

EYCOTT HILL

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Introduction

Located in the NE of the Lake District Lower Palaeozoic inlier, the Eycott Hill GCR site demonstrates a complete succession of lavas and interbedded volcanoclastic rocks of the Eycott Volcanic Group (EVG) (Figure 4.5) and may be regarded as the type section. The volcanic rocks are well exposed in typical trap topography of successive scarp and dip slopes. Ward (1876, 1877) first described the geology of Eycott Hill and included the sequence on a geological cross section. A detailed geological map and description of the succession is included in the Geological Survey memoir for the Cockermouth district (Eastwood *et al.*, 1968, pp. 70–72). The area is included in Geological Survey sheets 23 (1997) and 29 (1999).

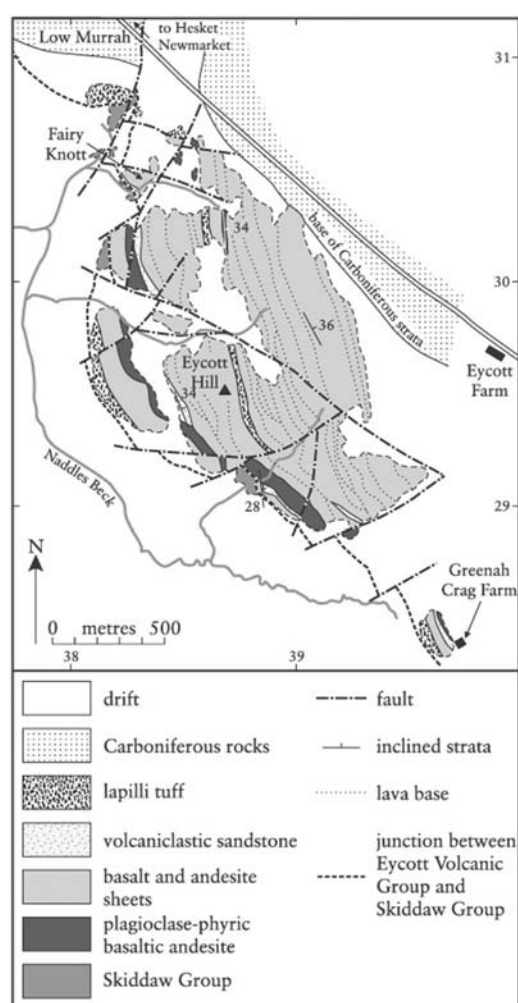


Figure 4.5: Exposure map of Eycott Hill (from Millward and Molyneux, 1992).

For many years the volcanic rocks in the northern part of the Lake District were considered to be an outlier of, and were included within, the Borrowdale Volcanic Group (BVG). It was not until the geochemical work of Fitton (1971) that the northern volcanic rocks, including those of Eycott Hill, were shown to be distinct from the larger outcrop in the central Lake District. A short while later the northern volcanic rocks were interpreted to be earliest Llanvirn in age and to overlie the Skiddaw Group conformably; they were then defined formally as the EVG (Downie and Soper, 1972). However, the age and basal relationship of the EVG have been challenged recently by Millward and Molyneux (1992) who mapped an unconformity at the base

of the group and suggested that the Eycott and Borrowdale volcanic groups may have been contemporaneous. The site provides evidence crucial to the current understanding of the base of the EVG.

The site is also of historical interest because it is the type area for the distinctive orthopyroxene-plagioclase-megaphyric basaltic andesite, given the local name of 'Eycott-type' basaltic andesite by Eastwood *et al.* (1968) (Figure 4.6). Ward (1875, 1876, 1877) first described and illustrated these coarsely porphyritic rocks that contain feldspar crystals locally more than 2 cm long, and Teall (1888, pp. 225–228), in his classic work on the petrography of British rocks, described them in detail as 'labradorite-pyroxene-porphyrite'.

