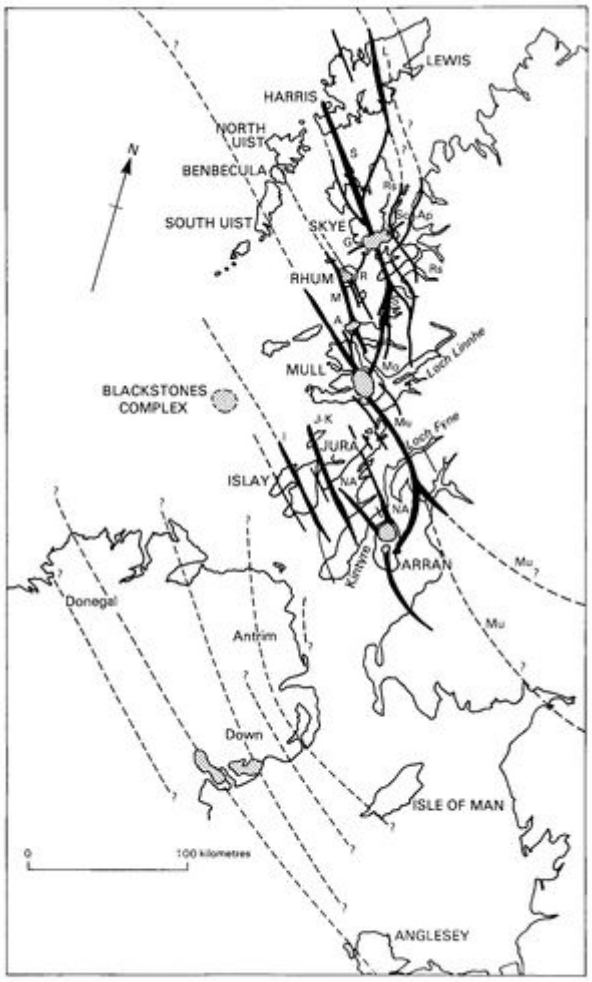
Post-Caledonian igneous activity, introduction

Tertiary dyke swarms of the Northern Highlands. P915494.



L Lewis **S** Skye **Rs** Raasay **Sc** Scalpay **Ap** Applecross **G** Glen Brittle **R** Rhum **M** Muck **Mu** Mull **A** Ardnamurchan **Mo** Morvern **J-K** Jura-Kintyre **I** Islay **Na** north-west Arran.

Dilation axes of the Terrtiary dyke swarms. P915495.

There were two main episodes of post-Caledonian igneous activity in the Northern Highlands. In Permo-Carboniferous times the area was intruded by numerous dykes and several vents, but there are no outcrops of extrusive rocks of this age. In Tertiary times the area covering the Inner Hebrides, Arclnamurchan and Morvern was the site of intense volcanic activity associated with the fracturing of the north-west seaboard of Eurasia on the margins of the developing Atlantic Ocean. The Tertiary volcanic centres are described in *British Regional Geology: The Tertiary Volcanic Districts* and will not be discussed here. The Tertiary dyke swarms, however, extend well beyond the limits of the area covered in that book, into the Northern and Grampian Highlands and beyond.

Late-Caledonian

A small volcanic vent of unknown age cuts the basal Old Red Sandstone of Ben Griam More in Sutherland; the rocks comprise porphyrite and basic andesite. They could have been formed during the phase of late-Caledonian igneous activity which is well known in the Grampian Highlands.

Permo-Carboniferous

Although dykes and vents of camptonite and monchiquite have long been known from the Northern Highlands and referred to briefly in several accounts, the overall importance of this suite was given curiously little recognition until the last three decades, when the rocks have received increasing

attention. A review paper by Rock (1983a) helps to establish the significance of this major episode in the igneous history of the area.

The Permo-Carboniferous dykes and vents of the Northern Highlands belong to the same phase of igneous activity as that which produced the Permo-Carboniferous volcanic rocks of the Midland Valley of Scotland, the Midlands of England, the North Sea and Scandinavia (notably the Oslo region). The rocks comprise camptonites and monchiquites, grading to subordinate basalts, basanites and analcimites with rarer picritic, pyroxenitic and felsic varients. The camptonites were probably derived from a volatile-rich primary alkalic basalt- basanite magma, itself derived from mantle melting. The monchiquites may be varieties of this, or even of a more nephelinitic magma.

