Craighead Quarry, South Lanarkshire

[NS 919 238]

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Introduction

A disused quarry on the west side of Craighead Hill, 2.5 miles east of Crawfordjohn, exposes steeply dipping Ordovician greywackes into which a dyke-like intrusion of a distinctive rock, known as the Crawfordjohn 'essexite' has been emplaced (Figure 5.20). This porphyritic alkali gabbro contains large well-shaped black crystals of augite that give it a distinctive coarsely spotted appearance, especially on surfaces on which the groundmass of the rock has weathered to a pale-creamy-grey colour. It was worked for curling stones which were manufactured nearby in the village of Crawfordjohn in the 19th and early part of the 20th centuries ((Figure 5.21)a). The only other locality in Scotland where nearly identical 'essexite' occurs is at Lennoxtown, north of Glasgow, on the southern margin of the Campsie Fells, but Craighead Quarry is the only place where it has been quarried.

The rock was first described by Teall (1888) but the most detailed description is that of Scott (1915) who carried out petrographical studies and whole-rock chemical analyses. He concluded that the intrusion is probably 'an elongated plug or small boss' and confirmed the interpretation of Tyrrell (1912) that it is allied to the Late Palaeozoic alkali dolerites, rather than to the Palaeogene dykes of the area which, although they have a similar north-west–southeast trend, have tholeiitic affinities. Greig (1971) referred to the intrusion as a NW-trending dyke of 'theralitic essexite' and more recent geophysical work has confirmed the dyke-like form. The most appropriate modern term for the rock-type is nepheline-gabbro.

Description

Craighead Quarry is the main exposure of the Crawfordjohn 'essexite', but smaller quarries and exposures occur between 120 m and 200 m to the south-east. The 1870 and 1937 editions of the Geological Survey map (Sheet 15) show the intrusion as a dyke extending for about 1.2 km to the north-west, beyond Duneaton Water. It is not exposed in the river, but boulders of 'essexite' occur on the west bank approximately on the projected line of the quarry outcrops and a trial pit some 130 m farther to the north-west has produced similar rock. A preliminary proton magnetometer survey has indicated that a magnetic anomaly extends south-eastwards for about 450 m beyond the last exposures, where drift cover is shallow (less than 6 m). To the north-west the anomaly can be traced for at least 1.3 km and it is concluded that the intrusion is in the overall form of a NW-trending dyke, 15 m to 25 m wide and at least 2 km long. The character of its dominant magnetization is consistent with a Permian field direction (D.W. Powell, pers. comm., 1971).

The main part of the quarry is entered along the line of the intrusion and a continuous cross-section is exposed in the main face at the southeast end (Figure 5.22). The intrusion margins are steeply inclined or near vertical and the width is somewhat variable, but at the quarry face it is about 24 m. At both contacts the intrusion is chilled against indurated sedimentary country rocks, which are tightly folded, near-vertical sandstone, siltstone and mudstone of the Ordovician (Caradoc) Kirkcolm Formation. Scott (1915) described the contact metamorphism in some detail. These greywacke facies rocks have been quarried extensively to the north of the main face where there is a major embayment on the north-eastern side of the quarry entrance.

In the main quarry face, there is a clear distinction between the chilled margins and most of the central porphyritic part. The margins are fine grained, with variable numbers of microphenocrysts of olivine, augite and rare plagioclase, set in an analcime-rich groundmass. This marginal rock was described as 'monchiquite' by Scott (1915) in view of its dominant feldspathoid. The central part of the intrusion, with its abundant large phenocrysts of augite, is separated from the marginal rock by a zone, a few centimetres in width, with few augite macrophenocysts. This zone, which was described by Scott (1915) as 'essexite-monchiquite', commonly has a spotted appearance due to abundant microphenocrysts of

olivine and augite. These mafic minerals are set in a framework of plagioclase laths that tend to be flow-orientated parallel to the contacts. Olivine has been replaced by 'fibrous serpentine' and the augite displays varying degrees of alteration. Although the spotted zone has a well-defined non-gradational contact with the central part of the dyke, there is no sign of chill.

