Hareheugh Craigs, Scottish Borders

[NT 688 401]

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Introduction

The Hareheugh Craigs GCR site has been selected because it contains a particularly good example of a plug-like composite intrusion of basaltic hawaiite to hawaiite composition, associated with the early Dinantian Kelso Lavas in the Tweed Basin, which are represented by the Lintmill Railway Cutting GCR site.

Hareheugh Craigs is a craggy hilltop about 2.5 km north-west of the village of Stichill and close to the town of Kelso (Figure 3.13) and (Figure 3.14). The 1879 Geological Survey one-inch map shows an intrusive body of lelstone' within the Kelso Lavas and the underlying Upper Old Red Sandstone strata. The revision survey concluded that this intrusion is probably a plug (Fowler and MacGregor, 1938). The petrography of the intrusion has been described in several papers on the igneous rocks of the Kelso area (Eckford and Ritchie, 1939; Tomkeieff, 1945, 1953) and it has been included in geochemical studies of Dinantian magmatism in northern Britain by Macdonald (1975) and Smedley (1986a).

Description

The Hareheugh Craigs intrusion cuts the Kelso Lavas, which are exposed intermittently in the immediately surrounding area and are represented by the nearby Lintmill Railway Cutting GCR site. The intrusion has a diameter of up to about 600 m and comprises two lithologically contrasting facies, one above the other. The best section through the lower part of the intrusion is seen in a former road-metal quarry [NT 6880 3990]. Though partially obscured by waste tipping and natural degradation, the lower parts of the 20 m-high, main face of the quarry expose a beautifully fresh, feldspar-macrophyric basaltic hawaiite or hawaiite, with dark, lustrous feldspars having a tendency to weather-out on rock faces. The feldspars are irregularly distributed giving a diffusely banded or layered appearance of alternating porphyritic and aphyric zones. The upper parts of the face show a coarser-grained, though less porphyritic, or aphyric basaltic hawaiite or hawaiite. The highest exposures in the quarry and those on adjacent hillsides are of the upper facies. This comprises large phenocrysts of olivine, clinopyroxene and spinel in addition to plagioclase in a fine-grained groundmass. The junction between the two types is poorly exposed, but appears to be regular with only a thin zone of transition and no obvious cooling of one facies against the other.

Columnar cooling joints are up to 1.75 m across and are inclined radially outwards at up to 70°. A number of calcite-filled vugs occur, and thin, irregular veins cut the intrusion. The presence of shear zones with some slickensides and veining probably indicates faulting.

Eckford and Ritchie (1939) described the intrusion as a 'Markle' (or related) basalt in the local classification scheme of MacGregor (1928); that is, an olivine basalt with feldspar phenocrysts, and ophitic augite forming part of a coarse-grained groundmass. Tomkeieff (1945) described the quarry exposures as olivine dolerite with patches and bands of 'Markle'-type basalt, and classed the exposures on the upper part of the hill as 'Dunsapie'-type basalt. In his later paper he referred to the intrusion as a composite plug of 'Markle' type (Tomkeieff, 1953). However, both Macdonald (1975) and Smedley (1986a) demonstrated that both facies of the Hareheugh Craigs intrusion are of hawaiite or basaltic hawaiite composition. Both are hypersthene-normative and are typical members of the mildly alkaline to transitional Carboniferous–Permian Igneous Province of northern Britain.

Interpretation

The Hareheugh Craigs intrusion is one of more than 50 intrusions and volcanic necks scattered across the area between Duns and Langholm (Tomkeieff, 1953). They occur on the margins of the Tweed and Solway basins and span the

intervening Cheviot Block. These intrusions do not cut later Carboniferous sedimentary rocks and the likelihood is that they represent the subsurface expressions of the sites from which most of the Dinantian volcanic rocks (Birrenswark Volcanic Formation, Kershopefoot basalts and Kelso Lavas) of the district were erupted. Some may have fed younger flows that have been subsequently lost through erosion. There is no evidence, in the form of linear dyke-swarms for example, for major fissure eruption, though some of these volcanic 'centres' define crude lineaments. The Hareheugh Craigs intrusion is one of several forming a NE-trending lineament from Hume [NT 710 420] towards Smailholm [NT 640 350] (Tomkeieff, 1953, fig. 1).