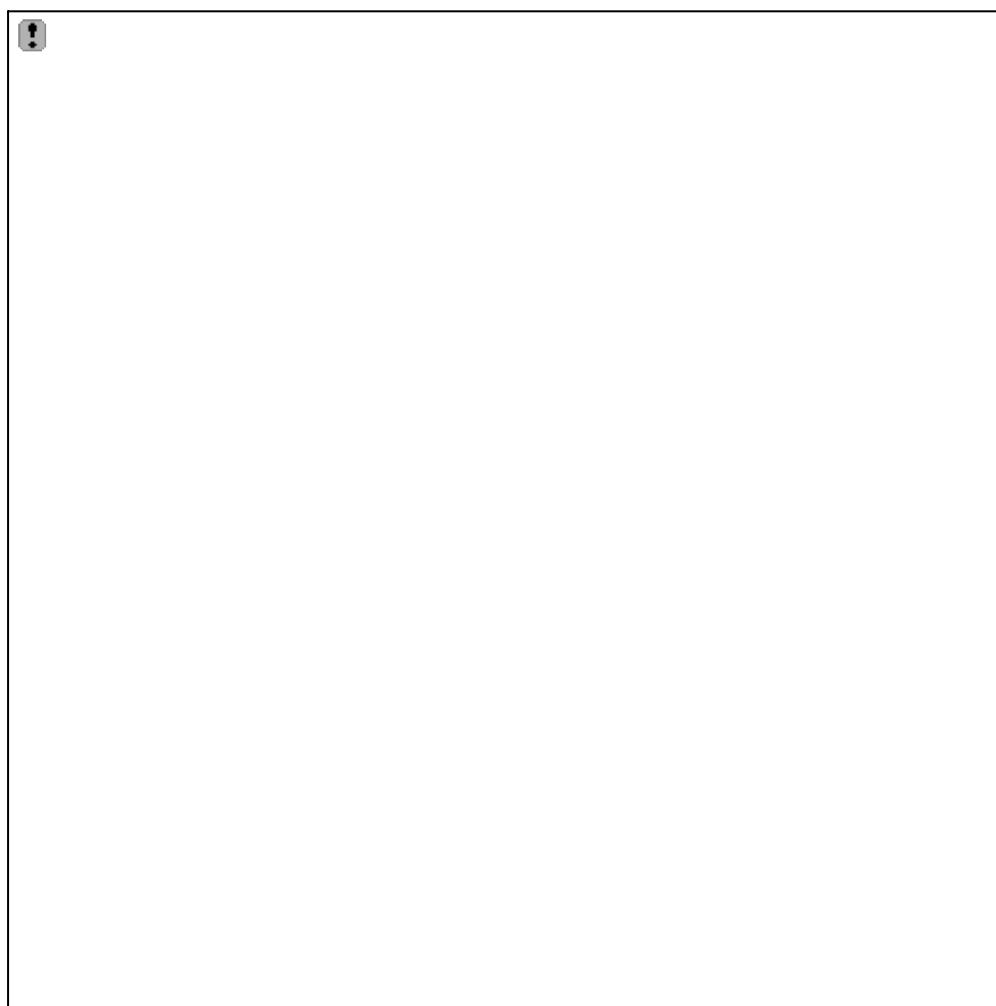


Figure 4.6: Pyroxene-plagioclase-megaphyric ('Eycott-type') basaltic andesite, Eycott Volcanic Group. The coin is 25 mm diameter. (Photo: BGS no. A6605.)

Description

The EVG in the GCR site is generally well exposed between Low Murrah and Greenah Crag Farm (Figure 4.5), consisting of an 800 m-thick succession of continental margin-type tholeiitic lavas and interbedded volcanoclastic rocks dipping eastwards at 30–40°. The volcanic rocks unconformably overlie Skiddaw Group mudstone of possible Cambrian age (Millward and Molyneux, 1992); the angular truncation of the uppermost lavas by the overlying basal beds of the Carboniferous cover rocks is well seen in the north of the GCR site (Figure 4.7).

