Roman Wall

[NY 715 667]–[NY 810 712]

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Introduction

The Roman Wall site is centred on a *c.* 10 km long section of Hadrian's Wall in Northumberland. The entire wall stretches for some 118 km across northern England from Wallsend, near the mouth of the Tyne in the east, to Bowness-on-Solway in the west. It is probably the most famous of the Roman walls in Britain, and its archaeological and cultural significance has been described in numerous publications (e.g. Breeze and Dobson, 1978; Johnson, 1989; Richards, 1993; Crow, 1995). The wall was built for defensive purposes and for much of its length it follows natural topographical barriers resulting from the underlying geology. This is particularly the case in its central portion around Roman Wall [NY 715 667]–[NY 810 712], where a large quartz-dolerite sill (the Whin Sill) provides steep north-facing cliffs that show the influence of geological structure on the landforms produced by glacial erosion. A particular highlight of the site is the development of a cuesta (scarp and dip) landscape. This is particularly well developed in the basaltic sills and dykes associated with the Whin Sill, with shallow rock basins developed in the less resistant sedimentary rocks (mainly limestones) between the sills. A suite of complimentary cuesta landforms of various magnitudes also occurs to both the north and south of the Whin Sill itself; in association with the outcrops of limestone and sandstone.

Johnson (1997) provides an overview of the solid geology along the entire route taken by Hadrian's Wall and numerous publications exist on the nature of the quartz-dolerite Whin Sill (Holmes and Harwood, 1928; Johnson, 1959; Dunham and Kaye, 1965; Fitch and Miller, 1967; Thorpe and McDonald, 1985). Surprisingly, however, there is little reference to the cuesta landscape in the published literature. A detailed record of Holocene environmental change is preserved in the shallow peat-filled depressions developed in the less resistant sedimentary rocks between the sills (Manning *et al.,* 1997).

Description

Solid geology

The solid geology upon which the wall rests in its central portion is dominated by Lower Carboniferous (Dinantian) sediments into which are intruded a series of quartz-dolerite sills (Figure 5.71). These quartz-dolerite sills are known collectively as the 'Whin Sill' or 'Great

Whin Si The central sector of the wall is an upland region of rugged scarps with well-exposed geological strata that contrasts with the more subdued and drift-dominated landscape to both the east and west (Johnson, 1997). The Whin Sill is the largest of a number of basaltic sills and a suite of dykes of Late Carboniferous age emplaced into the surrounding Carboniferous sedimentary rocks of north-east England (Thorpe and Macdonald, 1985). The individual sills that together comprise the Whin Sill complex are composed primarily of quartz dolerites with thin, chilled upper and lower margins. The sills were injected at successively higher horizons in the sedimentary rocks when traced from east to west across the region (Johnson, 1959). The age and mechanism of emplacement of the sill are considered in detail by Holmes and Harwood (1928), Johnson (1959), Dunham and Kaye (1965), Fitch and Miller (1967) and Thorpe and McDonald (1985). Deep weathering of the dolerite sill to a depth of 15 m has been reported around the Middleton-in-Teesdale area (Hornung and Hatton, 1974). Occurrences of deep weathering are limited along the Roman Wall, being confined to shallow isolated pockets and to small patches of spheroidal weathering in the Bamburgh area (Hornung and Hatton, 1974).

Although much of the Whin Sill complex is not visible at the surface, and across the rest of northern England is encountered only in deep boreholes (Ridd *et al.,* 1970), the sill is particularly well-exposed in the vicinity of Roman Wall.

At this point, approximately 2 km to the north of Haltwhistle in Northumberland, the Whin Sill forms a spectacular north-facing escarpment in a series of cliffs up to 20 m high. On the southern side of the sill, where the dip of the strata decreases, the slopes are more gentle and bedding-parallel. The route of Hadrian's Wall takes advantage of this natural topographical feature and follows the crest of the escarpment at this point.