At Hareheugh Craigs, basaltic hawaiites and hawaiites are intruded into the generally more basic Kelso Lavas. Contact relationships are not entirely clear. There is some suggestion of systematic variations in grain size across the margins of the intrusion and some evidence for the presence of steeply inclined contacts. These features suggest that the body does indeed have an irregular plug-like geometry, as deduced by previous surveyors.

The differentiation of the intrusion into two separate but closely related, and possibly intergradational, lithologies suggests that the body is composite. The less porphyritic facies is the lower of the two. This arrangement is similar to that shown by composite Dinantian lavas from the Clyde Plateau Volcanic Formation near Greenock (Kennedy, 1931; Boyd, 1974) (see Dunrod Hill GCR site report) and in the Stirling area (MacDonald, 1967; Francis *et al.,* 1970) (see Campsie Fells GCR site report). Several other composite bodies from the province are listed by Macdonald (1975), the closest to Hareheugh Craigs being the hawaiite–basalt association exposed on Lurgie Craigs some 1.3 km to the west.

The compositions of the two facies indicate a degree of differentiation of the original magma from alkali olivine basalt to hawaiite, probably through the mechanism of crystal fractionation at relatively high pressures (Macdonald, 1975). It is unlikely that such differentiation occurred *in situ* at the levels seen today in the Hareheugh Craigs intrusion. Rather, the emplacement may have resulted from a series of closely spaced, pulsed evacuations of a deeper level, internally stratified or zoned magma chamber, in which there was a downward gradation from more to less differentiated material. Another possibility is that fractionation took place during slow ascent of the magma and that this led to the postulated vertical zonation. Both mechanisms could lead to the internal intrusive arrangements seen today.

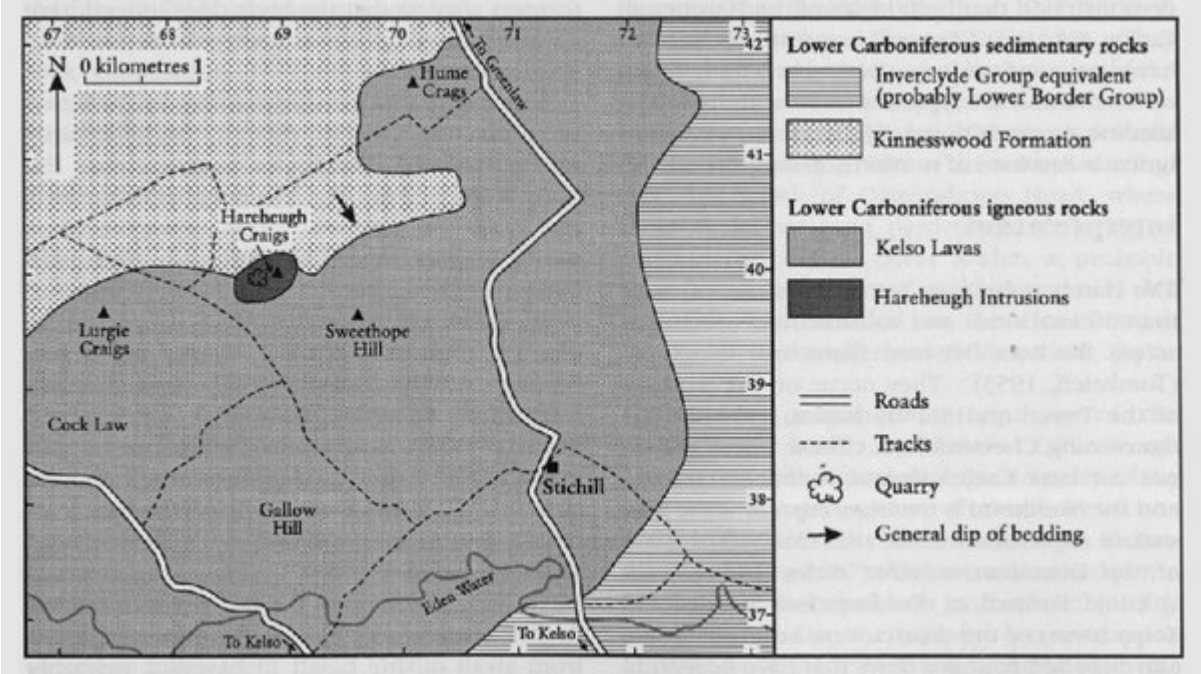
In general, where relative ages of emplacement can be deduced in such composite bodies, the more evolved aphyric or microporphyritic component is intruded before the less evolved macroporphyritic one. This is probably because, due to crystal-settling mechanisms, most phenocrysts are concentrated in the lower parts of the underlying magma chamber, and this crystal-charged batch of magma is usually the last to be either erupted or intruded at shallower crustal levels. It is significant that the porphyritic facies includes plagioclase in addition to mafic phenocrysts, suggesting that the magma at this level was already somewhat fractionated and hence of lower density that a basaltic magma, allowing the plagioclase to sink. At Hareheugh Craigs, the relative ages of the two facies are not known and the few available analyses suggest little correlation between the phenocryst content and whole-rock composition. Hence the exact sequence of fractionation and emplacement remains somewhat enigmatic.

