Kershope Bridge, Scottish Borders

[NY 496 833]–[NY 501 835]

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Introduction

The Kershope Bridge GCR site has been selected to represent the Kershopefoot basalts, a sequence of basaltic rocks that occurs within the upper part of the (Holkerian) Middle Border Group in a number of places south and southeast of Langholm. The site includes the disused road-metal quarry at Kershope Bridge and a section in the nearby Kershope Burn that here forms the border between Scotland and England (Figure 3.16). There are several other small, disconnected outcrops in the area, mostly on the Scottish side of the border to the west and north-east. These rocks represent a phase of tholeiitic to mildly alkaline volcanic activity younger than that of the Kelso Lavas, the Birrenswark Volcanic Formation and the Cockermouth basalts but older than the Glencartholm Volcanic Beds. All of these are associated with the early tectonic and sedimentary evolution of the Northumberland, Solway and Tweed basins.

The various exposures of the Kershopefoot basalts occupy more-or-less the same strati-graphical position throughout their outcrop. They attain a maximum thickness of about 36.5 m and probably represent several lava flows. Doubt has been expressed about their extrusive origin. Peach and Horne (1903) believed that some of the outcrops of the Kershopefoot basalts are lavas whereas others are intrusions. Garwood (1931), Lumsden *et al.* (1967) and Day (1970) referred to these rocks non-committally as the 'Kershopefoot Basalt'. Detailed descriptions of the rocks are to be found in Geological Survey memoirs (Lumsden *et al.,* 1967; Day, 1970) and the basalts were included in a widespread geochemical study of Dinantian magmatism in northern Britain by Smedley (1986a).

Description

The Kershopefoot basalts occur within the Middle Border Group, part of the Carboniferous Limestone Series. Possibly up to 490 m thick, the group shows an overall upward transition from mudstones and limestones with marine faunas and algal bands, through alternating, thinly bedded siltstones, sandstones, calcareous siltstones and limestones, to a massive, current-bedded sandstone unit known as the Larriston Sandstone. However, according to Lumsden *et al.* (1967), this sandstone facies cannot be traced confidently south of Newcastleton into the region occupied by the Kershopefoot basalts. Here, the sequence in the Kershope Burn shows sandstones with many more interbeds of argillaceous and calcareous units (Day, 1970). Beds below the basalts, exposed on neighbouring hillsides, comprise yellow, cross-bedded, fine-grained sandstone.

Basaltic lava is well exposed in the quarry by Kershope Bridge [NY 5005 8339]. Neither the top nor the bottom contact of the basalt is seen in the area, but Lumsden *et al.* (1967) reported sedimentary rocks in the floor of the quarry. The quarry faces reveal a bluish- to greenish-grey fine- to medium-grained basalt with unevenly distributed, large feldspar phenocrysts (typically 5–6 mm). These are rare to absent towards the base and top of the section. The main mass of the rock is neither vesicular nor amygdaloidal, though there are scattered large drusy cavities with infillings and coatings of carbonate, quartz in various forms, and baryte. The higher parts of the exposed section are much more vesicular and brecciated with some scoriaceous fragments. Long-exposed surfaces show the development of spheroidal weathering. The worked faces are cut by jointing with well-developed near-vertical to steeply inclined NE-(prominent) and SW-directed sets.

In the Kershope Burn, downstream (southwestwards) from the bridge, there are exposures of basalt and associated sedimentary rocks. The burn crosses the axes of two synclines with the result that beds are repeated. The amygdaloidal basalt is weathered greenish-brown, and shows some signs of brecciation. In the more northeastern exposures [NY 4973 8332], it is overlain by massive sandstone and limestone dipping to the south-west though the contact is not seen. The upper parts of the basalt are also seen a little farther to the south-west at [NY 4941 8310]. Here amygdales are filled with

red and green clay and may be flattened and streaked out, parallel to a faint flow-induced igneous lamination. The basalt is overlain by limestones, cherty sandstone breccia and sandstones dipping to the south-east, but here also, the contact relationships are not seen. Dips are typically in the range 20° to 45°.

