Palmers Hill Rail Cutting, Scottish Borders

[NT 549 965]

Introduction

Scattered outcrops of Upper Old Red Sandstone extend from Kirkbean, south-west of Dumfries (Leeder, 1976; Leeder and Bridges, 1978) northeastwards through Annandale to Liddesdale (Lumsden *et al.,* 1967; Leeder, 1973, 1976). In Liddesdale, the strata range in thickness from less than 15 m to over 180 m in a narrow and sinuous outcrop that extends for 20 km northeastwards from Langholm to Robert's Linn and around the outlier of Carboniferous rocks on Arkelton Hill. To the north-east, the outcrop of Upper Old Red Sandstone fluvial sandstones broadens and extends from Jedburgh to the Merse of Berwick-shire and to Cockburnspath (see Siccar Point to Hawk's Heugh GCR site report, Chapter 3).

The Palmers Hill Rail Cutting in Liddesdale (Figure 4.3) exposes about 23 m of Upper Old Red Sandstone fluvial sandstones. The uppermost 7–8 m of strata contain pedogenic carbonate (calcrete) nodules and two regionally significant, mature calcrete horizons (Lumsden *et al.,* 1967; Leeder, 1976). The calcrete-bearing strata are referred to the Kinnesswood Formation of the Lower Carboniferous Inverclyde Group and the underlying strata to the Upper Devonian Stratheden Group (Paterson and Hall, 1986; Browne *et al.,* 2002). In the Palmers Hill Rail Cutting, the strata rest with angular unconformity on wacke sandstones of the Lower Palaeozoic (Wenlock) Riccarton Group (Lumsden *et al.,* 1967). They are overlain by weathered vesicular olivine basalt lavas of the Tournaisian Birrenswark Volcanic Formation.

Description

The Palmers Hill Rail Cutting lies on the northeastern flank of Arnton Fell in Liddesdale and is one of several sections including those in the Dinley Burn, Laidlehope Burn, Riccarton Burn, Dawston Burn, Caddroun Burn and Robert's Linn (Figure 4.4) in which calcrete is recorded in the upper part of the Upper Old Red Sandstone succession. About 120 m of thinly bedded, massive and cross-bedded, brownish red, medium- to coarse-grained sandstones are exposed in Riccarton Burn, south-west of Palmers Hill Rail Cutting.

The cutting exposes about 23 m of strata, which dip about 15° ESE. The lowermost 15 m are here assigned to the Stratheden Group. They comprise coarse-grained, massive, reddish brown sandstones containing well-rounded quartz pebbles and rounded clasts of deep reddish purple siltstone and silty mudstone. The lowest 1.8 m of sandstone have yielded unidentified fish scales (Lumsden *et al.,* 1967). The overlying Kinnesswood Formation is 7–8 m thick, contains nodular and massive calcrete (Leeder, 1976; the 'sandy cornstones' of Lumsden *et al.,* 1967) and is overlain by weathered lavas of the Birrenswark Volcanic Formation ((Figure 4.4); Leeder, 1976). The strata comprise cross-bedded and planar-laminated sandstones interbedded with silty mudstone. The lower 4 m contain numerous carbonate nodules and a dolomitic calcrete horizon (Palaeosol 1 of Leeder, 1976) developed in a sub-arkosic sandstone. The sandstones between this horizon and a higher dolomitic calcrete (Palaeosol 2 of Leeder) are lithic-rich and contain chloritized basaltic detritus. In thin section, the calcrete is invariably seen to be a ferroan dolomite sparite exhibiting replacive and displacive fabrics of carbonate after quartz sand and silt (cf. Steel, 1974; Balin, 2000). Basaltic detritus is present above the higher calcrete, in the uppermost metre of the section, and the top few centimetres immediately below the basaltic lavas contain stringers and nodules of chert, interpreted by Leeder (1976) as silcrete.

