Dubh Loch, Isle of Colonsay, Argyll and Bute

[NR 369 947]

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Introduction

The Kilchatten Dyke is one of a pair of NW-trending Late Palaeozoic dykes on the Isle of Colonsay in the Inner Hebrides that are remarkable for their unusual compositions and their content of xenoliths and xenocrysts. Although both the Kilchatten and the nearby Riasg Buidhe dykes contain large biotite and amphibole crystals, the Kilchatten Dyke is the more spectacular of the two. The first detailed description of the dyke was provided by Flett (in Cunningham Craig *et al.,* 1911). The dykes also have considerable historical importance in that they were the subject of one of the earliest attempts at dating by radiometric methods (Urry and Holmes, 1941); detailed descriptions and analyses were also included in the same paper. Brief descriptions of the xenolith and xenocryst inclusions were given within a general overview of inclusions of mantle and lower-crustal rocks brought up by alkaline basic dykes in the north of Britain (Upton *et al.,* 1983) and they provided material for a detailed trace-element and isotopic study of Scottish mantle material by Menzies and Halliday (1988).

Description

The Kilchatten Dyke cuts rocks of the Colonsay Group, an enigmatic Late Proterozoic meta-sedimentary sequence that has been variously assigned to the Torridonian and lower Dalradian (Bentley, 1988). It has a width of approximately 1 m and can be followed on a north-west trend for several hundred metres across the hills to the east of the Lower Kilchatten cottages [NR 367 949] (Figure 5.23). The most striking feature of the dyke is its content of large lustrous biotite crystals up to 4 cm in diameter (Figure 5.24). The biotites, although somewhat resorbed, tend to retain a subhedral morphology. The big mica crystals, together with other 'megacryse species and included rock fragments, are concentrated in the more central parts of the dyke, with the marginal facies being essentially devoid of them. Associated megacrysts include kaersutitic amphibole and augite, which also occur as partly resorbed crystals up to several centimetres across. Apatite prisms over 1 cm long and fragments of magnetite megacrysts are also present. A range of ultramafic rocks is represented among the xenoliths, including spinel lherzolite (generally carbonated), olivine-pyroxenite, wehrlite, biotite- and kaersutite-pyroxenite and 'glimmerite' (biotite-rich ultramafic rock). Other xenoliths of granulite-facies, pyroxene-bearing meta-igneous rocks with gabbroic and dioritic compositions also occur, together with some metasedimentary xenoliths. The xenoliths rarely exceed a few centimetres in diameter.

The matrix of the dyke is composed of twinned augite prisms (exhibiting an hour-glass structure), magnetite and strongly pleochroic red-brown biotite in a mesostasis of analcime, calcite, apatite, zeolites (natrolite?) and chloritic interstitial material probably secondary after residual glass. Ocelli, up to 2 mm across, occur abundantly. These contain analcime and calcite, with subordinate alkali feldspar, biotite and augite. (Figure 5.23) Map of the area around the Dubh Loch GCR site, Isle of Colonsay. Based on British Geological Survey 1:50 000 Provisional Series Sheet 35, Colonsay (1996). The inset shows the location of the main map.

Analysis of the dyke rock shows it to be strongly silica-undersaturated (less than 40% SiO_2) and distinctly potassic with $K_2O > Na_2O$. The rock could be described as a monchiquite, i.e. a feldspar-free lamprophyre containing silica-poor glass, commonly with analcime. However, typical monchiquites contain olivine (or pseudomorphs after olivine) whereas the Kilchatten Dyke, unlike the neighbouring Riasg Buidhe Dyke, is olivine-free. The term 'ouachitite', as used by Flett (in Cunningham Craig *et al.,* 1911), is similarly inappropriate and is now obsolete, so the rock is best referred to as an analcime monchiquite despite the qualifications.

Interpretation

The Kilchatten Dyke has long been regarded as one of a family of alkaline lamprophyric (mainly monchiquitic to camptonitic) dykes that traverse the western Highlands and Hebrides. The distinctive petrographical and geochemical features serve to distinguish these dykes from the more numerous dykes of Palaeogene age, which in many areas, including Colonsay, have an identical trend. Correlation of the lamprophyric dykes with the volcanic rocks of the Mauchline, Sanquhar and Thornill basins in south and central Scotland (see Chapter 4) suggested to Geological Survey workers that they are of Late Carboniferous to Permian age. However, this could not be proved from field relationships and the Kilchatten and Riasg Buidhe dykes were selected as representatives of this problematic set of rocks by Urry and Holmes (1941) for radiometric age determination by the Helium Method (see also Clee Hill Quarries GCR site report). These workers obtained ages of 130 Ma and 125 Ma respectively for the two dykes which, given the crude timescale of the day, was thought to be in accord with that tentatively assigned on geological grounds. It at least established them as post-Carboniferous and pre-Tertiary. More recent K-Ar determinations on amphibole and biotite from the Kilchatten Dyke have yielded 266 ± 7 Ma and 283 ± 8 Ma respectively (De Souza, 1979). These give a mean of 281 ± 8 Ma using new constants (Baxter and Mitchell, 1984), and an Ar-Ar determination on an amphibole megacryst has yielded a weighted mean age of 280 ± 2.6 Ma (M. Timmerman, pers. comm., 2002), confirming the Early Permian age.

