Lintmill Railway Cutting, Scottish Borders

[NT 727 463]–[NT 736 466]

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Introduction

The Lintmill Railway Cutting GCR site has been selected to represent the basaltic to hawaiitic Kelso Lavas of the Tweed Basin. These early Dinantian volcanic rocks, along with the broadly coeval, but geographically separated, Birrenswark Volcanic Formation and Cockermouth Lavas in the Solway Basin to the south-west, are important to the understanding of crustal development during the early phase of the tectonic and sedimentary evolution of the Northumberland, Solway and Tweed basins (see also Langholm–Newcastleton Hills, Gill Beck and Bothel Craggs Quarry GCR site reports).

The Lintmill Railway Cutting GCR site is located some 3 km east of the small town of Greenlaw, at the northern end of the arcuate outcrop of the Kelso Lavas (Figure 3.1). Here, the volcanic rocks are exposed over a distance of about 600 m within the old railway cutting and along the banks of the Blackadder Water, west of Lintmill Bridge (Figure 3.11) and (Figure 3.12); elsewhere, exposure of the Kelso Lavas is only sporadic.

The Kelso Lavas attracted some interest during the early days of Scottish geology. The well-exposed parts of these igneous rocks were first mapped by Milne (1837) and the synclinal form of the outcrop was traced by Nicol (1847). The Geological Survey six-inch to one-mile map of the Kelso area was made by J. Geikie and published on the scale of one-inch to one-mile in 1879 (Sheet 25). No memoir for the area has been published, and as yet there has been no published re-survey. Brief references to the Kelso Lavas have subsequently been made by J. Geikie (1893), A. Geikie (1897) and Goodchild (1904), but the main descriptions of the rocks are by Eckford and Ritchie (1939) and Tomkeieff (1945, 1953). More recently, the geochemistry of the Kelso Lavas has formed part of major petrogenetic studies of the Dinantian volcanic rocks of northern Britain by Macdonald (1975) and Smedley (1986a,b, 1988a).

Description

The Kelso Lavas comprise up to 12 basic and intermediate flows in their maximum development to the south of the Lintmill area (Tomkeieff, 1953), but there is little information on thickness variations over their outcrop. In the Lintmill Railway Cutting GCR site a 120 m-thick sequence of volcanic rocks rests unconformably upon sandstones of Upper Old Red Sandstone facies, and comprises perhaps six or seven lavas, interbedded with breccias, sparse thin volcaniclastic sedimentary units and possibly some thin palaeosols (see stratigraphical section below). The volcanic sequence within the site dips towards the south-east, with dips of individual units varying from 15° up to about 40°, but averaging about 25°. The top part of the sequence is not seen within the site, though nearby to the east in the Blackadder Water there are exposures of younger sedimentary rocks, dipping to the south-east at 4°–7°. The composite stratigraphical section, described from top to bottom, is described below.

	Thickness (m)
Sandstone and pebbly coarse sandstone seen 3–4 m above uppermost lava; contact not seen	
Basalt, feldspar-phyric, deeply weathered	*c.* 4
Basalt, feldspar-phyric, greenish-grey, amygdaloidal, weathered	*c.* 5
Hawaiite or basaltic hawaiite, showing crude columnar jointing and platy joints inclined at 45°–50° to the south-east, weathered; exposed in crags along the river, but not exposed in the cutting	*c.* 20

Basalts, olivine- and olivine-feldspar-phyric, interbedded massive, scoriaceous and amygdaloidal facies; localized thin, reddish-brown tuffs and/ or volcaniclastic siltstone, some beds with palaeosol development; dip in cutting is 30°–40°; some calcite mineralization	*c.* 33
Basalt, predominantly massive, sporadic and irregularly developed amygdaloidal facies; feldspar phenocrysts rare and widely scattered	*c.* 12
No exposure	*c.* 12
Basalt or basaltic hawaiite, massive, fine grained, rare feldspar phenocrysts; thin amygdaloidal basal facies; crude prismatic jointing inclined to the north-west at 70°–80°	*c.* 8
Basalt or dolerite, massive; may represent a thin sill intruded along base of overlying flow	*c.* 5
Sandstone, tuffaceous, fine grained to medium grained, reddish-brown; thin lenticular unit	*c.* 1
Basalt and locally basaltic hawaiite, olivine-phyric; flow jointed in part; undulating sharp base	
Sandstones, medium grained, red and reddish-brown with some red-grey to pale-buff mottling, cross-bedded; dip about 30° to the south-east or ESE (Upper Old Red Sandstone facies) ?	

