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# Little Mell Fell Quarry, Cumbria

[NY 429 239]

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## Introduction

A number of small, basalt intrusions and a single exposure of probable pyroclastic rocks crop out on the eastern flanks of Little Mell Fell, up to about 400 m west and north of Mellfell House (Figure 3.7). Published evidence suggests that they are related to the Dinantian Cockermouth Lavas of the north-west Lake District (Capewell, 1954; Macdonald and Walker, 1985). The igneous rocks were emplaced into cobble conglomerates of the Mell Fell Conglomerate, an alluvial-fan deposit of probable Mid- or Late Devonian age (Capewell, 1955; Wadge, 1978; Cooper *et al.*, 1993). The basalts are compositionally similar to, but are fresher than, rocks of the main outcrop of Cockermouth Lavas (see Gill Beck and Bothel Craggs Quarry GCR site reports). Thus, the intrusions represent the easternmost manifestation of this volcanic episode along the northern margin of the Lake District. Furthermore, the nearby exposure of pyroclastic rocks is the only known example of tephra deposits associated with Dinantian volcanism at the southern margin of the Solway Basin.

The igneous rocks were located during the primary geological survey and described briefly in the memoir for the area (Dakyns *et al.*, 1897). Dykes near this location were mapped by Green (1918). Capewell (1954) described the Mell Fell rocks in detail, and geochemical analyses of these rocks have been interpreted by Macdonald and Walker (1985). The Little Mell Fell Quarry GCR site is included within the British Geological Survey's 1:50 000 Sheet 30, Appleby (in press).

## Description

Description of these rocks is based on the accounts by Capewell (1954), and Macdonald and Walker (1985). The Little Mell Fell Quarry GCR site is the small abandoned quarry [NY 4291 2397] adjacent to the road, approximately 100 m north of Folly Cottage (Figure 3.7). Within the quarry a northerly trending basalt dyke cuts the Mell Fell Conglomerate, here composed of greywacke cobbles. The dyke forms a steep bank for about 180 m to the north of the quarry and it is further exposed immediately below the cottage; however, the dyke is not exposed in the stream 100 m south of the cottage. The width of the dyke was not recorded by Capewell (1954), but during a recent re-survey of the area the dyke width was recorded as approximately 10 m (M. McCormac, pers. comm., 1999). Capewell recorded that the western contact of the dyke dips at about 60° to the west, but that the eastern contact is irregular and nearly vertical. Trails of mainly quartz-filled vesicles are present parallel to, and 0.3–0.6 m from, the contacts. Adjacent to the dyke contacts the conglomerate matrix is slightly hardened and bleached. Towards the north end of the quarry, bleached conglomeratic rock probably represents screens of the host rock within the dyke.

Three further exposures of basalt between the road and Tongue Farm (Figure 3.7) were recorded by Capewell (1954). These may be *en échelon* segments of the dyke in the quarry or may represent at least one other separate, northerly trending dyke. At one of these exposures Capewell recorded similar contact relationships to those seen in the quarry. Other small occurrences of basalt are found in the water course approximately 300 m north-west of Mellfell House. An isolated crag of basalt 300 m south-west of Mellfell House is close to the mapped contact of the Mell Fell Conglomerate with the underlying Skiddaw Group. The geometry and contact relationships of these occurrences are not known. A NNE-trending dyke WSW of Little Mell Fell illustrated by Green (1918) could not be located by Capewell (1954), nor was it recorded during the primary geological survey.

Basalt in the Little Mell Fell Quarry is micro-porphyrific, with euhedral olivine and subordinate plagioclase phenocrysts. The fine-grained groundmass comprises plagioclase, augite and iron oxide. These rocks are altered, but considerably less so than the Cockermouth Lavas; olivine in particular is replaced by a chlorite-like mineral ('serpentine' according to WW Watts in Dakyns *et al.*, 1897; 'chlorophaeite' according to Capewell, 1954). Amygdales are of chlorite, carbonate and chalcedony. The rock exposed in the water course north-west of the quarry is a fresh sub-ophitic dolerite, in which the

olivine is remarkably fresh and only serpentinized at the crystal margins.