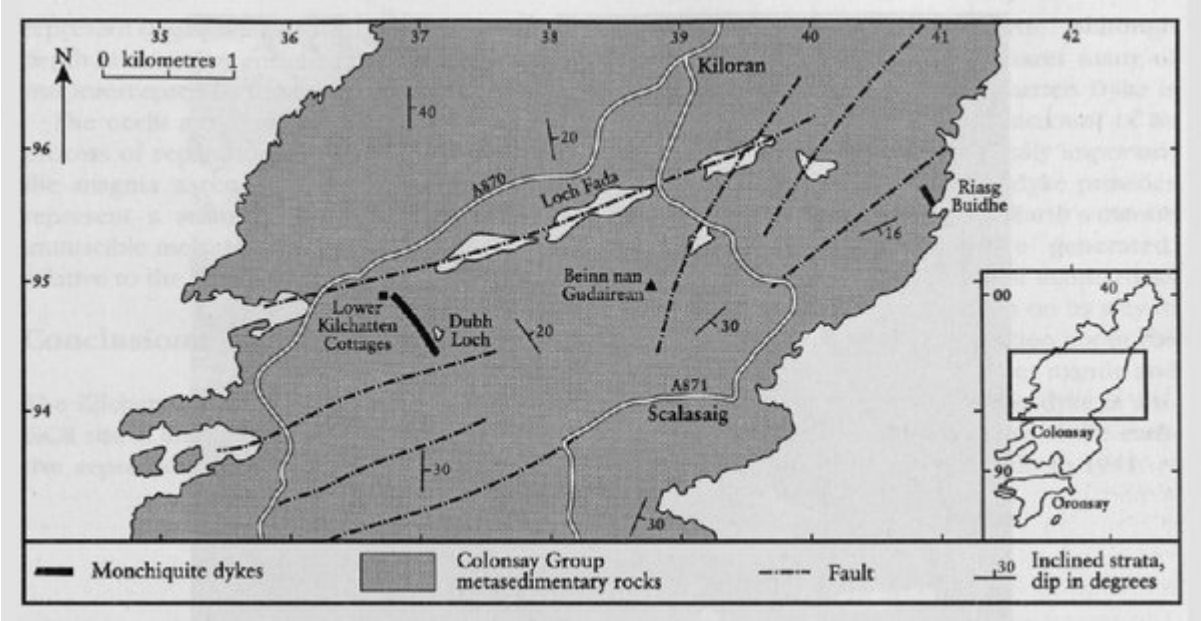
The dyke is typical of the very silica-deficient rocks with high contents of incompatible elements and volatiles (water and CO_2) that characterize this west of Scotland Late Palaeozoic swarm. They were probably generated by the melting of a geochemically enriched source in the lithospheric mantle as a result of pressure release related to extensional tectonics (Upton *et al.,* 1998). These volatile-rich magmas are inferred to have ascended at high velocities from depths of 70 km or more, breaking off fragments of both upper-mantle and lower-crustal side-walls as they arose and sweeping these up to shallow levels. The upper mantle (at depths of *c.* 60–30 km) is inferred to be of spinet lherzolite associated with younger veins and layers of wehrlite, olivine-pyroxenite, biotite- and/or amphibole-pyroxenite and 'glimmerite'. The xenoliths in the monchiquitic magmas are regarded as 'accidental' samples acquired from these sub-Moho depths, whereas the granulite-facies meta-igneous xenoliths are samples from the lower crust. The megacrysts were probably derived partly from the mechanical and thermal disaggregation of very coarse-grained (pegmatitic) facies in the upper mantle although some (especially the subhedral biotites) may represent large phenocrysts that were forming at depth in an earlier enriched magma fraction that was intercepted by the monchiquite magma.

The ocelli are likely to owe their origin to a process of separation of two liquid fractions as the magma ascended. They are inferred to represent a relatively water-rich alkali silicate immiscible melt that was deficient in Mg and Fe relative to the host monchiquite melt.

