Cottonshope Head Quarry, Northumberland

[NT 803 058]

D. Millward

Introduction

A thin succession of tholeiitic, olivine-phyric basalts, referred to as the 'Cottonshope lavas' or 'Cottonshope basalts', is the only exposed record of effusive volcanic activity associated with development of the Northumberland Basin in Early Carboniferous times. The lavas crop out in a handful of localities south-west of the Cheviot Block, including Spithope Burn [NT 760 050], Hungry Law [NT 747 062], and between the Baseinghope Burn [NT 700 045] and the Chattlehope Burn [NT 730 028]. They are thickest and best exposed in the valley of the Cottonshope Burn, in Upper Redesdale. The Cottonshope Head Quarry GCR site is located on the north-facing side of an unnamed tributary, due south of Cottonshope Head, where these rocks are seen particularly well (Figure 3.15). The basalts occur within a probable Tournaisian succession of sedimentary rocks that are currently included in the Cementstone Group of Northumberland (Miller, 1887; Taylor *et al.,* 1971).

The few published descriptions of the Cottonshope basalts are brief. C.T. Clough carried out the original geological survey of the area and his description of these rocks was incorporated in the Otterburn and Elsdon memoir (Miller, 1887). The succession and petrography were described later by Tomkeieff (1931). The area including the GCR site was re-mapped in 1932 by W Anderson and is included in the Geological Survey Sheet 8 (1951). Previous work was summarized by Randall (1995a).

Description

The description of the Cottonshope Head Quarry GCR site is based on the published accounts and on field maps and manuscript notes in the British Geological Survey archives; this is supplemented by recent observations.

The upper part of the Cottonshope valley provides a complete section through the relatively poorly exposed Cottonshope basalts (Figure 3.15). Lower Carboniferous strata there dip at about 10° to the SSW or south. The succession underlying the basalts is dominated by red or grey flaggy sandstones with brown ochreous spotting, along with interbedded purple, red, lilac and green mudstones containing ochreous concretions. Thin beds of concretionary carbonate ('comstone') were noted during a visit to the site in 2000. These strata were called the 'Lower Freestone Beds' by Miller (1887) and Taylor *et al.* (1971), but the presence of the 'cornstones' is a diagnostic feature of the Kinnesswood Formation of central Scotland. In places, grey mudstone is exposed just beneath the basalts and a prominent spring line occurs along the junction. The volcanic rocks are overlain by dark-grey and greenish mudstones with sandstones and thin 'cementstones'.

The volcanic succession comprises three sheets of basalt. The lowest one is 12 m thick and has an undulating pillow-like to slaggy, scoriaceous top in which there are sedimentary infills. This is overlain directly by vesicular basalt, 6 m thick. The uppermost basalt is also 6 m thick, but is separated from the underlying ones by 6 m of bedded mudstones, flaggy sandstones and 'cementstones'. In the Spithope Burn [NT 767 057], 3 km west of the GCR site, these beds contain fragments of basalt. The lowest two basalt sheets are exposed in a small road-metal quarry within the GCR site (Figure 3.15). The section exposed there in 1946 is recorded in manuscript notes in the British Geological Survey archives as follows:

'Upper lava:

lava, dark grey with a few small vesicles 10 feet [3 m].
Vesicular lava with inclusions of shale and cementstones up to 2 x 1 feet in size, 1 to 10 feet [0.3–3 m].
Junction between lavas slightly undulating.

Lower lava:	vesicular lava, coloured. The amygdales are filled with quartz and calcite, lined with green earth (chlorite) 3 feet [0.9 m]. Grey lava, apparently similar to top lava 8 feet [2.4 m].'

Miller (1887) described the inclusions of sedimentary rock recorded from the upper unit as having been bleached and altered by heat. The base of the upper unit was poorly exposed at the rear of the quarry in the summer of 2000, adjacent to a small stream. There, unbedded carbonate rock appeared to contain scattered angular fragments of basalt.