Interpretation

The red beds of the Upper Old Red Sandstone have been variably assigned a Late Devonian and Early Carboniferous age. In the Langholm district, the presence of *Holoptychius noblissimus* Agassiz in red beds with 'cornstones' led earlier workers (e.g. Peach and Horne, 1903) to assign the strata to the Late Devonian (Lumsden *et al.,* 1967), but these criteria are not diagnostic of age. Indirect evidence of a minimum age of the strata is provided by radiometric age determinations on the overlying basalts. An olivine basalt flow of the Birrenswark Volcanic Formation at Watch Hill near Langholm and an aphyric basalt from a plug at Mellerstain Hill near Kelso have been dated by the K–Ar whole-rock method as 361 ± 12 Ma and 361 ± 7 Ma respectively, close to the Devonian–Tournaisian boundary (De Souza,1982).

The calcrete horizons and volcanic detritus in the sandstones at these other localities provide the basis for the palaeogeographical reconstruction of a shallow, alluvial, inland basin, the Scottish Border Basin. During Early Carboniferous times, this became the northern margin of the larger successor basins — the Northumberland and Solway basins. The Upper Old Red Sandstone of the Scottish Border Basin is interpreted as a fluvial succession of sandstones and pebbly sandstones deposited in braided streams (Leeder, 1973; 1976). Palaeocurrent data are consistent with dominantly south-westerly derivation and compositional characteristics indicate an igneous and sedimentary sourceland in Galloway. However, in the eastern part of the basin, derivation from the south-east and north-east has been postulated by Smith (1967) and Paterson *et al.* (1976). A semi-arid continental climate and periodic emergence is indicated by the presence of wind-rounded sand grains, pedogenic calcrete and silcrete, and numerous desiccation-cracked surfaces.

The presence of calcretes in the Kinnesswood Formation of the Scottish Border Basin, similar to those in south Ayrshire (Burgess, 1961), indicates periodic uplift, emergence and dissection of the alluvial plains. The uplift probably took place in response to partial melting in the upper mantle, which eventually resulted in basaltic volcanism (Leeder, 1974, 1976). The first regionally recognizable calcrete (Palaeosol 1) was partially buried by lava flows during subsequent local volcanic activity, and volcanic detritus was reworked into the overlying fluvial sandstones. Further uplift resulted in the development of a second calcrete (Palaeosol 2), to be followed by the more extensive fissure eruption of basalt lavas of the Birrenswark Volcanic Formation, the outcrop of which extends discontinuously from the Kirkbean district to Kelso.

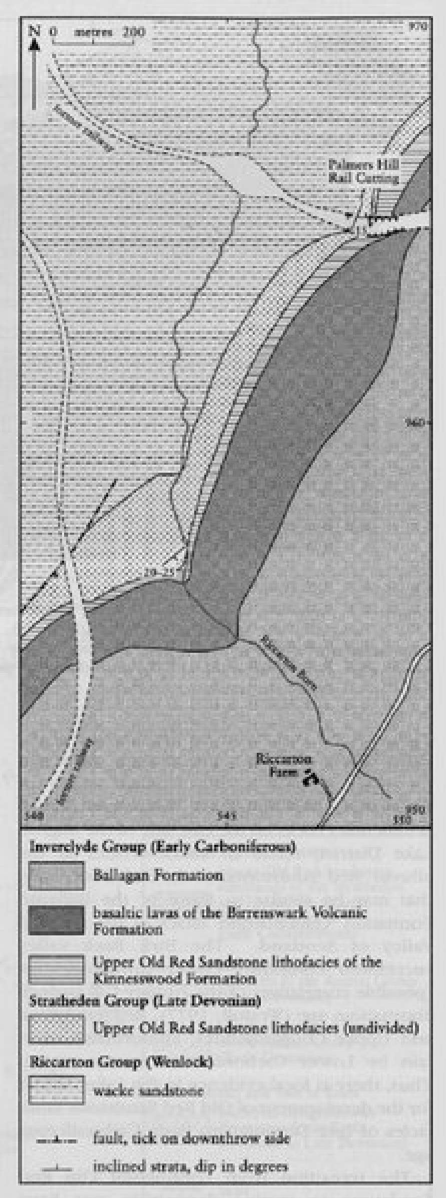
In thin section, the replacive and displacive fabrics of the dolomitic carbonate are typical of many modern and ancient pedogenic carbonates, and an analogy may be made with modern accumulations of carbonate in soil profiles of semi-arid regions (e.g. Steel, 1974; Balin, 2000). Peach and Horne (1903) noted that the cornstone (calcrete) is commonly accompanied by a lenticular red chert bed in the Riccarton area. The chert, which replaced dolomite, is interpreted as a pedogenic silicification phase (Leeder, 1976). Detailed petrological research on the origin of the dolomite at this site has yet to be undertaken.

