The Shiant Isles

OS Grid Reference: NG415980

Highlights

The Shiant Isles sill complex provides spectacular evidence for the differentiation of alkali-olivine basalt magma: basal olivine-rich picrites formed by accumulation under gravity outcrop on Eilean an Tighe–Garbh Eilean and analcite syenites, representing late differentiates, are present on Eilean Mhuire.

Introduction

The rocky Shiant Isles lie about 20 km north of Skye and 8 km south-east of Lewis. They consist of sheets of dolerite intruded into Jurassic sediments and form the exposed part of a sheet complex in the Little Minch. Their geological interest lies in the considerable textural, compositional and mineralogical variation exhibited by the dolerite which is magnificently exposed in the cliff sections (Fig. 7.1) and has been further explored by drilling.

Figure 7.1: The north-west corner of Garbh Eilean, showing the main sill (left) and the lower sill (with natural arch), Shiant Isles. (Photo: F.G.F. Gibb.)

Early accounts of the geology of the Shiant Isles were given by MacCulloch (1819), Judd (1878, 1885), Heddle (1884) and Geikie (1897), and the picrites were figured in the classic British Petrography by Teall (1888, plate 3). The first detailed account was by Walker (1930) and subsequently, the mineralogy and petrology were investigated by Johnston (1953), Murray (1954), Drever (1953, 1957), Drever and Johnston (1958, 1965) and Gibb (1973). Reassessments of the structure of the sill complex has been provided by Gibb and Henderson (1984, 1989).

Description

The sills of the Shiant Isles are members of a major alkali-dolerite sheet complex intruding Jurassic sediments of the Little Minch Basin (Chesher *et al.*, 1983, Fig. 3) and probably represent an extension of the Trotternish sills of northern Skye (Rubha Hunish). Thick sheets of alkaline-olivine dolerite form the islands of Eilean Mhuire, Garbh Eilean, Eilean an Tighe and the Galtachean islets to the west. Jurassic (Lias) sedimentary rocks crop out on all three large islands although the outcrop on Eilean an Tighe is limited to a small coastal exposure. Fairly flat-lying contacts between sediments and dolerites, and the steep, massive columnar jointing of the dolerite (cf. Walker, 1930, plates 31, 32 and 33), indicate that the intrusions form sheets more or less conformable to the bedding of the sediments. The main body of sediments on Eilean Mhuire forms a major raft in the dolerite and the base of the sill is probably exposed on the west of the island, where Gibb and Henderson (1984) found sediments at sea-level. On Garbh Eilean, a lower sill on the north coast is separated by sediments from the main sill which is at least 130 m thick. The southern continuation of the main Garbh Eilean sill is on Eilean an

Tighe and the base of this sill was proved about 30 m below sea-level in a drill hole near the north end of the isthmus connecting the two islands. Walker (1930) considered that the Shiant Isles consisted of three separate sills:

1. the main sill of Garbh Eilean–Eilean an Tighe plus the Galtachean outcrops;

2. the lower sill of Garbh Eilean plus, the upper sill of Eilean Mhuire; and

3. the lower sill of Eilean Mhuire.

Drever (1957) argued that there were only two, subsequently reduced to a single sill (for example, Drever and Johnston, 1965; Wager and Brown, 1968, p. 532). A re-examination of the three main islands by Gibb and Henderson (1984) provided convincing evidence that there are at least three, and probably four, sills:

1. the main sill of Gharb Eilean–Eilean an Tighe;

2. the lower sill of Garbh Eilean;

3. the Eilean Mhuire sill with a large raft of sediment, and perhaps also a separate sill;

4. forming the Galtachean islets.

Analcite-olivine dolerite (crinanite) forms the majority of exposures, but towards the base of the Garbh Eilean main sill there is a noteworthy increase in modal olivine giving rise to over 45 m thickness of picrodolerite; this is in sharp contact with an underlying 23 m of picrite (modal olivine >40%). This in turn is separated from underlying sediments by a thin layer of fine-grained, olivine-free analcite dolerite (teschenite) (Drever and Johnston, 1965; Gibb and Henderson, 1984, Fig. 2). A thin picrite *(c.* 2 m) occurs in sharp contact with underlying crinanite at the top of the main sill (Gibb and Henderson, 1978a, 1984, Fig. 2; Fig. 7.3). Vesicular crinanite high on Eilean an Tighe, estimated to be from near the top of the sill, contains poikilitic nepheline. The upper part of the Eilean Mhuire sill, exposed towards the south-east end of the island, contains a layer about 20 m thick much enriched in alkali feldspar and alkali pyroxene; this is an analcite syenite with essexite segregations (Walker, 1930). It is therefore apparent that both the main sill of Garbh Eilean–Eilean an Tighe and the Eilean Mhuire sill show vertical variations suggestive of crystal fractionation and differentiation. Variation in modal mineralogy and texture, for example, is accompanied by variation in the mineral compositions (cryptic variation); clinopyroxenes range upwards in the sills from diopsidic augite to hedenbergite, with marked soda-enrichment in late pegmatitic facies. The pyroxenes follow the typical flattish alkaline trend when plotted in the pyroxene quadrilateral (Gibb, 1973, figs 3 and 4). Olivines in the picrite and picrodolerite maintain core compositions of about Fo80, but at higher levels in the sills become increasingly zoned, with margins of more iron-rich olivine. Intense zoning of the olivine also occurs in the crinanites (Johnston, 1953, Fig. 2). The olivine-rich rocks contain zoned plagioclases, again the core compositions remain fairly constant at about An80 but zoning to sodic margins becomes more pronounced upwards and is strongly developed in the crinanites. Pegmatitic veins cut the picrites and pegmatite veins and bands occur in the higher parts of sills and, according to Walker (1930), are common in the Galtachean crinanites. The veins tend to be rich in analcite and natrolite, after original feldspar, and some carry small proportions of nepheline, alkali amphibole, aegirine and biotite.