Though the volcanic rocks are generally conformable with the sedimentary rocks, Miller (1887) noted possible irregularity at the base of the lowest basalt in a stream about 800 m south of Cottonshope Head, probably at about [NT 799 054]. There, the base of the basalt cuts down at least 20 cm into the underlying 'cementstone' bed.

Generally, the basalt is closely fractured and considerably altered, though fresher material is noted from Calley Sike [NT 804 064], 600 m NNE of the quarry. The rock has been described by Tomkeieff (1931), as a typical 'Dalmeny' type basalt, according to the classification of MacGregor (1928). It is a grey microporphyritic basalt containing phenocrysts of olivine, plagioclase and augite. There are numerous subhedral pseudomorphs of 'serpentine', iddingsite, chlorite and calcite after olivine phenocrysts. The groundmass comprises altered feldspar laths with intergranular chloritized augite and iron oxide. The major element composition of the lowest basalt in the succession, collected a little downstream from the GCR site at [NT 7959 0537], is given by Tomkeieff (1931). Recalculation of this analysis shows the rock to be hypersthene-and very slightly quartz-normative.

The manuscript notes also record that the southern face of the quarry is formed by an easterly trending vein of quartz and galena about 80 mm wide. This is one of two similarly orientated veins, the second of which is exposed in Cottonshope Burn, 250 m downstream from Cottonshope [NT 7891 0456].

Interpretation

The Cottonshope basalts were interpreted as subaqueous by Miller (1887) and as submarine by Taylor *et al.* (1971). However, the presence of 'cornstones' in the sequence below the lavas suggests a subaerial environment. 'Cornstones' form as a result of a fluctuating water table through the soils of semi-arid floodplains. The 'cementstone' succession interbedded with, and overlying, the lavas is also thought to have been deposited on a fluvial coastal plain with lagoons (Taylor *et al.,* 1971).

Miller (1887) considered that the inclusions of sedimentary rock seen in the basalts were caught up in the moving flow and that some of the larger masses of sandstone represent the filling of an irregular topography during the intervals between eruptions. However, the undulating and pillow-like form to the top of each basalt was thought by Tomkeieff (1931) to resemble the hummocky and ropy surface of subaerial pahoehoe lava, though similar surface features are now known to be characteristic of submarine sheet-flows. He also concluded that fragments of sediment within the lava, and clasts of basalt within the sedimentary rocks overlying the second unit at Spithope, indicate that the basalts and sediments were contemporaneous, and hence imply an extrusive origin.

The three basalt lavas preserved in the Cottonshope Burn outcrop make this the thickest and best development of the Cottonshope basalts. Elsewhere, only one lava is thought to be present. Tomkeieff (1931) speculated on the source of the lavas. On Carter Fell [NT 680 060], a basalt plug and associated mushroom-like sill cut through a lenticular bed of agglomerate, rising into the lower part of the Fell Sandstone Group above the Cementstone Group. Though this basalt is clearly later than the Cottonshope basalts, Tomkeieff thought it possible that, as the agglomerate rests directly on the Lower Freestones, it could have been the site of an active volcano at the earlier time.

The Cottonshope basalts, which lie only about 100 m beneath the top of the Cement-stone Group in Redesdale, have been tentatively assigned an early Tournaisian age. This is not well constrained because of the restricted nature of the fossils in the enclosing sedimentary rocks (Taylor *et al.,* 1971). The Cementstone Group of Northumberland probably correlates with the Lower Border Group farther west, and the top of the latter corresponds approximately to the

