POINT OF AYRE

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OS Grid Reference: HY590038

Introduction

On the Deerness Peninsula of eastern mainland Orkney, and on the neighbouring island of Shapinsay, volcanic rocks of the Deerness Volcanic Member (formerly known as the Eday volcanic rocks) occur within the Middle Devonian, Eday Flagstone Formation (Peach and Horne, 1880; Flett, 1898; Wilson *et al*., 1935). Exposures of the volcanic rocks are generally very poor, but good exposures occur on the foreshore at Point of Ayre in the SE of Deerness. Here, the member consists of a vesicular basalt flow that was extruded on to wet lake sediments. The basalt has been substantially altered, which led to an original 'alkaline' classification (Kellock, 1969), but later geochemical studies have shown that it has similar calc-alkaline characteristics to other volcanic rocks of the Old Red Sandstone volcanic suite (Thirlwall, 1979; Fitton *et al*., 1982). The lava has also provided significant palaeomagnetic information (Robinson, 1985).

Description

There are two outcrops of lava at Point of Ayre (Figure 9.51). The larger outcrop, in the north of the GCR Site, consists of the upper 7 m of an altered greenish-black basalt flow, which forms the foreshore and low cliffs above the Misker rocks. A second outcrop, on the upper shore 30 m to the SW, consists of the top 0.5 m of a vesicular lava. As the two exposures appear to be faulted against each other it is impossible to ascertain whether they represent different flows or different portions of the same flow. However, T. R. Astin (pers. comm., 1997) considers that the two exposures demonstrate a lateral reduction in thickness that occurred at the margin of a single flow.

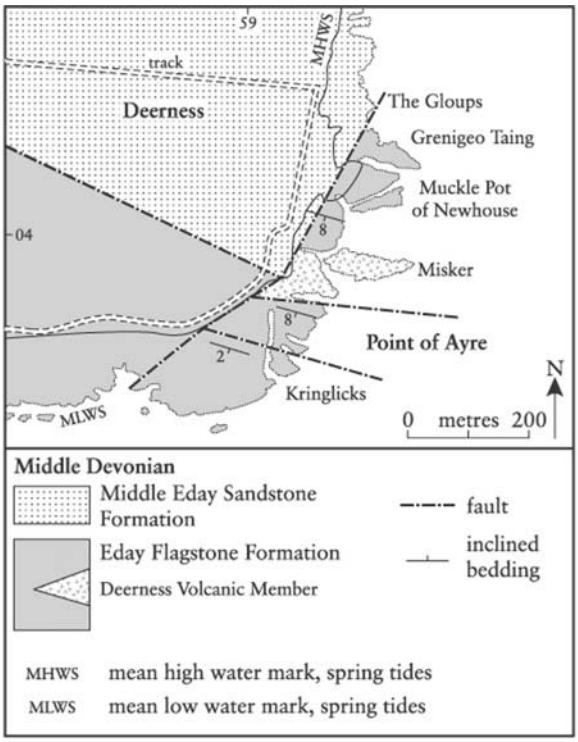

Figure 9.51: Map of the Point of Ayre GCR site, Orkney.

The top 30 cm of the flow, exposed in low cliffs above high-water mark, contains numerous pipe amygdales up to 20 mm in diameter that are orientated perpendicular to the flow top.

Although, most of the amygdales are filled with carbonate and zeolites, some now form hollow voids and so have either lost their filling or are simple vesicles. The pipes terminate at least 25 mm from the flow top and none connect with the upper surface. Below the amygdaloidal zone, the flow exhibits spectacular spheroidal weathering. Near the top of the flow the spheroidal masses are separated by a grid of sediment-filled fractures originating from the overlying Eday Flagstone Formation, indicating that the weathering occurred prior to burial. On the foreshore, cross-bedded tuffaceous sandstones fill hollows in the upper surface of the flow (Kellock, 1969, pl. 1B) and undisturbed laminations in the sediment can be traced to within 5 cm of the top of the igneous rock. The sediments filling the veins and immediately overlying the basalt show no evidence of thermal alteration.