Some of the lavas are probably as flows, in which massive and rubbly or scoriaceous facies are well developed. However, the middle parts of the sequence comprise a number of individual flow units, a characteristic of pahoehoe lavas. Most of the rocks are altered and weathered with mafic phenocrysts typically replaced by iddingsite, chlorite and calcite. Brecciation and calcite veining is conspicuous locally. Tomkeieff (1953) recognized a two-fold petrographical division within the Kelso Lavas: a lower group of dominantly feldspar-phyric rocks and an upper group with clinopyroxene and/or olivine phenocrysts. The Kelso Lavas include basalt, basaltic hawaiite and hawaiite; all are hypersthene-normative and a few also have quartz in the norm, and hence they are tholeiitic (Smedley, 1986a). These rocks have remarkably similar geochemistry to the Birrenswark Volcanic Formation, but are enriched in most elements relative to the Cockermouth Lavas (Smedley, 1988a).

Interpretation

The Kelso Lavas overlie Upper Old Red Sandstone facies rocks (Kinnesswood Formation) that are thought to have been deposited on a hot semi-arid alluvial floodplain by a system of interior drainage (Leeder, 1974). The sedimentary rocks are very early Carboniferous in age and the lavas are thought to be Tournaisian, probably Courceyan (Lumsden *et al.,* 1967; George *et al.,* 1976; House *et al.,* 1977). The lavas are therefore thought to be contemporaneous with the Birrenswark Volcanic Formation and the Cockermouth Lavas.

There is no major linear dyke-swarm associated with the volcanism though small dykes and sills occur locally. The lavas are therefore presumed to have been erupted from a series of small volcanic vents (Eckford and Ritchie, 1939). More than 50 such centres are scattered over a distance of about 16 km from Langholm to Duns. They are exposed at various levels of erosion so that some appear wholly or partially filled by plugs (see Hareheugh Craigs and Langholm–Newcastleton Hills GCR site reports), or by tuff and pyroclastic breccia.

