TOO OF THE HEAD

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OS Grid Reference: ND184992–ND196990

Introduction

The coastal exposures at Too of the Head, on the west side of Rackwick Bay, Isle of Hoy show the most extensive section through the Hoy Volcanic Member (Figures9.52, 9.53). Here, the member comprises a lower volcaniclastic unit of ash-fall tuffs, agglomerates and tuffaceous sandstones and an upper basaltic lava. Elsewhere, one or other of the two units is commonly absent. The lower, volcaniclastic unit is only known from a number of outcrops north of the Bring Fault on Hoy and one small occurrence on the neighbouring coast of Mainland Orkney near Houton. The Hoy lava crops out most extensively in the north of Hoy, in particular at Too of the Head and at the base of the Old Man of Hoy sea stack. Only one limited outcrop occurs in the south of Hoy near the township of Melsetter. The Hoy Volcanic Member rests unconformably on an eroded surface of the previously folded and faulted Middle Old Red Sandstone, Lower Eday Sandstone Formation and is succeeded, apparently conformably, by the Lang Geo Sandstone Member of the Hoy Sandstone Formation.

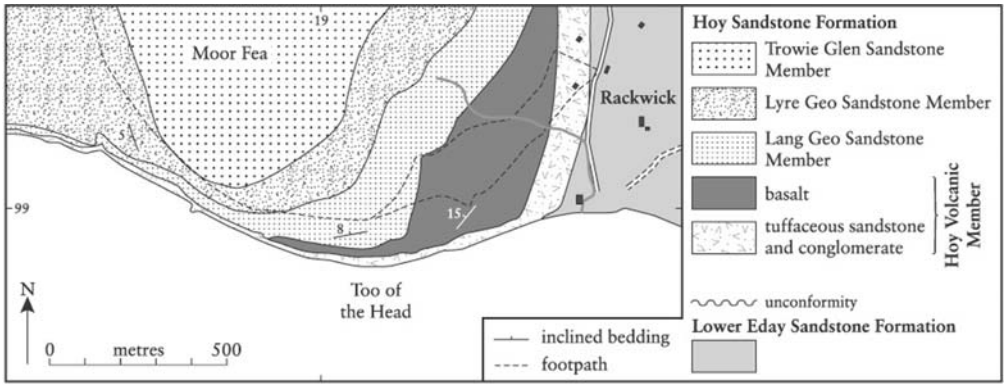

Figure 9.52: Map of the Too of the Head GCR site, Hoy, Orkney.