Comprehensive descriptions of the petrography of the Kershopefoot basalts were given by R.W. Elliot (in Lumsden *et al.,* 1967) and R.K. Harrison (in Day, 1970). In thin section they show some lateral variation. At Kershope Bridge the rock is a porphyritic olivine basalt with phenocrysts of abundant labradorite, and subordinate olivine and clinopyroxene. The ground-mass consists of labradorite laths, commonly strongly flow-banded and ophitically enveloped by anhedral to subhedral, purplish titaniferous augite. At other localities the groundmass clinopyroxene of the basalt may be colourless and either microlitic or skeletal. Minor constituents include titaniferous magnetite, ilmenite, orthopyroxene and apatite. There is also a little interstitial analcime. Vesicles are infilled by chlorite, calcite, baryte, quartz, chalcedony and agate; amethystine quartz has been reported from low levels within the mass.

Whole-rock analyses show that the rocks range from basalt to hawaiite, with a range of silica saturation from hypersthene-normative to slightly nepheline-normative (Smedley, 1986a). As such they are typical of the transitional tholeiitic to mildly alkaline Dinantian lavas of northern Britain.

A yellow-weathered silty dolostone in the Kershope Burn [NY 4974 8332], about 0.6 m above the top of the basalt, is intensely brecciated, with veins of ankerite and joint surfaces coated with bitumen. There are also patches of chlorite, scattered grains of pyrite and the rock has been partially recrystallized. These features have been explained as a diagenetic rather than a contact metamorphic phenomena (Day, 1970).

Interpretation

On the first edition of the one-inch Geological Survey map (Sheet 11, Scotland; 1883), the western outcrops of the Kershopefoot basalts were shown as intrusive, whereas the others, including the outcrop of which the Kershope Bridge GCR site is part, were regarded as lava. Peach and Horne (1903) included the Kershope Bridge to Carby Hill outcrop as lavas within the Glencartholm Volcanic Beds. Elliott (1960) also considered some of the western outcrops of the Kershopefoot basalts to be intrusive, though the outcrop at Kershope Bridge was outside his area of study. Uncertainties over the mode of emplacement of these rocks were also expressed by Lumsden *et al.* (1967) and Day (1970), though eruption as lavas was suggested because of the slaggy vesicular upper part of the sequence. However, these authors agreed that the various outcrops are part of the same mass at a single stratigraphical level, and are at least 60 m (Day, 1970) or 120 m (Lumsden *et al.,* 1967) beneath the Glencartholm Volcanic Beds.

