Carron Water, Dumfries and Galloway

[NS 885 017]–[NS 887 024]

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Introduction

The gorge of the Carron Water, 4 km NNE of Carronbridge, Nithsdale and 0.5 km downstream from Jenny Hair's Bridge, is the type section for the Early Permian Carron Basalt Formation (Figure 4.13). The site is continuous with the Hapland Burn GCR site that represents the associated fluvial and aeolian sedimentary rocks (see Benton *et al.,* 2002).

The Carron Basalt Formation, defined by Brookfield (1978) from this type section, comprises basaltic lavas and some interbedded sedimentary units. It is restricted to the Thornhill Basin, a small N–S-elongated fault-bound outlier of Carboniferous and Permian rocks within the Southern Uplands, and to very small outliers in the adjoining Sanquhar Basin. Originally these lavas may have formed part of a more extensive volcanic field that included the volcanic rocks in the Mauchline Basin (see Howford Bridge GCR site report).

These volcanic rocks were identified by Geikie (1866, 1897) and were first described in some detail in the Geological Survey memoir for the Sanquhar and Thornhill coalfields (Simpson and Richey, 1936). A general description of the Thornhill Basin appears in the memoir for the adjacent Sheet 9 (McMillan, 2002) and aspects of the Permian sedimentology and stratigraphy were discussed by Brookfield (1978, 1980) and McMillan and Brand (1995). The basalts have been included in geochemical studies of Silesian and Permian igneous rocks of southern Scotland by Macdonald *et al.* (1977) and Wallis (1989) and have also been investigated as a potential source of gold that occurs as trace amounts in the associated red beds (Leake *et al.,* 1997). Brief descriptions of the GCR site and nearby localities have been included in field excursion guides (Brookfield, 1981; McMillan in Stone, 1996).

Description

The Carron Basalt Formation is exposed only intermittently within the northern and western parts of the Thornhill Basin. The sequence of lavas with associated thin breccias and sandstones is no more than 50 m thick at maximum, though thicknesses of 20 m are most usually quoted (e.g. McMillan, 2002). It unconformably overlies mainly reddened Middle Coal Measures strata, though in the south-east it rests upon Lower Palaeozoic rocks. It is succeeded by the Durisdeer Formation and the Thornhill Sandstone Formation of the Lower Permian Appleby Group.

The Carron Water GCR site is the type locality for the Carron Basalt Formation, where 20 m or so of lavas and sedimentary rocks dip gently to the north. The type succession of the formation (after Simpson and Richey, 1936) is shown below.

Top

Sandstone, brick-red with occasional 'blocks' of basalt

Sandstone, brick-red, cross-bedded, aeolian

Breccia, basaltic

Non-exposed gap

Olivine basalt, amygdaloidal; 2 flows, each with fissured upper surfaces

Sandstone, red, fine grained

Olivine basalt, amygdaloidal

Sandstone, very fine-grained, with basaltic pebbles in upper part

Non-exposed gap

Carboniferous sedimentary rock

Bottom

Locally, the base of the volcanic formation is a breccia with small angular clasts of greywacke and basalt in a sandy matrix. The presence of basaltic clasts indicates that lavas were already present and were being eroded elsewhere in the basin. Some basalts incorporate wind-blown sand in their matrix (Brookfield, 1980). The lavas, for the most part, comprise deeply and extensively weathered olivine basalts, 1–3 m thick (Figure 4.14). Olivine microphenocrysts and other ferromagnesian phases are easily seen on weathered surfaces as they are pseudomorphed by amorphous mixtures of 'serpentine', haematite, chlorite and clay minerals, giving a red speckled appearance to the rock. All three flows are amygdaloidal to a greater or lesser degree, but locally they have a slightly more massive facies overlain by a thicker amygdaloidal zone. This upper part is often reddened and fissured. Where the flows are overlain by contemporaneous sedimentary rocks, these fissures have been partially infilled, and neptunian dykes of sandstone are quite common. The top of the formation is a basalt breccia, irregularly overlying fissured, amygdaloidal basalt. However, the contact between basalt and breccia cannot be seen.