The cuesta landscape

The term 'cuesta' can be applied to any large-scale asymmetric landform. However, the term generally is reserved for landforms whose development is structurally controlled. In many cases, cuestas are created in situations where there is a gently inclined surface parallel to the dip of bedding planes and an escarpment or scarp face that is steeply inclined in the opposite direction to the dip slope and cuts across bedding planes. 'Cuesta' is Spanish for a flank or slope, and geomorphologists have used the term to describe asymmetric landforms in a variety of climatic settings (see e.g. Dayan, 1993; Tippett and Kamp, 1995). A landscape dominated by a series of cuestas is developed in the Whin Sill and its host sedimentary rocks along much of the length of Hadrian's Wall, especially in its central portion. The cuestas are particularly well developed where glacial erosion has exploited structural lines in the bedrock and accentuated the natural variability in the durability of the bedrock.

As a result, high north-facing cliffs and gentler south-facing dip slopes dominate the landscape wherever the Whin Sill has been subjected to glacial erosion. Farther away from the wall itself, limestone and sandstone strata around King's Crag and Queen's Crag [NY 795 704] also define a more subdued cuesta landscape, where differences in overall relief are less than at the wall. Structural control is still obvious in the form of scarp and dip contrasts, minor cliffs and rock basins. The most famous of the rock basins is the large Crag Lough [NY 765 681], where a lake occupies an ice-scoured bedrock hollow immediately beneath the plucked north face of the Whin Sill escarpment. Farther west, near Winshields Crag [NY 740 675] is the highest point of the wall at 375 m OD. Good examples of glacial meltwater channels are incised into the Whin Sill at elevations of up to *c.* 320 m OD at the top of Green Slack [NY 742 675]. Here a large flat-floored channel runs south-east down the dip slope of the escarpment. Other examples of meltwater channels at Lodhams Slack [NY 738 672], at *c.* 300 m OD, also cut across the escarpment in the same orientation.

Interpretation

Johnson (1997) suggests that around Roman Wall the striking scarp and dip landforms arise from a combination of three factors. Firstly, the Carboniferous succession comprises a repeated or cyclic sequence of limestone, mudstone, sandstone and coal. This produces an alternation of hard and soft beds of different susceptibility to weathering and erosion. The quartz-dolerite Whin Sill, intruded into this succession in the Late Carboniferous is of varying thickness and transgresses from one horizon to another. By comparison with the limestone, mudstone, sandstone and coal, the Whin Sill is very durable and therefore stands proud of these other rocks. Secondly, uplift associated with the Cheviot pluton to the north resulted in doming of the sediments surrounding the igneous centre. This imparted a significant southerly dip to the strata in the Roman Wall area. Thirdly, that Late Devensian ice movement in this area was predominantly west to east, parallel to the strike of the beds. Evidence for this easterly ice flow across the area comes from the movement eastwards of Lake District erratics (Johnson, 1952). This ice movement direction is partly responsible for accentuating the scarp and dip topography.