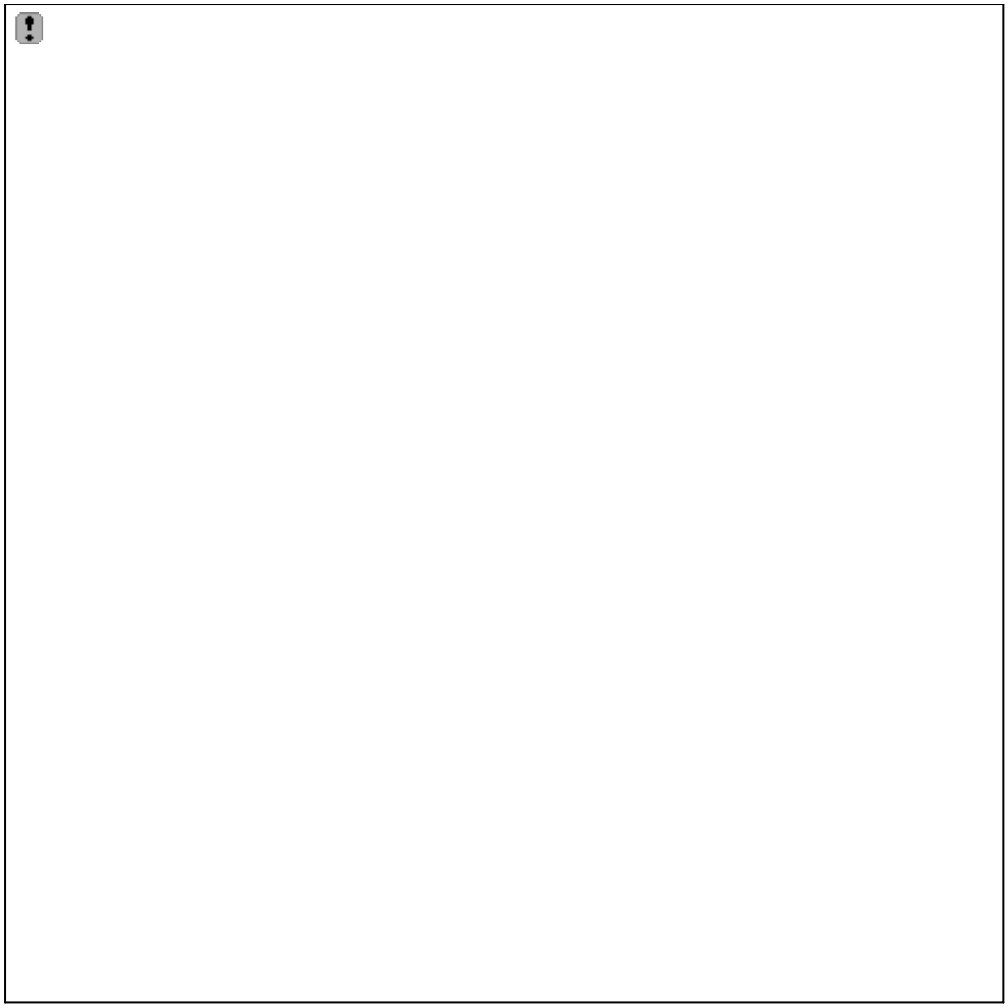

Figure 9.53: The cliffs of Too of the Head on the west side of Rackwick Bay, Hoy. The pale rocks of the cliffs close to the buildings are composed of the Lower Eday Sandstone Formation. The lower and middle parts of the cliffs above and behind the buildings are composed of the basal volcaniclastic rocks and lava of the Hoy Volcanic Member. The paler rocks at the top of the cliff belong to the Lang Geo Sandstone Member of the Hoy Sandstone Formation. (Photo: BGS no. D1489.)

The volcanic rocks of Hoy were described first by Peach and Horne (1880) and later by Flett (1898) and Wilson *et al*. (1935). More detailed descriptions, especially of the volcaniclastic rocks, are given by McAlpine (1979). The basalt from Too of the Head has been included in a geochronological study by Halliday *et al* . (1977, 1979b, 1982), and its geochemistry has been discussed by Thirlwall in relation to other Siluro-Devonian volcanic rocks of northern Britain (Thirlwall, 1979, and in Fitton *et al*., 1982). The lava has also been the subject of a palaeomagnetic study (Storetvedt and Petersen, 1972; Storetvedt and Meland, 1985). The Hoy volcanic rocks are of particular interest because they are one of the youngest preserved representatives of the Old Red Sandstone volcanic suite and appear to represent a transitional phase between the dominantly calc-alkaline volcanism of Silurian and Devonian times and the alkaline volcanicity characteristic of the Carboniferous in Scotland.

Description

The basal unit at Too of the Head consists of an ash-fall tuff that contains numerous angular blocks and lapilli of basalt and rounded volcanic bombs, and a brownish-red, locally cross-bedded tuffaceous sandstone. In the east of the GCR site, the unit is 20 m thick, but it thins to only a few metres and becomes finer grained in the west, below the headland of Moor Fea. The overlying columnar-jointed lava also thins markedly westwards from over 60 m at Rackwick, and it wedges out completely about one kilometre west of Rackwick Bay. The lava is a porphyritic basalt that contains phenocrysts, up to 4 mm, of euhedral to subhedral bytownite, euhedral or anhedral forsteritic olivine and anhedral sodic augite. All of the phenocryst phases

are zoned and are variably resorbed. The groundmass consists of aligned laths of bytownite–labradorite with intergranular olivine, clinopyroxene, magnetite, K-feldspar and devitrified glass. The primary mineral assemblage is variably altered and analcime and calcite are significant secondary minerals.