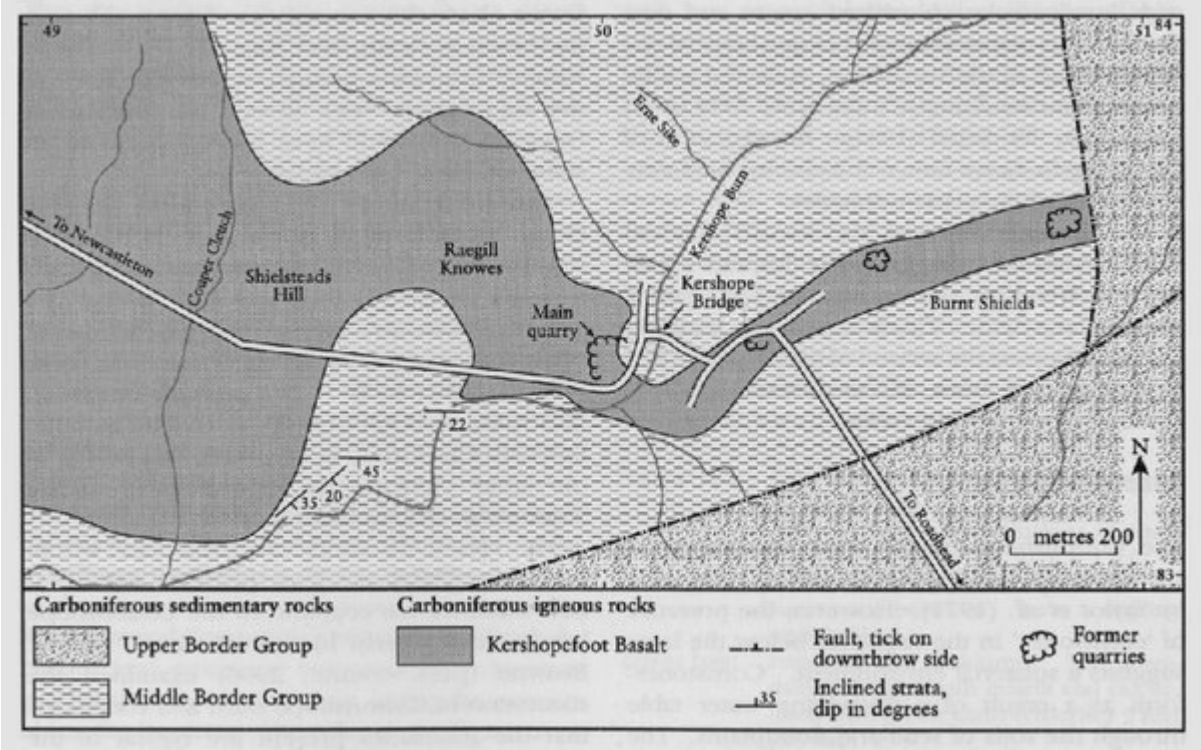
The doubt as to whether the Kershopefoot basalts are extrusive or intrusive arises because no contacts are exposed. There is a general lack of post-depositional recrystallization of the adjacent strata, but there are some thermal effects. At the base of the basalt in the Kershope Burn there is a general induration and some subtle bleaching of the more argillaceous beds. This is typical of both lavas and shallow intrusions but is not diagnostic. The upper contact is potentially more informative and, in Kershope Quarry, the uppermost parts of the basalt show well-developed vesiculation and brecciation, both phenomena more typical of, but not exclusive to, extrusive rocks. The basalt here is considered to be most probably a lava and, though inconclusive, the weight of evidence suggests that the basalts in general are extrusive rather than intrusive, and hence are contemporaneous with sedimentation in the Middle Border Group. Although no interflow junctions are known, the overall thickness of the basalts (over 36 m) and the variation in petrography and geochemistry between the various outcrops suggest the presence of more than one flow

In terms of major-and trace-element compositions the Kershopefoot basalts are similar to the older lavas of the Birrenswark Volcanic Formation, which crop out in the same area (Smedley, 1986a, 1988a). However, there are notable differences in some incompatible trace-element ratios that have been attributed to the derivation of magmas from a different portion of the mantle, despite the close geographical proximity and the relatively short time interval between the two volcanic episodes.

Conclusions

The Kershope Bridge GCR site is representative of the Kershopefoot basalts, a localized extrusive event during the deposition of the Visean Middle Border Group. Olivine-clinopyroxene-plagioclase-phyric basalt, basaltic hawaiite and hawaiite comprise a succession up to 36.5 m thick. Though commonly interpreted as lava, there is some doubt about this and an intrusive emplacement is possible. Like the younger Glencartholm Volcanic Beds and the older Kelso Lavas and Birrenswark Volcanic Formation, the activity that produced the basalts seen at Kershope Bridge is thought to relate to tensional fracturing along the northern margin of the actively subsiding Northumberland and Solway basins. This site provides important evidence within this framework for continued stretching and crustal thinning, allowing intermittent eruption of basaltic magmas during the development of Early Carboniferous basins.

References



(Figure 3.16) Map of the area around the Kershope Bridge GCR site. Based on Geological Survey 1:63 360 Sheet 11, Langholm (1968).