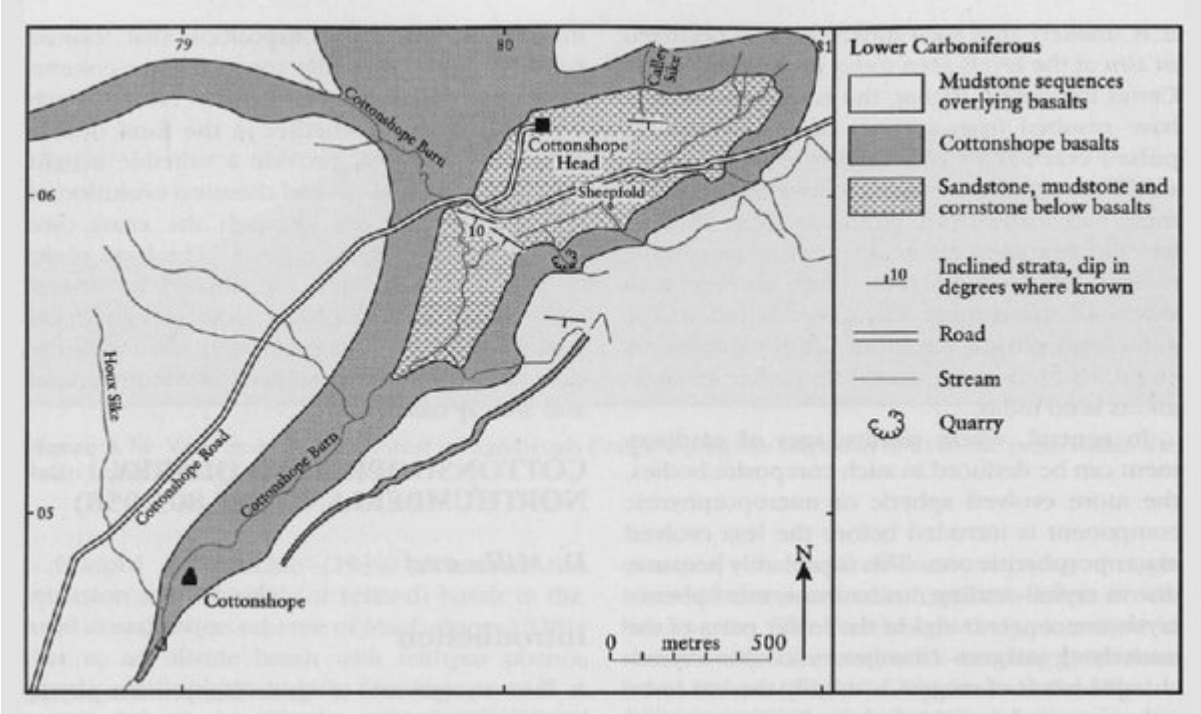
Tournaisian–Visean boundary.

The recent discovery of 'cornstones' within the Lower Freestone Beds provides significant new evidence for eruption of the Cottonshope basalts during early Tournaisian times. M.A.E. Browne (pers. comm., 2000) examined the succession in Cottonshope Burn and concluded that the lithofacies present are typical of the Kinnesswood Formation of central Scotland. In the New Cumnock area [NS 6670 2158] this formation has been found to contain miospores of earliest Tournaisian age (LN–PC biozones) (Turner, 1994). This would place the volcanism at approximately the same time as the Birrenswark Volcanic Formation and the Kelso Lavas. Though the geochemical composition of the Cottonshope basalts is known only from a single major-element analysis, this suggests that these rocks are probably little different from the transitional, tholeiitic to mildly alkaline rocks that constitute the other early Dinantian volcanic rocks of northern England.

Conclusions

The Cottonshope Head Quarry GCR site is representative of the Cottonshope basalts, the only exposed sequence of Early Carboniferous volcanic rocks within the Northumberland Basin. The volcanic succession crops out southwest of the Cheviot Block and comprises up to three intensely altered, massive to highly amygdaloidal and scoriaceous, basalt lavas. The lavas are intercalated with sedimentary rocks of the Cementstone Group of Northumberland and overlie a sequence of sandstone, mudstone and concretionary carbonate ('cornstone') that was deposited on a semi-arid floodplain. The sedimentary rocks below the lavas were formerly assigned to the Lower Freestone Beds, a local formation, but they may be correlated with the Kinnesswood Formation of central Scotland. The age of the latter suggests that the Cottonshope basalts are early Tournaisian in age and hence they are part of the Birrenswark–Kelso volcanic episode.

References



(Figure 3.15) Map of the area around the Cottonshope Head Quarry GCR site. Based on geological mapping by W. Anderson (1932, Geological Survey Archives).