Beneath the amygdaloidal zone the lava is composed of an intimate association of two types of basalt. The more abundant, massive component contains microphenocrysts of olivine and plagioclase set in a groundmass of lilac-coloured clinopyroxene, plagioclase, analcime and carbonate. The primary mineralogy has been subjected to extensive alteration, much of the olivine now being replaced by serpentine and bowlingite. The second component consists of pegmatitic veinlets and patches within the massive basalt. In the veins and patches, olivine up to 0.5 mm and feldspars up to 2 mm are ophitically enclosed by lilac-coloured clinopyroxenes up to 10 mm in diameter. The feldspars are mantled by clear rims of sanidine–anorthoclase and the olivines are substantially altered to serpentine. Analcime, carbonate and zeolite are present as interstitial patches.

Interpretation

The Point of Ayre basic rocks have been subject to a number of differing interpretations in the past (Peach and Horne, 1880; Flett, 1898; Wilson *et al*., 1935). However, more recently Kellock (1969) has suggested that the lack of thermal alteration and disruption of the overlying sediments, and the presence of sediment-filled veins are evidence that the flow became inundated by sediment only after it had cooled significantly. As the base of the flow(s) is not exposed it is impossible to tell what the nature of the underlying sediment was at the time of the basalt eruption. However, T. R. Astin (pers. comm., 1997) has reported synsedimentary, dish-shaped loading structures in the sediments below the flow and has suggested that these are the result of seismic tremors associated with the eruption of the lava. If so, the lava must have been erupted onto unconsolidated, possibly wet sediments.

The Deerness Volcanic Member occurs within the Eday Flagstone Formation, which is of Givetian age (Westoll, 1977; Marshall, 1996) and can be correlated throughout eastern Orkney (Astin, 1985). It has been suggested that the formation can be correlated on sedimentological grounds with the lower part of the Hoy Sandstone Formation of Hoy (D. Rogers, pers. comm. in Astin, 1990, p. 150; Marshall *et al*., 1996, p. 459) and hence it is possible that the Deerness Volcanic Member is near-coeval with the Hoy Volcanic Member. In a study of the palaeomagnetism of the 'Eday Group', Robinson (1985) found that most samples of sedimentary rock have been affected by a widespread remagnetization, possibly attributable to deep sub-unconformity weathering and oxidation in the Late Palaeozoic. The basalt of the Point of Ayre and sedimentary rocks in the contact zone, however, give a consistent remnant pole position of 8°N 167°E (present-day grid). Thus the Point of Ayre rocks are significant in preserving a late Mid-Devonian magnetic signature from the Orcadian Basin.

Kellock (1969) noted that the Deerness lava has many geochemical and petrographical features in common with the alkali basalts of the Carboniferous of the Midland Valley. However, Thirlwall (1979) (and in Fitton *et al*., 1982) noted that, although the major element bulk composition of these substantially altered rocks is that of an alkali basalt, their trace element signature is more allied to calc-alkaline rocks and is similar to the volcanic rocks of Shetland (see the Eshaness Coast GCR site report). It seems probable, therefore, that the apparent alkaline nature of these rocks is due to alteration, in particular the large amount of secondary analcime present in the groundmass. Thus, although the Deerness lava is possibly near-contemporaneous with the Hoy Volcanic Member (see theToo of the Head GCR site report), its inferred primary composition contrasts with the alkaline nature of the Hoy lava and shows that these two lavas cannot be related. The Deerness Volcanic Member comprises the youngest calc-alkaline rocks known in the Orcadian Basin, and hence marks the last possibly subduction-influenced magmatism in this area. The Hoy Volcanic Member shows geochemical features that

are transitional between calc-alkaline and alkaline trends, whichFrancis (1988) considers to mark a change to an extensional tectonic regime. If so, these two GCR sites on Orkney mark an important time when magmatism ceased to be influenced by subducted Iapetus oceanic lithosphere, and became characteristic of the extensional tectonics that were to dominate Carboniferous times in Scotland.

Conclusions

The Point of Ayre GCR site is representative of the poorly exposed Eday volcanic rocks (the Deerness Volcanic Member). The basalt flow and surrounding sedimentary rocks are particularly interesting as they contain many features characteristic of lava extrusion in a subaerial environment. Although the alteration of the basalt has imparted an apparent alkaline character to the rock, the trace element geochemistry preserves evidence of an original calc-alkaline nature. These rocks therefore provide evidence of the last calc-alkaline volcanism associated with the closure of the Iapetus Ocean. Together with the Hoy Volcanic Member (see the Too of the Head GCR site report), the Eday volcanic rocks are significant in preserving a Mid-Devonian magnetic field, unmodified by the widespread late Palaeozoic remagnetization event which affected most of the associated sedimentary rocks.

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