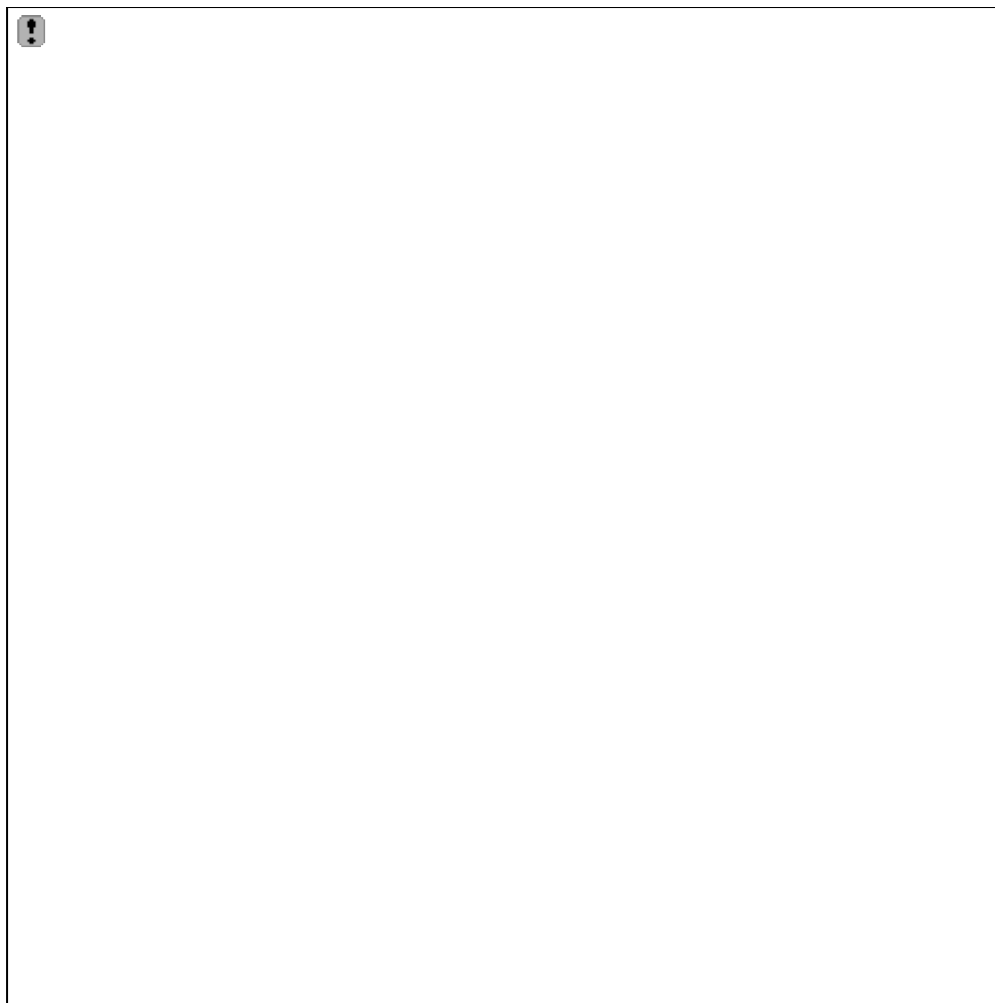


Figure 4.7: Eycott Hill: craggy scarp and dip-slope topography of the Eycott Volcanic Group in the foreground, contrasted with smooth, regular scarps in the overlying Carboniferous Limestone in the background. View looking NE. (Photo: BGS no. A6616.)

More than 20 aphyric and highly porphyritic basaltic andesite and andesite lavas, varying from 20–90 m thick, constitute most of the sequence; several lava margins are present. Two 'Eycott-type' basaltic andesite lavas, each about 25 m thick, and one rhyolite crop out near the base of the sequence. Simple lavas dominate, having massive central zones, and becoming increasingly amygdaloidal towards the top and bottom; flow-banding and a fine-scale platy jointing parallel to the base are typically present in the lower part of the lavas. Rubbly flow-breccia indicates that most are aa-lavas. The lowest lava is heterogeneous with repeated alternations of massive and amygdaloidal, clinkery material suggesting that it is compound.

The lavas are typically porphyritic, containing up to 46% phenocrysts and glomerocrysts set in a fine- to very fine-grained groundmass of stumpy plagioclase laths, intergranular clinopyroxene, opaques and interstitial chlorite or dark-brown mesostasis, presumably after glass. A small number of lavas are aphyric or nearly so. Most of the phenocrysts are labradorite euhedra and scattered glomerocrysts; in the 'Eycott-type' basaltic andesite these may be up to 5 cm, but are mostly 1–1.5 cm. The plagioclase is fresh to turbid, typically with multiple and compound zoning. Small inclusions of chlorite or brown mesostasis are scattered throughout some crystals or in rings. Small 'rounded' anhedral of fresh clinopyroxene are present only in the lowest lavas on Eycott Hill. Chlorite pseudomorphs after orthopyroxene occur in basaltic andesite and andesite. Though Eastwood *et al.* (1968) reported pseudomorphs after olivine from elsewhere in the EVG, this mineral has not been found in rocks from Eycott Hill.

On the southern side of the inlier, less than 10 m of volcanoclastic rocks underlie the 'Eycott-type' basaltic andesite lavas, thickening to 90 m in the north. Thin interbeds, up to 5 m thick, are also present between andesites at higher levels in this sequence. These sedimentary rocks

are generally parallel-bedded, fine- to coarse-grained volcanoclastic sandstone, though rock fragments in the soil on the west side of Eycott Hill (3829 3013) comprise graded, very coarse-grained sandstone and pebbly layers with mudstone clasts, presumably derived from the Skiddaw Group.

The basal unit of the succession west of Eycott Hill and at Greenah Crag Farm is a weakly bedded, poorly sorted lapilli-tuff comprising closely packed fragments of intensely amygdaloidal or wispy scoria along with angular to subrounded clasts of non-amygdaloidal, variously textured basalt, andesite and rhyolite; rare fragments of gabbro are present. These beds were probably deposited from mixed scoria-fall and hydroclastic eruptions. By contrast the basal, unbedded, massive, poorly sorted, matrix supported lapilli-tuff north of Fairy Knott is probably an ignimbrite.