In the Northern Highlands over 3000 dykes (with a small number of vents) have been recorded; specific search has revealed many more previously unmapped. They are arranged in nine swarms comprising both types (P915493) of which that centred on Loch Eil and Loch Arkaig is the largest. The trends of the separate swarms define a roughly arcuate pattern from WNW–ESE (Outer Isles) through E–W (southern part of the Northern Highlands) to ENE–WSW in Orkney. The dykes are sparse, or absent, from the northern half of the Northern Highlands but are abundant in south and central Orkney (Mykura, 1976). They average about 1 m in thickness, and rock dilation due to their intrusion varies from about 1% to 4%. The vents (P915493 inset) are composed of explosion breccias, commonly with a matrix of monchiquite. They are most abundant where the dykes (especially monchiquitic dykes) are also abundant.

Most of the dyke swarms lie beyond the limits of the Tertiary dyke intrusions, but in Ardgour and the Inner and Outer Hebrides not only do the swarms overlap, but the trends of dykes of different swarms differ little. The camptonite dykes (the dominant variety of the suite) can usually be distinguished from the Tertiary dykes by the presence within them of pinkish or white ocelli containing needles of mafic minerals (amphibole or biotite). Dykes of the swarm may contain megacrysts of apatite, anorthoclase and mafic minerals; many are xenolithic. The dykes are commonly carbonated, and their close association with lead-zinc mineralisation (as at Strontian (p.177) has led to speculation that the dykes and mineralisation may have a genetic connection. It seems that if any connection exists it is unlikely to be genetic, but more probably related to the fact that the dykes form pathways or barriers to later mineralising fluids.

Also thought to be of Permo-Carboniferous age are broad (up to 50 m wide) dykes and small elongate bosses of quartz dolerite, in places linearly arranged and trending between E–W and SE–NW. They are cut by the E–W camptonites. The bosses cause intense contact alteration of the schists at their margins, and Butler (1961) considers that in Ardnamurchan some of these may be of Tertiary age.

Tertiary activity

Basalt lavas forming a landward part of the lava plateaux of the Hebridean islands are found on the peninsula of Morvern, where they overlie Mesozoic sediments and locally rest directly on Moine basement. The western 17 km or so of the peninsula of Ardnamurchan, while including some lavas, is made up largely of the Ardnamurchan Plutonic Complex, the root zone of one of the volcanic centres of the Hebridean province. These basic plutonic igneous rocks form successive intersecting ring structures, with an intricate pattern of overlapping ringdykes, cone-sheets, sills and dykes. This world-famous ring complex (and the other major centres on the islands) is described in *British Regional Geology: The Tertiary Volcanic Districts*. The dyke swarms of Tertiary age, however, extend well beyond the region of the lava fields and central volcanoes.

Tertiary dykes in the Northern Highlands (P915494; P915495) are confined to the area west of a line

extending from Stornoway to the east end of Loch Sunart (and continuing in the Grampians towards Cowal). Two major concentrations are notable, passing through the central complexes of Skye and Mull respectively. The main trend of the dykes in each case is more or less NW–SE through the plutonic centre; some dykes deviate from the main trend (mainly to a more N–S direction).

It was formerly thought (Richey, 1939) that these concentrations defined two major swarms emanating (and to a slight extent radiating) from the plutonic centres, but recently more rigorous mathematical study of the orientation, numbers and dilation of the dykes (Speight and others, 1982) indicates that the swarms reflect a deep underlying pattern of elongate, magma-filled ridges arranged *en echelon* with cross-structures in the pattern more familiar as gash veins in sheared rock. These ridges developed by shearing stress during the fracturing of the crust, in response to stress occasioned by the opening of the Atlantic Ocean. The pattern of dykes developed over these ridges is thus linear, but intertwining. While the plutonic centres lie within the swarms on the same ridges, they are not necessarily the prime centres of emanation.

The magma which supplied the intrusion of the Tertiary igneous province was a mantle-derived basic rock which varied in a complex manner by degrees of partial fusion of mantle material, by degrees of fractionation, and by contamination with crustal material from various levels. Several magma types thus became available. Rocks derived from the various varieties of magma are represented in both lavas and plutons, but the dykes themselves consist mainly of two contrasted suites: the alkali-olivine-basalt suite of the Mull Plateau Group or Skye Main Lava Series, and the tholeiitic suite of the Preshal Mhor type. Thomson (1982) has a major review article, with full bibliography, concerning this complex subject.

The intrusion of the dykes spanned the entire period of Tertiary igneous activity. Dykes both predate and post-date the effusion of the lavas and emplacement of the central complexes, but most were emplaced at a late stage in the volcanic history.

Selected bibliography

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