The top of the Carron Basalt Formation inter-digitates with the base of the Durisdeer Formation. The latter comprises a variable unit, some 70 m thick in the Hapland Burn, of arenaceous sedimentary rocks dominated by polymict conglomerates, pebbly sandstones, cross-bedded sandstones and tabular sandy breccias (Brookfield, 1978). Clasts in the conglomerates and breccias are dominated by locally derived basalt, up to boulder size, but also include local Carboniferous and Lower Palaeozoic sedimentary rocks. These coarse-grained fluvial litholo-gies interdigitate with and pass upwards into aeolian dune-bedded sandstones that typify the overlying Thornhill Sandstone Formation.

There are few analyses of lavas from the Thornhill Basin (Macdonald *et al.,* 1977; Wallis, 1989). Although the latest Carboniferous and Early Permian igneous rocks of south-west Scotland are dominantly alkaline and silica-undersaturated, the lavas of the Thornhill Basin, like those of the Mauchline Basin, show a range of compositions from hypersthene-normative (transitional) basalts to nepheline-normative alkali basalts and basanites.

Interpretation

Because of its association with red fluvial and aeolian strata, the Carron Basalt Formation has long been considered to be Permian in age (Geikie, 1866, 1897; Simpson and Richey, 1936). Plant remains in beds intercalated with similar flows in the Mauchline Basin have been assigned to the earliest Permian (Wagner, 1983), and by inference the Carron Basalt Formation is probably also of earliest Permian age. Being so close to the Carboniferous–Permian boundary, the basalts therefore have potential international significance as a source of material for radiometric dating, although finding fresh material could be difficult.

The palaeoenvironment of the Thornhill Basin during the volcanic period is best assessed by considering both the lavas and the facies of the associated sedimentary rocks. The volcanism appears to have been short-lived and intermittent. Locally, flows show reddened upper surfaces suggesting atmospheric weathering, and the incorporation of unconsolidated sand into the matrix of some flows and the sandstone dykes in fissures also point to surface exposure. The lavas were emplaced subaerially; there is no evidence by way of pillow structures or hyaloclastites for the existence of bodies of standing water, despite the presence of interbedded, waterlain sedimentary rocks.

The lower sandstones and those infilling fissures on the flow surfaces contain mainly sub-angular grains, typical of immature fluvial facies. Brookfield (1978, 1980) and McMillan and Brand (1995) have interpreted the basal breccias and conglomerates of the Durisdeer Formation as piedmont and minor stream-flood deposits with some alluvial fan

sheet-flood sands and breccias and marginal fluvial facies. There are some interbedded aeolian sandstones and climatic conditions became progressively more arid, but true desert conditions may not have been fully established until well after the volcanic period. The succeeding beds of the Thornhill Sandstone Formation contain mainly well-rounded grains and polished and faceted pebbles. They are dominated by desert dune sands and a few interdune sheet deposits.