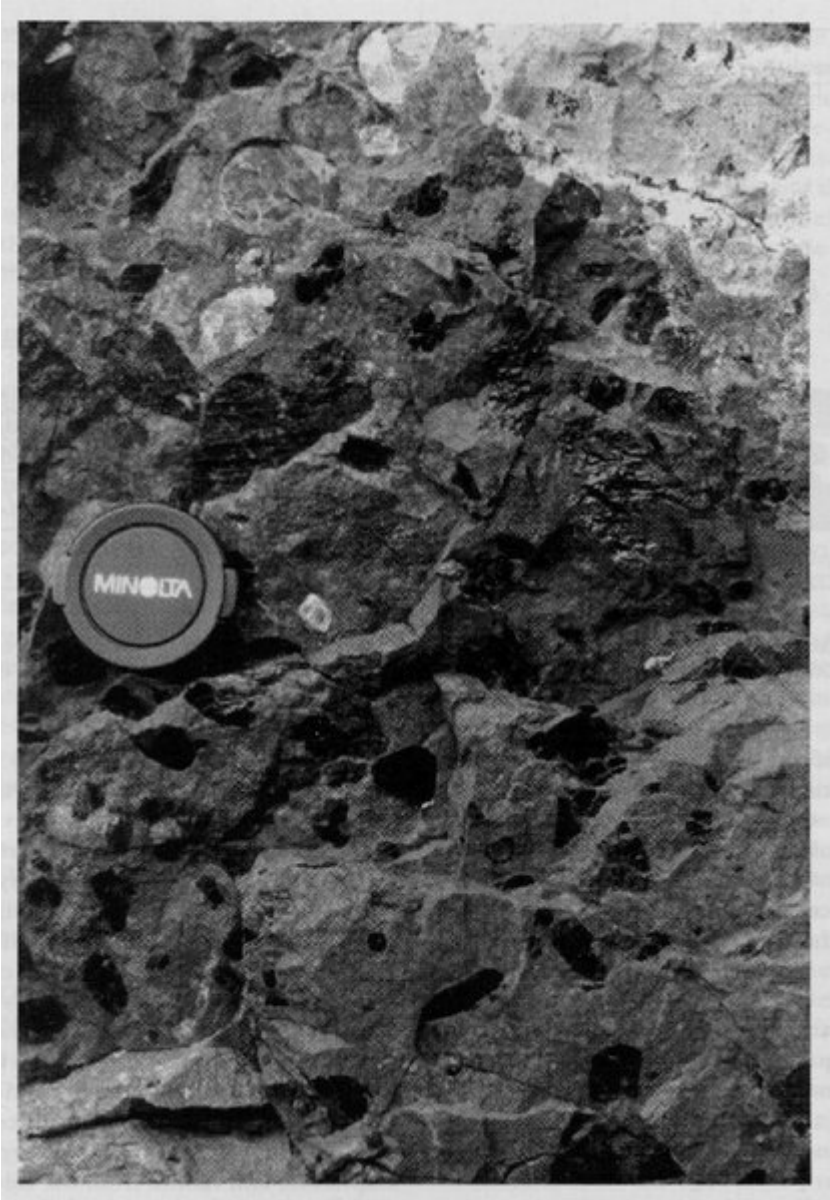
Conclusions

The Kilchatten Dyke exposed at the Dubh Loch GCR site is important in that it is a very distinctive representative of the Late Palaeozoic west Highland lamprophyric dyke-swarm. Although the nearby Riasg Buidhe Dyke shares many of the same characteristics, the Kilchatten Dyke is by far the most eye-catching on account of its large mica crystals. It is scientifically important because the geochemistry of the dyke provides information on the nature of the Earth's mantle from which the magmas were generated. Detailed study of the fragments of exotic rocks and minerals that it has picked up on its way to the surface also provides information about the rock-types present within the upper mantle and deep crust beneath Colonsay. The dyke is also significant historically in being one of the earliest rocks to be dated radiometrically in 1941.

References



(Figure 5.23) Map of the area around the Dubh Loch GCR site, Isle of Colonsay. Based on British Geological Survey 1:50 000 Provisional Series Sheet 35, Colonsay (1996). The inset shows the location of the main map.



(Figure 5.24) Close-up view of the analcime monchiquite dyke at the Dubh Loch GCR site, showing xenoliths of pyroxenite (dull black) and biotite-rich ultramafic rock 'glimmerite' (glossy black) in addition to large megacrysts of biotite

(black). The lens cap is about 50 mm in diameter. (Photo: M. Anderson.)