Geochemical analyses of two rocks from this area were presented by Macdonald and Walker (1985). In common with the Cockermouth Lavas, the basalts at Little Mell Fell are tholeiitic; one of the samples is quartz-normative, the other is just olivine-normative. The Mell Fell basalts have incompatible element concentrations that are at the higher end of the compositional range encountered in the Cockermouth Lavas, suggesting that they represent some of the more enriched rocks in this formation. Macdonald and Walker (1985) expressed little doubt that the Mell Fell rocks are similar to the Cockermouth Lavas and considered them to be part of this volcanic episode.

An exposure of highly porous, greenish, unbedded lapilli-tuff, identified first by Capewell (1954), is located on the eastern slopes of Little Mell Fell approximately on the 400 m contour and 140 m ENE of the summit. The marked colour difference with the Mell Fell Conglomerate is readily noticeable. However, the contact relationship between the lapilli-tuff and the conglomerate is seen nowhere. Sub-horizontally bedded conglomerate is exposed nearby, and Capewell (1954) interpreted a steep margin to the pyroclastic rock. He also noted seepages at the base of the crags and inferred that the lapilli-tuff is underlain by impermeable basalt, either a plug or one of the north–south dykes at the base of the slope.

The lapilli-tuff comprises sub-angular clasts, mainly cobbles and pebbles of country rock, but also with glassy basaltic lapilli and blocks (Figure 3.8). Some clasts of the probable juvenile material appear to have been fused together while they were still plastic. In thin section the smaller clasts and sand-grade grains also include greywacke, siltstone and slaty mudstone. Capewell (1954) noted that parts of the rock are apparently cemented by palagonite.

## Interpretation

The basalt in the quarry at Little Mell Fell was interpreted as an intrusion during the primary survey of the area (Dakyns *et al.*, 1897). The pyroclastic rocks were described first by Capewell (1954), who suggested that, because of their close proximity to the dyke-like masses of basalt, they belong to a single volcanic episode. It is also possible that these are the sub-surface remains of a single volcano. Capewell considered that, although a pipe-like geometry for the lapilli-tuff was far from certain from the field evidence, the pyroclastic rocks are likely to infill a vent conduit. The substantial amounts of country-rock pyroclasts and the presence of plastic, juvenile tephra in the lapilli-tuff clearly suggest a phreatomagmatic mode of emplacement. No other occurrences are known of pyroclastic rocks associated with the Early Carboniferous volcanism on the southern side of the Solway Basin.

Some uncertainty surrounds the age of the volcanic rocks at Little Mell Fell because there is no biostratigraphical control and no radiometric ages of these rocks have been determined. Intrusion into the probable Middle or Upper Devonian Mell Fell Conglomerate gives a maximum age, but a minimum age is not discernible from the geological relationships. Ward (in Dakyns *et al.*, 1897) considered these and other basalts in the area to be associated with the Late Carboniferous Whin Sill magmatism. Wadge *et al.* (1972) proposed a similar correlation for some olivine-dolerite dykes cutting the Eycott Volcanic Group near Melmerby in the northern part of the Cross Fell inlier. However, Capewell (1954) thought the association of olivine basalt with the quartz-dolerite sills unlikely on petrological grounds. He considered the few other occurrences of olivine-bearing basalt in the north-west of England and concluded that the best association for the Little Mell Fell rocks was with the Cockermouth Lavas. Thus, he concluded that the dykes and pyroclastic rocks were Early Carboniferous in age and that these occurrences can be regarded as an outlier of the southern Scottish Early Carboniferous volcanism. This conclusion gained further support from Macdonald and Walker (1985), who demonstrated the geochemical similarity of the Little Mell Fell Quarry rocks with the Cockermouth Lavas.