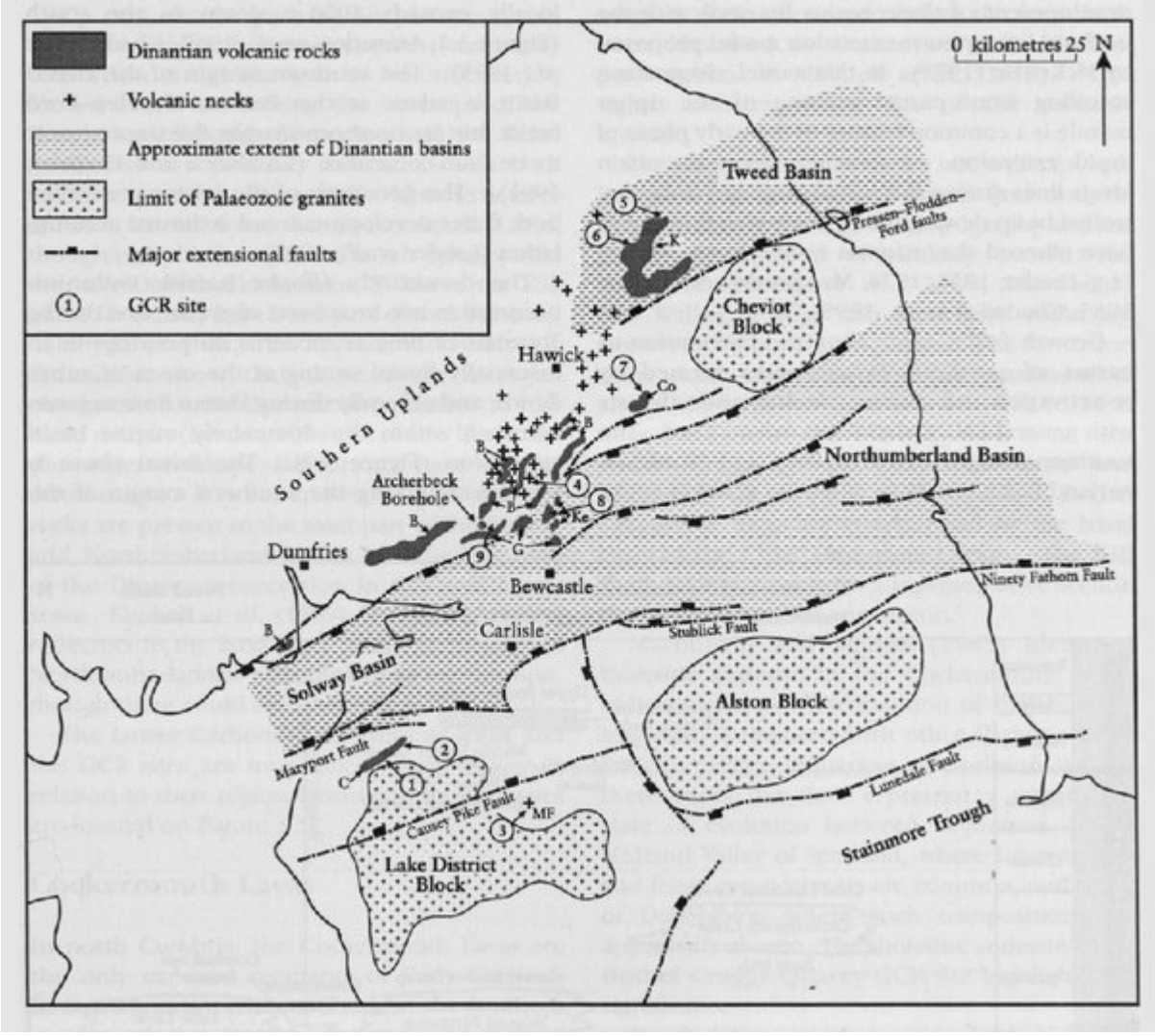
The similarity in rock-types of the Kelso Lavas and Birrenswark Volcanic Formation and the abundance of volcanic necks between the outcrops led Francis (1967) to suggest that the outcrops were once continuous. However, by constructing isopachytes for the Birrenswark lava field, Leeder (1974) demonstrated convincingly that the two most likely developed as separate though coeval fields. He also suggested that their original extent was little more than that occupied by the lavas today.

Macdonald (1975) and Smedley (1986a) demonstrated the overall similarity in geochemistry between the Kelso Lavas, the Birrenswark Volcanic Formation and the Cockermouth Lavas. However, the volcanic rocks from the Scottish Borders are considerably more enriched in minor and trace elements than those from the southern margin of the basins (Smedley, 1988a). The tholeiitic Kelso Lavas were shown clearly to be part of the mildly alkaline to tholeiitic suite that is characteristic of the Early Carboniferous volcanism in southern Scotland and northern England.