Conclusions

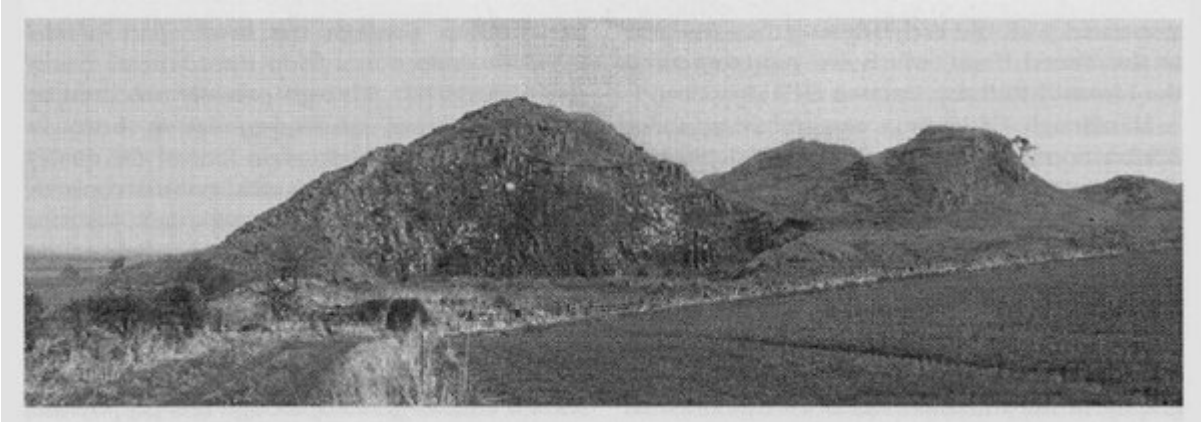
The intrusion at the Hareheugh Craigs GCR site is representative of the many small plug-like intrusions that cut the Tournaisian Kelso Lavas and forms part of a swarm of over 50 sub-volcanic necks extending south-westwards into the Birrenswark Volcanic Formation. These may have been the sites of eruption of the lavas. It is one of few intrusions in the swarm that are composite. The two components present are basaltic hawaiite or hawaiite in composition; the lower one is generally aphyric to sparsely porphyritic, but the upper component contains large phenocrysts of feldspar, olivine, clinopyroxene and spinel.

The components of the composite intrusion are considered to have been emplaced as two magmas of differing composition that formed within a single, vertically zoned magma column at deeper levels in the Earth's crust. Such composite bodies, whether in the form of lava flows or intrusions, provide a valuable insight into the crystallization and chemical evolution of magmas as they rise through the crust (see Dunrod Hill GCR site report). The fresh rocks of this intrusion have contributed to several important petrographical and geochemical studies of the igneous rocks associated with the early development of the Tweed, Northumberland and Solway basins.

References



(Figure 3.13) Map of the area around the Hareheugh Craigs GCR site. Based on Geological Survey Old Series 1:63 360 Sheet 25, Galashiels (1879).



(Figure 3.14) View from the south-west of Hareheugh Craigs; a plug-like intrusion of hawaiitic rocks within the Kelso Lavas. (Photo: C. MacFadyen.)