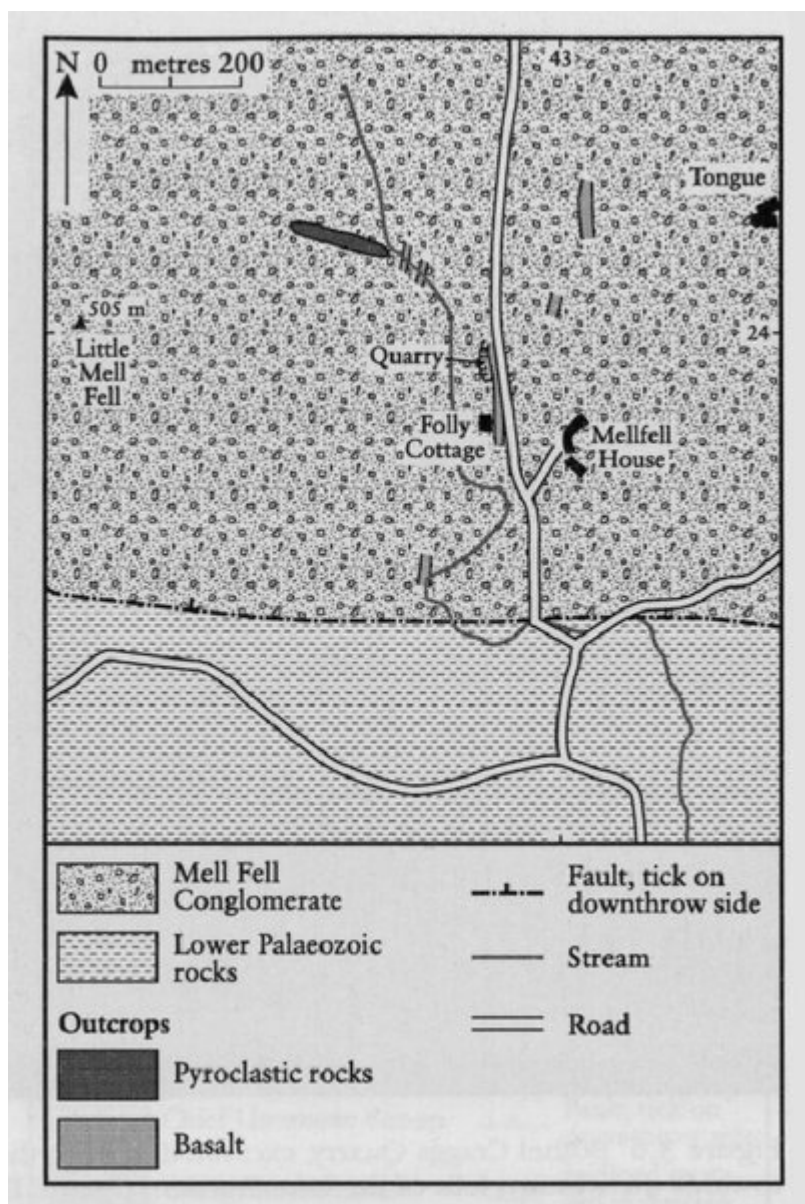
The nearest outcrop of the Cockermouth Lavas lies some 27 km to the WNW of Little Mell Fell Quarry. No similar rocks have been encountered in the intervening ground, though the base of the Carboniferous strata is well exposed. Furthermore, no dykes of similar affinity have been reported within the Lower Palaeozoic strata, an observation commented on long ago by Green (1918). However, the geochemical analyses of the dykes at Little Mell Fell confirm the earlier suggestion by Capewell (1954) that Dinantian volcanism did occur on the Lake District Block, some distance from the defined margin of the Solway Basin. Just to the north of Little Mell Fell lies the ENE-trending Causey Pike Fault (Chadwick *et al.*, 1995, fig. 3). This structure is of major importance in the development of the Lower Palaeozoic rocks of the Lake District Block (Cooper *et al.*, 1988) and is probably linked at depth to the major crustal shear zone that was

re-activated during Carboniferous extension to form the Solway Basin (Chadwick *et al.*, 1995). Re-activation of the Causey Pike Fault may have provided the necessary channel for magma to reach the surface.