Conclusions

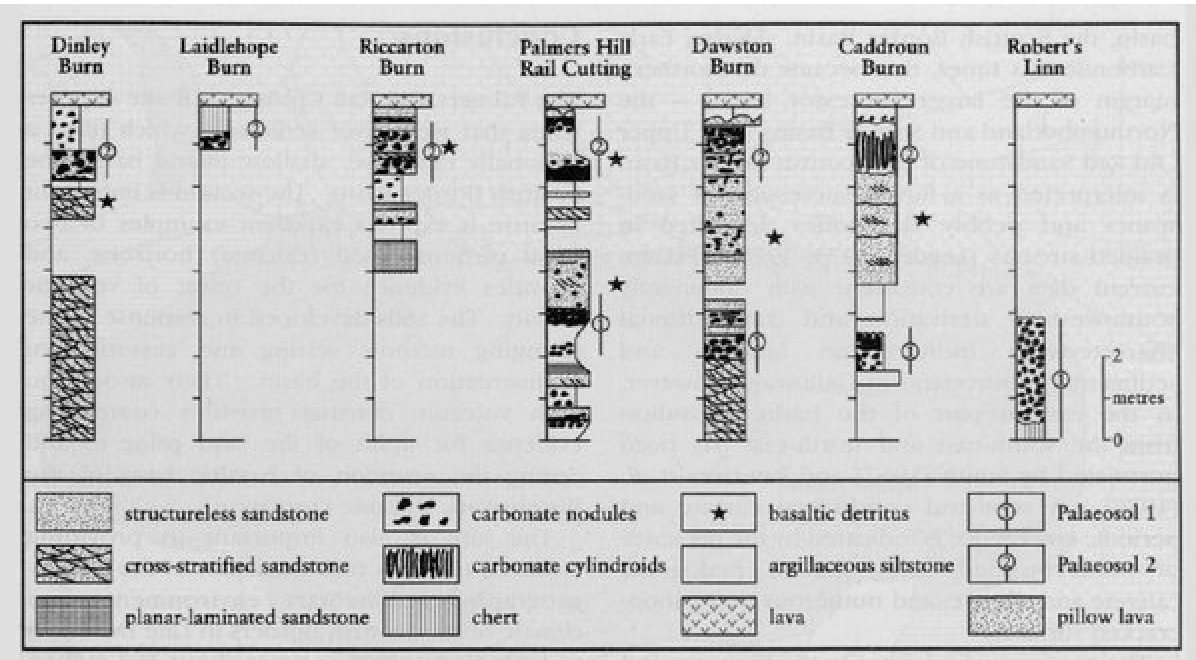
The Palmers Hill Rail Cutting GCR site exposes strata that were river sediments which filled a regionally extensive, shallow inland basin, the Scottish Border Basin. The section is important because it exposes excellent examples of two fossil carbonate soil (calcrete) horizons, and provides evidence for the onset of volcanic activity. The soils developed in response to the changing tectonic setting and cessation of sedimentation of the basin. Their association with volcanic detritus provides compelling evidence for uplift of the land prior to and during the eruption of basaltic lavas of the Birrenswark Volcanic Formation.

The site is also important in providing evidence to allow reconstruction of the palaeogeography, sedimentary environments and climate of the Scottish Borders in Late Devonian to Early Carboniferous times about 362 million years ago.

References



(Figure 4.3) Geological map of the area around Palmers Hill Rail Cutting.



(Figure 4.4) Graphic logs of the Kinnesswood Formation of Liddesdale showing the distribution of calcrete. After Leeder (1976).