The bulk of the intrusion is strongly por-phyritic (Figure 5.21)a,b. The rock commonly comprises over 25% phenocrysts of titanaugite and more than 40% in places. The phenocrysts are equidimensional or slightly elongated, with well-developed crystal faces. They commonly exceed 5 mm and can exceed 10 mm in length. In thin section they have the purple coloration characteristic of titanium-rich augite and display both sector twinning and oscillatory zoning. Inclusions of groundmass minerals, including olivine, labradorite and apatite, are common and in many instances are aligned parallel to the crystal outlines. The groundmass consists dominantly of laths of labradorite, commonly exceeding 2 mm in length, and abundant rounded crystals of fresh olivine, generally less than 1 mm in diameter. Nepheline and analcime are fairly abundant, the latter as interstitial patches, and small grains of iron-titanium oxide make up about 5% of the rock. Small amounts of orthoclase, biotite and apatite also occur. (There is probably insufficient orthoclase to justify classification as nepheline-monzogabbro, the modern equivalent term for an essexite.)

Chemical analyses of the main part of the intrusion confirm the close affinity of the Crawfordjohn 'essexite' with that of Lennoxtown. The analyses are nepheline-normative and rich in alkalis, and Scott (1915) suggested that the rock has affinities with the 'theralitic' and 'kylitic' rocks of the western Midland Valley (see Benbeoch GCR site report).

Interpretation

There is little doubt that the Crawfordjohn 'essexite' was intruded as a NW-trending dyke. The only other major occurrence of a similar rock-type in Scotland is at Lennoxtown, where it occurs as a plug-like intrusion and an inclined sheet, and intrusions of any composition of this age are unusual in the Southern Uplands. The form of the intrusion may be related to its location within competent and well-lithified Lower Palaeozoic country rocks. These are deformed into tight folds with steeply inclined axial planes and are likely to have behaved differently, tectonically and structurally, from the water-saturated and perhaps not fully lithified Carboniferous sedimentary rocks of the Midland Valley into which the alkali dolerite sills of the same age were generally emplaced.

The lack of sharp internal boundaries indicates that the intrusion was emplaced as the result of the injection of a single pulse of magma. However, there must have been some fractionation during the ascent of the magma, which is reflected not just in the variable abundance of phenocrysts, but more notably in the compositional contrasts between the monchiquitic marginal rock and the porphyritic nepheline-gabbro of the main body. The presence of flow-textured feldspar laths in the transitional zone between the chilled margin and the main mass of the dyke provides clear evidence that much of the ground-mass had already crystallized prior to intrusion. Hence the dyke must have been emplaced as a crystal mush in which as much as 50% of the material was already in solid crystalline form.

The abundance of large phenocrysts of titanaugite invites comparison with the highly mafic 'ankaramitic' lavas that commonly occur as members of alkaline to transitional volcanic sequences such as the Clyde Plateau and Arthur's Seat volcanic rocks (see Chapter 2).

However, the highly developed oscillatory zoning of the phenocrysts in the nepheline-gabbro and their lack of resorption textures appear to indicate that they were in a closer state of chemical equilibrium with the groundmass than is common in many ankaramitic rocks.