Interpretation

As the outcrop of the Hoy Volcanic Member is discontinuous it is not known whether it is the result of a single eruption or is composed of several separate flows. The three-dimensional geometry of the volcaniclastic unit in the north of Hoy cannot be reconstructed, but the presence of large blocks and bombs at Too of the Head and the westward thinning implies that the eruption centre was located only a short distance away. A likely location for the centre was close to or along the WSW-trending Bring Fault, which cuts across the north of Hoy and was one of the major faults active during the formation of the Orcadian Basin.

As the unfolded Hoy Volcanic Member rests unconformably on an irregular surface of gently folded Middle Old Red Sandstone rocks, the volcanic rocks and the succeeding ‘Hoy Sandstone' have formerly been regarded as Upper Old Red Sandstone (e.g.Mykura, 1976, 1991). However, it is now considered that the unconformity, although marked on Hoy, is of local extent only (Rogers *et al.*, 1989). It has further been suggested, on sedimentological grounds, that the ‘Hoy Sandstone' is laterally equivalent to the ‘Eday Group' of eastern Orkney (Rogers, pers. comm., in Astin, 1990, p. 150; Marshall *et al.*, 1996, p. 459). Although there is no palaeontological evidence from the Hoy Volcanic Member or the immediately overlying sandstones, the underlying strata on Hoy and the proposed laterally equivalent strata to the lower part of the ‘Hoy Sandstone' in eastern Orkney, are both assigned to the Givetian on palynological evidence (Marshall, 1996). Hence it seems likely that the Hoy Volcanic Member is of Mid-Devonian age and possibly near-contemporaneous with the Eday volcanic rocks of eastern Orkney (see the Point of Ayre GCR site report). The geochronological study of the basalt of Too of the Head (Halliday *et al.*, 1977, 1979b, 1982) has yielded an Ar-Ar age of 379 ± 10 Ma, broadly consistent with this biostratigraphical age, although the uncertainty in the date and the altered state of the rocks does not allow precise correlation. However, it is clear that the Eday and Hoy volcanic rocks of Orkney are the youngest expressions of Old Red Sandstone volcanism in Britain.

The basalt at Too of the Head has been examined by Storetvedt and Petersen (1972) and Storetvedt and Meland (1985) as part of a palaeomagnetic study of the Devonian rocks of Hoy. Storetvedt and Petersen (1972) found that the lava contains a two-polarity magnetization structure consisting of a high-temperature remanence associated with spinel and a lower temperature remanence associated with haematite. They concluded that the spinel reflects the geomagnetic field at the time of eruption as it is a product of high-temperature alteration soon after the solidification of the lava. Analysis of the spinel remanence indicated a consistent remnant pole position of 23°N 146°E (present-day grid). This compares tolerably well with a pole position of 8°N 167°E obtained by Robinson (1985) for the near-contemporaneous Eday volcanic rocks of Mainland Orkney (see the Point of Ayre GCR site report). As the haematite was formed at a much lower temperature, it is likely that its remanence has recorded a significantly later geomagnetic field.

Thirlwall (1979) reported four analyses of the Hoy lavas, of alkali olivine basalt to hawaiite composition (48–52% SiO_2). Although there is variation in the compositions, he found no significant trace element correlations and concluded that the rocks cannot be related by simple fractional crystallization processes. The samples are unique within the Old Red Sandstone volcanic suite of northern Britain in having between 3 and 5% normative*nepheline*, which, because of the presence of fresh olivine in the rock, is believed to be a primary characteristic. Trace element concentrations and ratios are also typical of alkali basalts, in particular the high Nb, P and light rare earth elements. The clearly alkaline nature of the Hoy basalt sets it apart from the more calc-alkaline character of volcanic rocks from the rest of the province, although the relatively low TiO_2 is typical of arc-related, rather than continental alkali basalts elsewhere. Francis (1988) has suggested that this is the first evidence of a change from compressional, subduction-related tectonics to the extensional regime that was later to produce the voluminous alkaline volcanic rocks of Scotland during the Carboniferous.