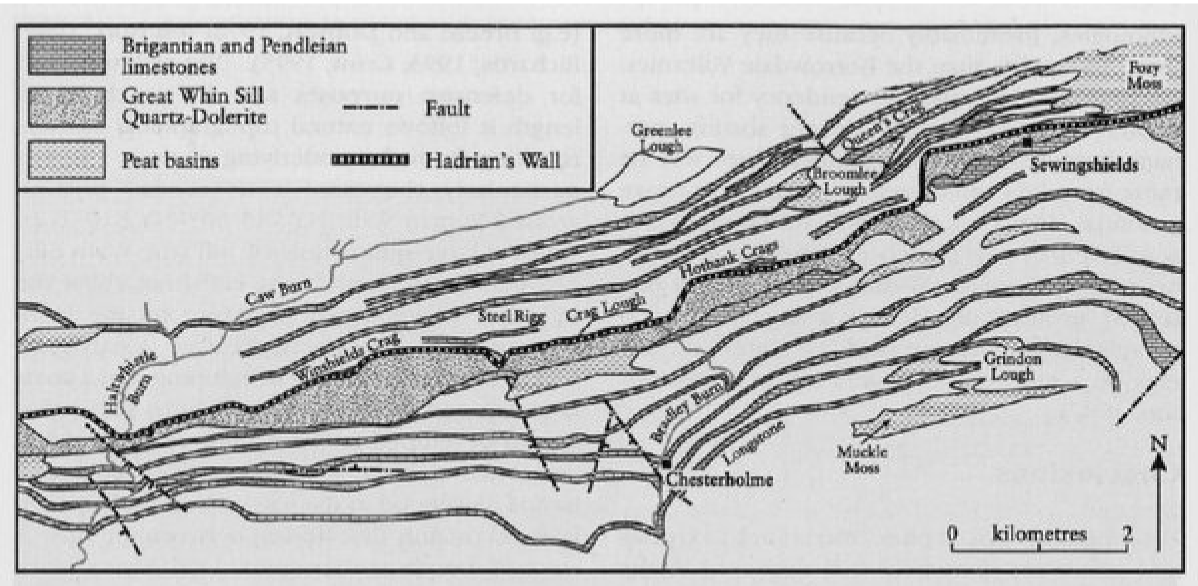
In addition to this landform interest, the cuesta landscape also provides insight into the processes of glacial erosion operating beneath the Late Devensian ice sheet. Ice-sheet erosion can be achieved by the physical processes of abrasion and plucking, and by meltwater erosion (both chemical and mechanical) (Bennett and Glasser, 1996). The resulting landforms are a complex amalgam relating both to the processes operating within the ice sheet itself and to the nature of its bed. Variables such as topography (Glasser, 1995), ice-sheet thermal regime (Gordon, 1979; Kiernan, 1994), pre-glacial relief and weathering (Klimaszewski, 1964; Lindstrom, 1988), ice dynamics (Nye and Martin, 1968; Andrews, 1972), scale (Glasser and Warren, 1990), the primary nature of the substrate (Boulton, 1979) and bedrock lithology (Gordon, 1981; Glasser *et al.,* 1998) are all important in this context. Variables external to the ice-sheet system, such as the duration of glaciation, also are important (Porter, 1989). The cuesta landscape exemplified at Roman Wall is primarily the result of glacial quarrying by rock fracture and entrainment that acts to produce rock steps, cliffs and plucked bedrock surfaces. Previous research has shown that at this scale glacial quarrying is most effective in situations where a cavity forms between the ice and its bed, usually in the lee of a bedrock obstacle (Glasser and Warren, 1990; Sugden *et al.,* 1992). Rock breakdown can then occur as a result of frost action (Walder and Hallet, 1985, 1986) and fluctuations in subglacial water pressure (Hooke, 1991; Iverson, 1991). The situation at Roman Wall is somewhat unusual because the landforms are orientated with the prominent cliff proximal to ice flow rather than distal. As the formation of cavities is favoured under thin ice with high velocities and abundant meltwater (Sugden *et al.,* 1992), this provides insight into the nature of the Late Devensian ice sheet. This fits well with other geomorphological evidence in the region (e.g. Common, 1953, 1957; Derbyshire, 1961; Clapperton, 1966, 1968, 1971a, b).

Finally, it should be noted that erosion of the escarpment could play an important role in former ice-sheet dynamics and in determining the distribution of debris within the Late Devensian ice sheet (Benn and Evans, 1998). For example, compressive flow is likely to encourage transportation of debris to the ice surface wherever an ice sheet flows against a topographical obstacle such as an escarpment (Straw, 1968a; Worsley, 1969; Eyles and Menzies, 1983; Paul, 1983; Sharpe, 1988). This control on sediment supply has important implications for landform development further afield, especially during ice recession.

Conclusions

The Whin Sill and surrounding sedimentary rocks demonstrate the strong influence of geological structure on the development of glacial erosional landforms. The steeply dipping scarp face on the north side forms a prominent escarpment, whereas a gentle dip slope is developed to the south, creating a cuesta landscape. Less resistant sedimentary strata also have been exploited by glacial erosion to form minor rock basins in the intervening linear depressions. The development of these landforms can be related directly to geological structure, ice movement direction and glacial erosional processes. In total, the site provides a striking example of the influence of geological structure on glacial landform development and provides insight into the nature of subglacial processes operating beneath the Late Devensian ice sheet.

[References]



(Figure 5.71) Geological map of Hadrian's Wall in the vicinity of the Roman Wall GCR site (after Johnson, 1997). Note how the route of the wall follows the Whin Sill and the general ENE–WSW grain of the landscape.