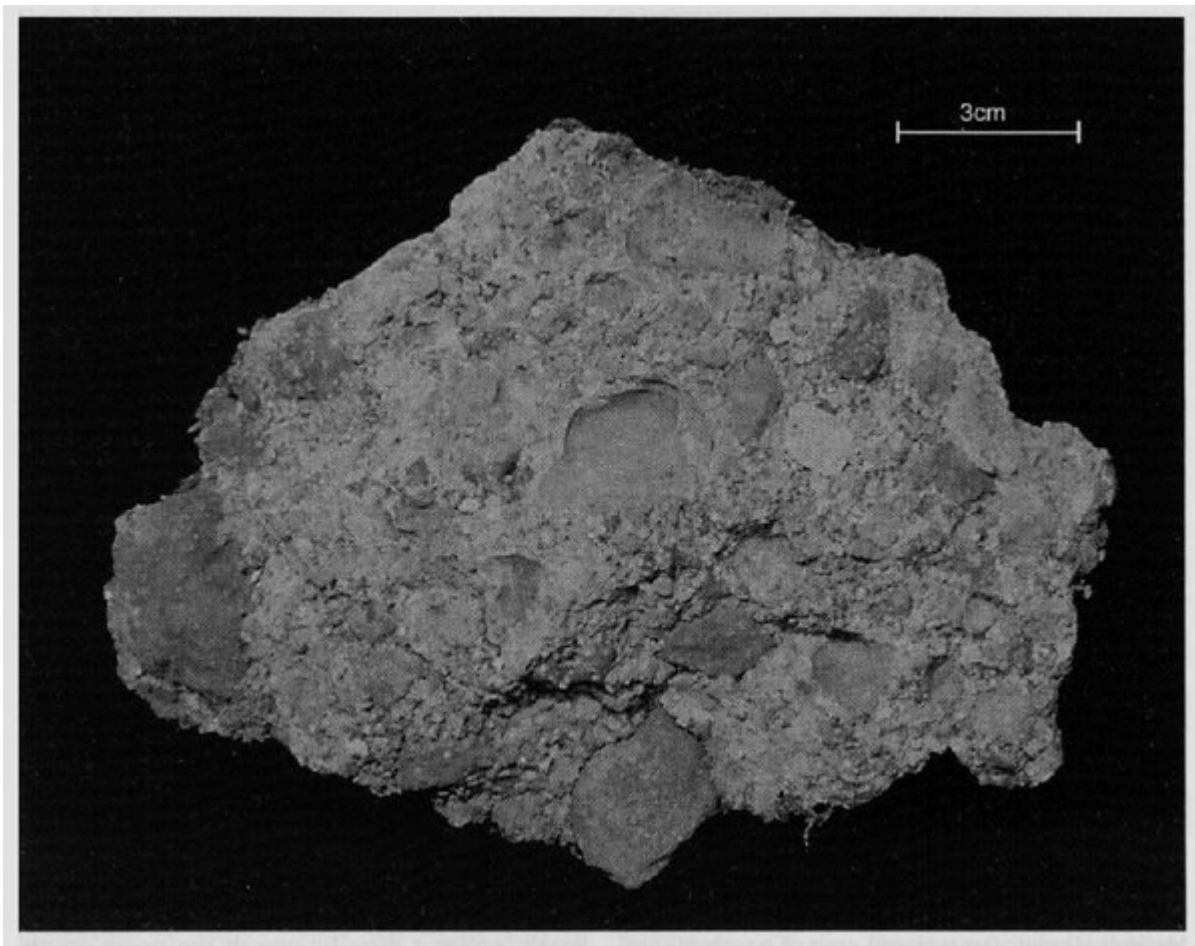
## Conclusions

Northerly trending, near-vertical dykes of tholeiitic olivine-microphyric basalt and dolerite intrude the Devonian (Old Red Sandstone) Mell Fell Conglomerate in a quarry on the eastern flanks of Little Mell Fell and nearby. Though the dykes occur some 27 km ESE of the Cocker-mouth Lavas they are considered to be the easternmost manifestation of this volcanism, and thus of Tournaisian age. Some of the mafic rocks on Little Mell Fell are fresh compared with the Cocker-mouth Lavas. A small outcrop of unbedded lapilli-tuff, comprising pyroclasts of basalt and country rock, is considered to be the remains of an infilled vent conduit and is the only recorded occurrence of pyroclastic rocks within the Lower Carboniferous rocks of the southern margin of the Solway Basin. The volcanic rocks at Little Mell Fell are located within the Lake District Block, and the nearby Causey Pike Fault may have acted as a channel.

## References



(Figure 3.7) Map of the area around the Little Mell Fell Quarry GCR site. Based on British Geological Survey 1:10 000 Sheet NY 42 SW (2000).



*(Figure 3.8) Lapilli-tuff from an inferred volcanic vent, possibly related to the Cockermouth Lavas, exposed on the hillside above the Little Mell Fell Quarry GCR site. (Photo: British Geological Survey, No. P505644, reproduced with the permission of the director, British Geological Survey, © NERC.)*