Conclusions

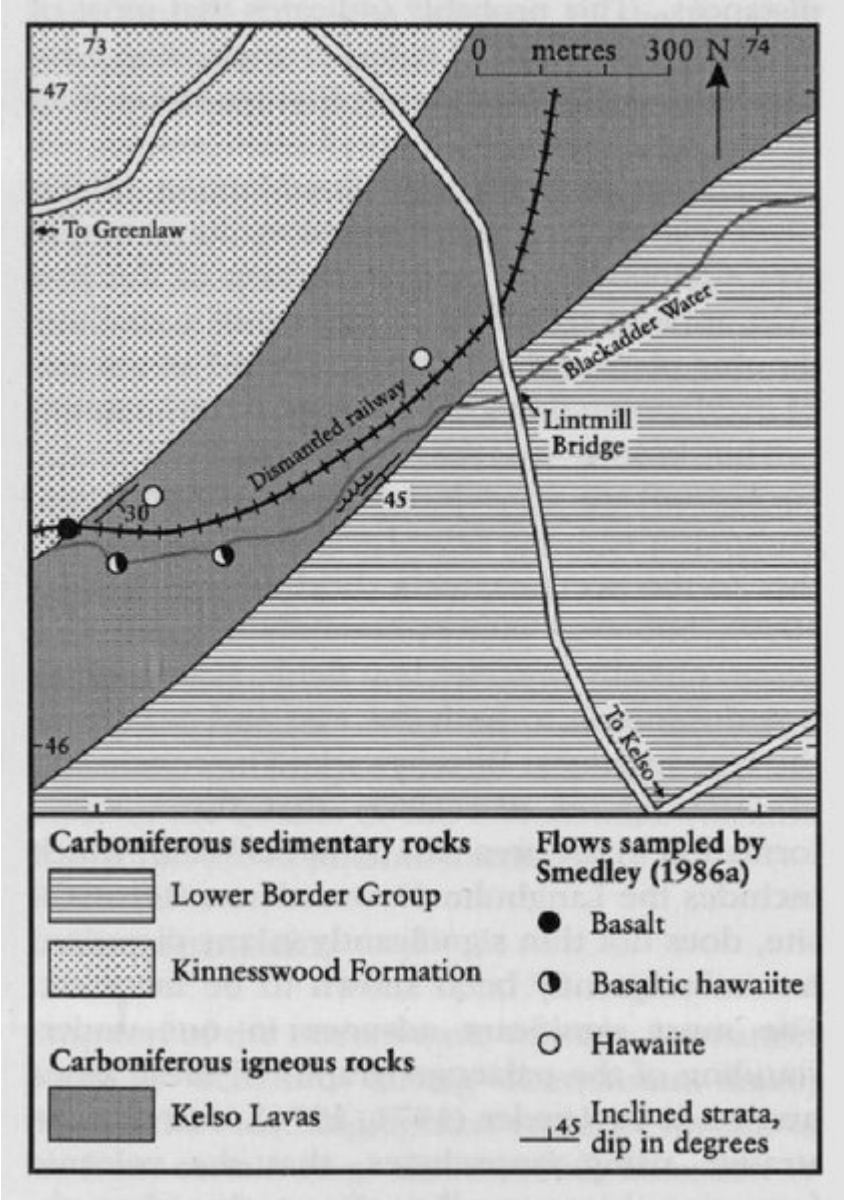
The Lintmill Railway Cutting GCR site is representative of the Kelso Lavas (see also Hareheugh Craigs GCR site report), a localized basaltic to hawaiitic lava field up to 120 m thick that was emplaced on the northern flank of the Tweed Basin during Early Carboniferous (Tournaisian, possibly Courceyan) times. The site provides a good section through six or seven basalt, basaltic hawaiite and hawaiite lavas with sparse intercalated volcaniclastic sedimentary rocks. The volcanic rocks are tholeiitic and are the products of magmatic events induced by crustal extension associated with the early evolution of the Tweed Basin. They provide vital information for the understanding of this development and also enable comparative studies with other Dinantian volcanic rocks from elsewhere within the Carboniferous–Permian Igneous Province of northern Britain.

References



(Figure 3.1) Map of the Solway, Northumberland and Tweed basins showing the outcrops of Dinantian volcanic rocks and the major structural components. GCR sites: 1 = Gill Beck; 2 = Bothel Craggs Quarry; 3 = Little Mel Fell Quarry; 4 = Langholm–Newcastleton Hills; 5 = Lintmill Railway Cutting; 6 = Hareheugh Craigs; 7 = Cottonshope Head Quarry; 8 = Kershope Bridge; 9 = River Esk, Glencartholm. (Volcanic units are as follows: B = Birrenswark Volcanic Formation; C = Cockermouth Lavas; Co = Cottonshope Basalts; G = Glencartholm Volcanic Beds; K = Kelso Lavas; Ke = Kershopefoot

Lavas; MF = Mell Fell Vent.) Information from published sources including Chadwick and Holliday (1991); Chadwick et al. (1995); Leeder (1974); and British Geological Survey (Tectonic map of Britain, Ireland and adjacent areas, 1996).



(Figure 3.11) Map of the area around the Lintmill Railway Cutting GCR site. Based on Geological Survey Old Series 1:63 360 Sheet 25, Galashiels (1879); geochemical sample points from Smedley (1986a).

(Figure 3.12) View east along the Lintmill Railway Cutting, with the Kelso Lavas exposed in the cutting on the left. (Photo: I.T. Williamson.)