A pinkish weathered welded dacitic lapilli-tuff, about 600 m in outcrop length and 20 m thick is present approximately 370 m above the base of the succession. This ignimbrite contains fiamme that are generally chloritized and contain coarse quartz-feldspar spherulitic devitrification. Crystal content comprises 16% plagioclase, 2.5% pseudomorphs after mafic minerals, and less than 1% granular opaque. Angular to subrounded, non-vesicular andesite clasts comprise the lithic component (4%).

Interpretation

The division of the middle Ordovician volcanic rocks in the Lake District Lower Palaeozoic inlier into separate lithostratigraphical units during the early 1970s marked a major change in the understanding of the history of the Lake District magmatic province, and arose from separate geochemical and biostratigraphical studies. Firstly, Fitton and Hughes (1970), and Fitton (1971) demonstrated clearly that the volcanic rocks of Binsey, the Caldbeck Fells and Eycott Hill show some tholeiitic characteristics compared with the calc-alkaline rocks of the central Lake District. Secondly, examination of microfloras from siltstone at the base of the volcanic succession in the Binsey area, west of the GCR site, led Downie and Soper (1972) to infer that the volcanic rocks are of earliest Llanvirn age. Thus, the northern volcanic rocks became known as the Eycott Volcanic Group, which was recognized as a precursor to the BVG. Wadge (1978) shortened the name to Eycott Group, but also included within it pelitic rocks in the eastern Lake District that were considered to be of similar age. Neither Moseley (1984) nor Millward and Molyneux (1992) followed this chronostratigraphical approach.

The relationship of the volcanic rocks to the underlying Skiddaw Group in the Lake District has been much in contention for many years (see Wadge, 1978, for summary). Eastwood *et al.* (1968) and Downie and Soper (1972) described passage beds comprising interbedded tuffaceous sedimentary rocks and andesite sheets at the junction in the west of the outcrop. However, Millward and Molyneux (1992, fig. 7) demonstrated a marked angular unconformity beneath these passage beds at the Chapel House Reservoir (2582 3551); biostratigraphical support showed that the Skiddaw Group beneath the mapped unconformity ranges in age from possible Late Cambrian to early Llanvirn. The andesite sheets in the passage beds were interpreted as sills and the sedimentary rocks designated as the Overwater Formation.

Ward (1876) showed a faulted contact on Eycott Hill and Eastwood *et al.* (1968) mapped a conformable base. A more complex basal relationship was discussed by Millward and Molyneux (1992). The characteristics of the lowest volcanic deposits vary along strike. North of Fairy Knott dark-grey, water-laid, laminated siltstone and silty claystone (Skiddaw Group) are overlain by a coarse, heterolithic, lapilli-tuff and tuff-breccia. In the stream just to the south of Fairy Knott about 4 m of tuffaceous sandstone overlie the Skiddaw Group and this bed can be mapped southwards to lie at least 120 m above the base of the volcanic sequence, with intervening pyroxene andesite and ash-fall lapilli-tuff. These lateral facies changes indicate emplacement of the volcanic rocks onto an existing topography.

The unconformable base and a succession predominantly of simple porphyritic lavas rather than volcanoclastic rocks demonstrate that the EVG has much in common with the Birker Fell Formation, the basal formation of the BVG. The sheeted andesite lava complex of the calc-alkaline BVG has been interpreted by Petterson *et al.* (1992) to have formed volcanoes with very shallow sides that constructed a plateau succession, probably within a graben-like

structure. The geochemically distinct EVG may thus be interpreted as the product of similar constructions in a penecontemporaneous but separate volcanic field (Millward and Molyneux, 1992).

Conclusions

The Eycott Hill GCR site is significant as the type section for the Eycott Volcanic Group and for the well-known coarsely porphyritic 'Eycott-type' basaltic andesites. Crucial evidence for the onset of volcanism in the Lake District is present. More than 20 basaltic andesite and andesite aa-lavas, along with thin intercalations of pyroclastic and sedimentary rocks are well displayed by the crag and dip-slope topography. The volcanic rocks have some tholeiitic characteristics and were erupted onto an eroded landscape of Skiddaw Group rocks at the continental margin of Eastern Avalonia during the closure of the Iapetus Ocean. Despite geochemical differences with the Borrowdale Volcanic Group, the Eycott Volcanic Group exhibits a remarkably similar style of volcanism to the lower part of the former.

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