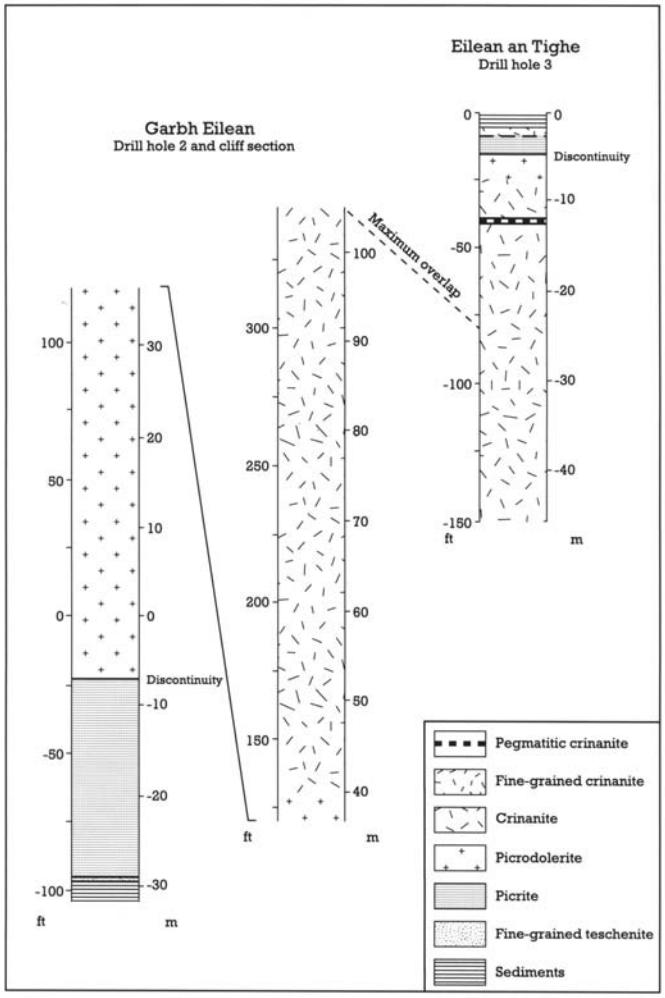

Figure 7.3: Simplified vertical sections through the main Garbh Eilean-Eilean an Tighe sill, Shiant Isles (after Gibb and Henderson, 1984, figure 2)

Interpretation

Correlation of the isolated outcrops of the Shiant Isles Sill Complex is difficult simply because the outcrops are on well-separated islands. However, the presence of roof and floor relationships on Eilean Mhuire, the occurrence of an obvious floor to the sheet forming much of Eilean an Tighe and Garbh Eilean, and a roof-like contact below sediments on the north of Garbh Eilean, make it fairly certain that we are dealing with a sheet complex with at least three and possibly four leaves.

The Shiant Isles sills were interpreted by Walker (1930) to provide a particularly clear example of magmatic differentiation through the *in situ* gravity settling of early-formed crystals within cooling magma: the picrites and picrodolerites represent rocks enriched through the settling of early-formed olivine, while the later-crystallizing and generally lower-temperature phases were concentrated towards the upper parts of the sill where the analcite syenite (syenoteschenite, of Gibb and Henderson, 1984, p. 29) and the alkaline segregations represent the extreme products of fractionation. The discovery by Drever and Johnston (1965) that the picrite had a sharp, undulating contact with the overlying picrodolerite rather than a gradational relationship, necessitated some reassessment of Walker's interpretation.

Conclusions

The Shiant Isles sill is a multiple intrusion in which an initial injection of picrite was followed by a large volume of analcite-olivine basalt magma. The sheets provide spectacular evidence for gravitational settling of olivine to form basal picrodolerites, with the concentration of residual differentiates to give segregations of analcite syenite in their higher parts. The contrasted rock

types demonstrate the wide range of products which may be derived from an alkali-olivine basalt magma.

It is possible to demonstrate from the field-relationships that the dolerites form a series of separate sheets rather than a single sill.

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