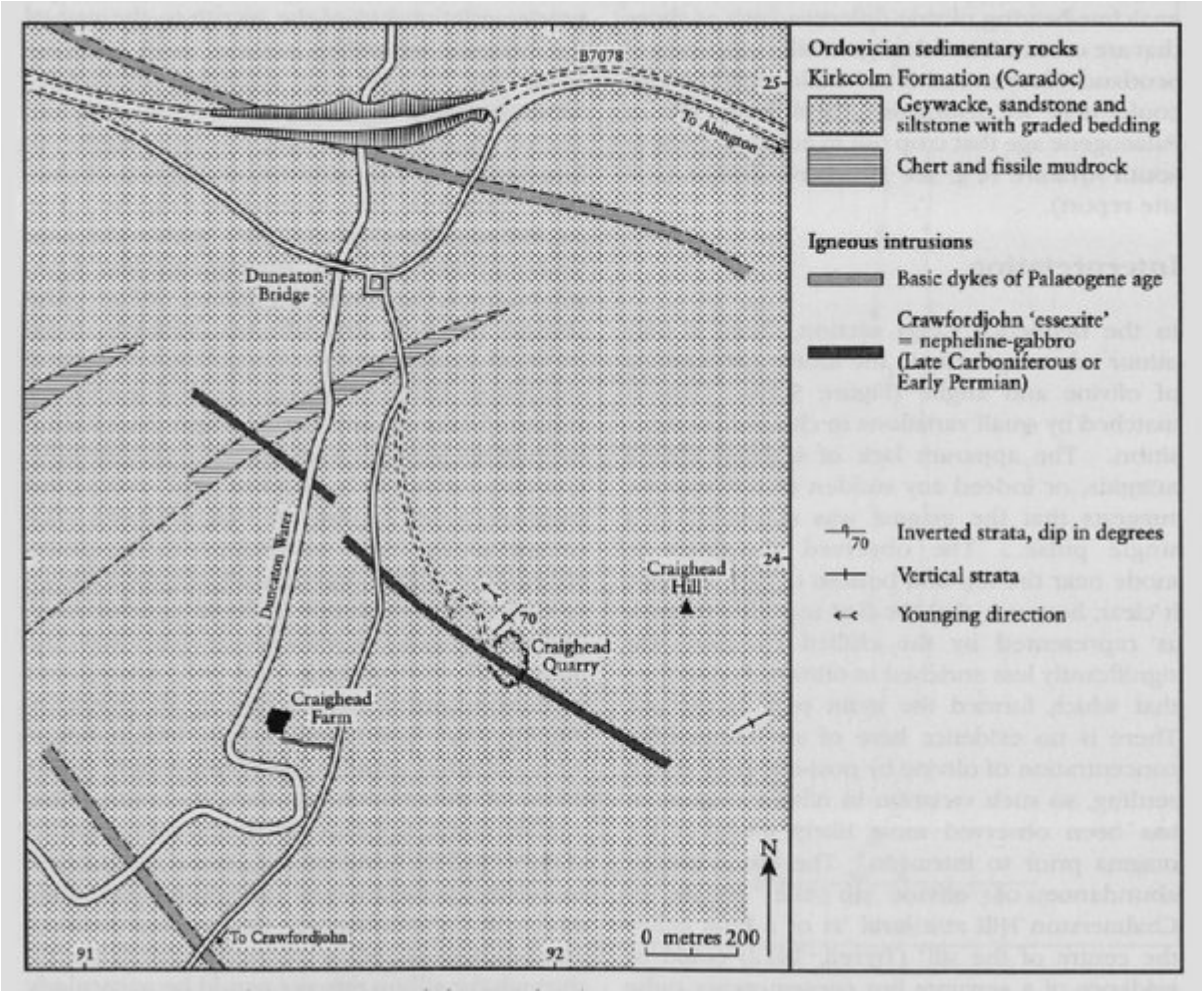
Inclusions of groundmass minerals within the augite crystals indicate that crystallization of the groundmass had begun prior to, or was taking place during, the growth of the phenocrysts, and small plagioclase laths have been trapped in the boundaries between individual crystals of augite in glomeroporphyritic clusters (Figure 5.21)b.

The close resemblance of the main part of the intrusion to the porphyritic facies of the Lennoxtown 'essexite indicates that the petrography is the result of processes, that, although unusual, were not unique in the petro-genesis of the Late Carboniferous to Early Permian alkali dolerites of Scotland.

Conclusions

The Crawfordjohn 'essexite' at Craighead Quarry constitutes an occurrence of an unusual and visually striking rock-type (a porphyritic nepheline-gabbro) that is known from only one other locality in Scotland. It is also a rare occurrence of an intrusion of Late Carboniferous to Early Permian age within the Southern Uplands. The quarry face provides easy access to fresh, little-weathered rock across the full width of the dyke, which exhibits significant variations in rock-type. Little of significance has been published on Scottish 'essexites' since the early part of the 20th century, and hence this site affords very significant potential for modern mineralogical and geochemical research which could throw light on the origin of augite-rich basic rocks of alkaline affinity. The site is also of historical significance in view of its use in the past as a source of rock for the manufacture of curling stones.

References



(Figure 5.20) Map of the area around the Craighead Quarry GCR site. Based on Geological Survey 1:63 360 Sheet 15, Sanquhar (1937); and original mapping and proton magnetometer survey by J.J. Doody and J.G. MacDonald (2000).

(Figure 5.21) (a) Curling Stone made of nepheline-gabbro ('essexite') from Craighead Quarry. Compare the texture with that seen in the photomicrograph (b). (b) Photomicrograph of nepheline-gabbro ('essexite') from Craighead Quarry. Ordinary light. The largest single phenocryst is 5 mm in diameter. (Photos: J.G. MacDonald.)

(Figure 5.22) The south-east face of Craighead Quarry. The nepheline-gabbro ('essexite') dyke, here about 24 m wide, is exposed in the centre of the photo and the margins of thermally metamorphosed greywacke stand out on either side of the dyke. (Photo: J.G. MacDonald.)