Conclusions

The Too of the Head GCR site is of national importance as it contains the most complete section through the Hoy Volcanic Member. It is of international importance because the volcanic sequence provides a rare potential time-marker within the Devonian successions of Europe. A radiometric age of 379 ± 10 Ma from the lava is consistent with the Givetian age extrapolated from plant spores in the underlying strata and lateral correlation of the overlying strata on sedimentological grounds. Studies of the magnetic field preserved by the lava show that at this time the north magnetic pole was situated at 23°N 146°E (present-day grid). The markedly alkaline character of the Hoy lava contrasts with other volcanic rocks of the Middle Devonian of Orkney and Shetland and provides important evidence of the transition to the extensional tectonic regime that characterized Scotland during the Carboniferous.

Reference list

Astin, T. R. (1990) The Devonian lacustrine sediments of Orkney, Scotland; implications for climatic cyclicity, basin structure and maturation history. *Journal of the Geological Society of London*, **147**, 141–51.

Fitton, J. G., Thirlwall, M. F. and Hughes, D. J. (1982) Volcanism in the Caledonian orogenic belt of Britain. In *Andesites* (ed. R. S. Thorpe), Wiley, Chichester, pp. 611–36.

Flett, J. S. (1898) The Old Red Sandstone of the Orkneys. *Transaction of the Royal Society of Edinburgh*, **39**, 383–424.

Francis, E. H. (1988) Mid-Devonian to early Permian volcanism: Old World. In *The Caledonian – Appalachian Orogen* (eds A. L. Harris and D. J. Fettes), *Geological Society Special Publication*, No. **38**, pp. 573–84.

Halliday, A. N., McAlpine, A. and Mitchell, J. G. (1977) The age of the Hoy Lavas, Orkney. *Scottish Journal of Geology*, **13**, 43–52.

Halliday, A. N., McAlpine, A. and Mitchell, J. G. (1979b) The age of the Hoy Lavas, Orkney: Erratum. *Scottish Journal of Geology*, **15**, 79.

Halliday, A. N., McAlpine, A. and Mitchell, J. G. (1982) 40Ar/39Ar age of the Hoy lavas, Orkney. In *Numerical Dating in Stratigraphy* (ed. G. S. Odin), Wiley, Chichester, pp. 928–31.

Marshall, J. E. A. (1996) *Rhabdosporites langii*, *Gemnospora lemurata* and *Contagisporites optivus*: an origin for heterospory within the Progymnosperms. *Review of Palaeobotony and Palynology*, **93**, 159–89.

McAlpine, A. (1979) The Upper Old Red Sandstone of Orkney, Caithness and neighbouring areas. Unpublished PhD thesis, University of Newcastle upon Tyne.

Mykura, W. (1976) *British Regional Geology: Orkney and Shetland*, HMSO, Edinburgh, for Institute of Geological Sciences.

Mykura, W. (1991) Old Red Sandstone. In *Geology of Scotland*, 3rd edn (ed. G. Y. Craig), The Geological Society, London, pp. 297–344.

Peach, B. N. and Horne, J. (1880) The Old Red Sandstone of Orkney. *Proceedings of the Royal Physical Society of Edinburgh*, **5,** 329–42.

Robinson, M. A. (1985) Palaeomagnetism of volcanics and sediments of the Eday Group, Southern Orkney. *Scottish Journal of Geology*, **21**, 285–300.

Rogers, D. A., Marshall, J. E. A. and Astin, T. R. (1989) Devonian and later movements on the Great Glen fault system, Scotland. *Journal of the Geological Society of London*, **146**, 369–72.

Storetvedt, K. M. and Meland, A. H. (1985) Geological interpretation of palaeomagnetic results from Devonian rocks of Hoy, Orkney. *Scottish Journal of Geology*, **5,** 337–52.

Storetvedt, K. M. and Petersen, N. (1972) Palaeomagnetic properties of the Middle-Upper Devonian volcanics of the Orkney Islands. *Earth and Planetary Science Letters*, **14**, 269–78.

Thirlwall, M. F. (1979) The petrochemistry of the British Old Red Sandstone volcanic province. Unpublished PhD thesis, University of Edinburgh.

Wilson, G. V., Edwards, W., Knox, J., Jones, J. C. B. and Stephens, J. V. (1935) The geology of the Orkneys. *Memoir of the Geological Survey*, *Scotland*.