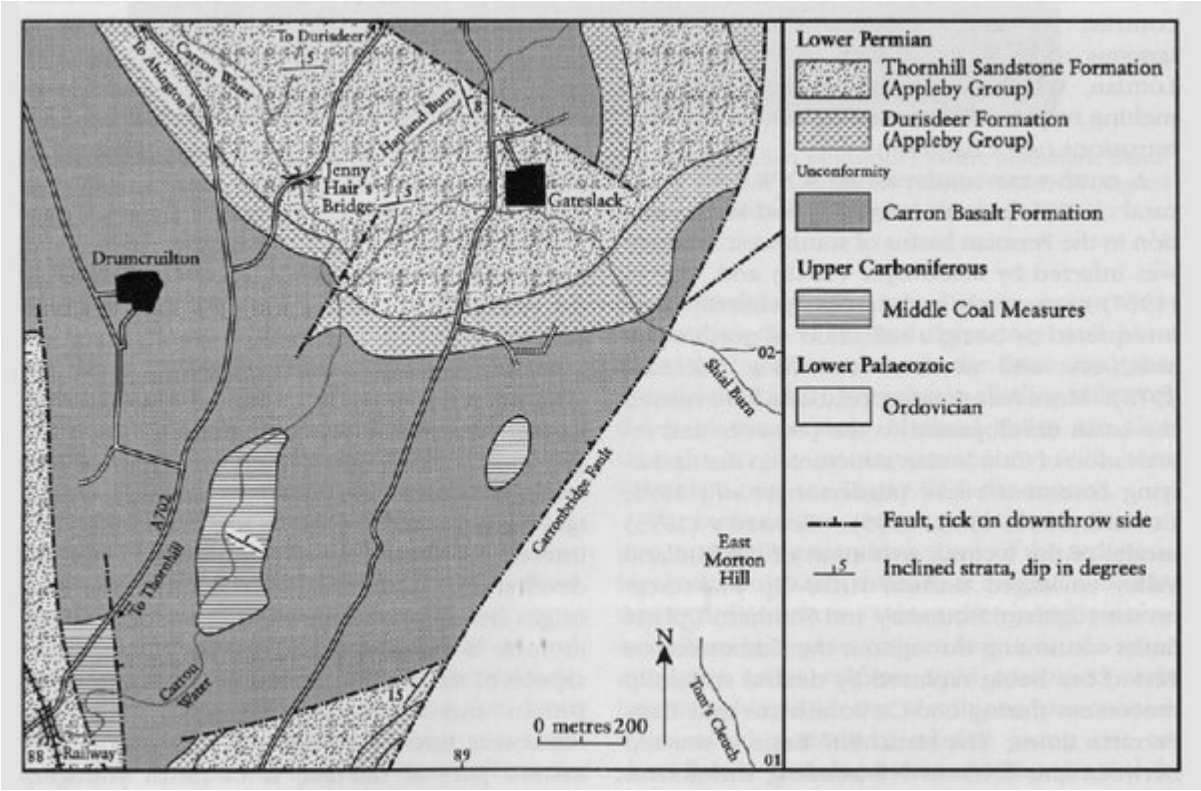
The Thornhill Basin is one of a number of now isolated Permian sedimentary basins in the Southern Uplands that are orientated perpendicular to the north-east–south-west Caledonian fabric of the underlying rocks. They developed under extensional regimes, with their shape and orientation controlled by the re-activation of deep-seated structures in the basement (Anderson *et al.,* 1995). Limited transitional to alkaline volcanism was associated with the early phases in the rift-history of the basin and may have been contiguous with other Permian volcanic sequences in southern Scotland, for example the Mauchline Volcanic Formation (see Howford Bridge GCR site report).

Conclusions

The Carron Water GCR site contains the type section for the Carron Basalt Formation, a series of subaerial, olivine basalts within the Early Permian 'red bed' sequence of the Thornhill Basin. The interaction between volcanism and contemporaneous sedimentation is a feature of the site that enables reconstructions of both palaeoenvironment and palaeogeography.

The basalts are among the youngest products of the Carboniferous–Permian Igneous Province of northern Britain and hence are important in any consideration of the overall magmatic evolution. Together with interbedded fluvial and aeolian sedimentary rocks, they are also critical to a full understanding of the complex interplay between magmatic events, sedimentation and basin tectonics in northern Britain and throughout north-west Europe during Early Permian times.

References



(Figure 4.13) Map of the area around the Carron Water GCR site. Based on British Geological Survey 1:10 000 Sheet NS 80 SE (2000).

(Figure 4.14) Residual 'core' within heavily-weathered basalt lava of the Carron Basalt Formation on the west bank of the Carron Water GCR site. (Photo: K.M. Goodenough.)