Todholes, Stirling

[NS 739 877]–[NS 754 878]

Introduction

The Todholes GCR site, a stream section in the valley of the Bannock Burn [NS 739 877]–[NS 754 878], 9 km south-west of Stirling, shows Lower Carboniferous rocks, included in the Kirkwood Formation, Lawmuir Formation and Lower Limestone Formation (upper Brigantian), overlapping onto lavas of the Clyde Plateau Volcanic Formation. Above North Third Reservoir the valley of the Bannock Burn essentially runs down to the east, cutting down into the dip-slope of the Carboniferous rocks. Due to irregularities in the stream profile and to minor structural complexities, the sequence is exposed in a series of highly instructive outcrops in the stream and valley sides. In addition to providing an important reference section, these Dinantian rocks exhibit sedimentologically and palaeontologically interesting facies variations (Dinham, 1920; Dinham in Flett *et al.,* 1927; Dinham and Haldane, 1932; Read, 1959; Francis *et al.,* 1970).

Description

The lowest beds in the sequence, the Kirkwood Formation (formerly known as the 'Volcanic Detritus'), are formed from the decay and re-distribution of volcanic material derived from the underlying Clyde Plateau Volcanic Formation (see (Figure 2.27)). Units within the Kirkwood Formation vary in grade from fine mudstones to conglomerates and are variegated green, grey, brown, yellow or red in colour. While some units contain sedimentary structures and are clearly waterlaid, the basal parts are structure-less and appear to represent a regolith of decomposed basalt that rests on and passes down into weathered lava. In consequence, although there was a prolonged erosional break between the Clyde Plateau Volcanic Formation and the Kirkwood Formation, the junction may be difficult to locate precisely. The thickness of the Kirkwood Formation is variable but thickens eastwards from 2.4 m to 7 m.

The Kirkwood Formation is discordantly overlain by shales with ironstone nodules which form the first of a series of beds of more normal sedimentary facies at the base of the Lawmuir Formation. These shales vary from 0.3 m to 1.2 m in thickness, and at the top, immediately below an overlying limestone (Bannock Limestone G), contain a marine fauna of bivalves, including *Cypricardella rectangularis,* and fragmentary productoids and spiriferoids. Bannock Limestone G is a grey micritic limestone characterized by the presence of gigantoproductid brachiopods and large solitary corals. It varies in thickness from 0.65 m thick at its most easterly exposure to 0.15 m thick 300 m to the west, and it has apparently thinned to nothing 300 m farther to the west (see (Figure 2.25)).

About 10 m of shales, mudstones and sandstones separate Bannock Limestone G and a higher limestone unit, which includes Bannock Limestones E and F. The basal parts of the shale immediately above Bannock Limestone G contain marine fossils but higher parts, including the overlying greenish- and yellow-coloured mudstones and sandstones, contain only plant fragments and stigmarian roots and rootlets. These upper beds appear to have a high content of highly weathered volcanic material.

Bannock Limestones E and F were once treated as separate marine units (Dinham, 1920; Dinham in Flett *et al.,* 1927; Dinham and Haldane, 1932) but are now considered to be contrasting parts of a single marine unit (Read, 1959; Francis *et al.,* 1970). The lower part (Bannock Limestone F) is a grey-coloured, argillaceous, bedded limestone with shale partings (0.4–1.3 m), which rests on a thin shale with marine fossils (see (Figure 2.27)). It contains an abundant and diverse fauna dominated by crushed brachiopods including productoids, crinoid ossides and trepostomous bryozoans. Bannock Limestone E (1.1–1.7 m) contains a similar fauna (Francis *et al.,* 1970) but is distinguished by irregular nodules and its creamy white, 'bleached' colour. These latter features are secondary palaeosol features that have been superimposed on the limestone by penecontemporaneous weathering. In places, rootlets and laminated structures, of a possible pedogenic origin, occur in the more massive top of the limestone. The lower limit of the bleaching lies within, and is apparently controlled by, a thick shale parting, which may have acted as an impervious layer. This parting thins and disappears to the east. The most easterly exposure of this horizon also shows a marked change of facies as the

upper parts of the exposed limestone (1.5 m), which are irregularly bleached but not nodular, are an argillaceous limestone containing goniatite fragments (0.3 m). These pass up into irregularly bleached shales, the top of which is, unfortunately, not exposed.

The remainder of the succession is less well exposed due to past working of the Murrayshall Limestone (Bannock Limestone D). Bannock Limestones E and F are sharply overlain by shales (4 m) which make up the whole section between these limestones and the Murrayshall Limestone. The basal parts of the shale are dark and pyritous and contain a sparse marine fauna and thin bands of ironstone and limestone. The central parts of the shale are contorted and the upper parts are more calcareous and become increasingly fossiliferous close to the passage into the Murrayshall Limestone. This fauna includes productoids (e.g. *Eomarginifera longispina, Dictyoclostus*), other brachiopods (*Spirifer, Lingula, Orbiculoidea*), bivalves (*Sanguinolites costellatus*), bellerophontids, orthoceratid cephalopods, zaphrentid corals, the trilobite *Paladin eichwaldi,* bryozoans, crinoid ossifies and echinoid remains. A notable feature is that plates, scales and lantern elements of the echinoid *Archaeocidaris urii* may be abundant locally.

The Murrayshall Limestone, at the base of the overlying Lower Limestone Formation, is about 2 m thick, but only the basal 0.3 m, a dark, crinoidal limestone with brachiopod fragments, can be seen. Immediately above this limestone there are shales (1.2 m), with a diverse marine fauna, which pass upwards into barren shales (1.0 m) and flaggy sandstones (0.7 m). A gap (5 m) in the sequence includes the position of the Bannock Limestone C, which may have been economically exploited. Above this, the uppermost beds of the exposed sequence comprise 9 m of sandstone and siltstone. Exposures of quartz dolerite (the Midland Valley Sill) occur a short distance above these, but its contact with the underlying strata is not seen. This gap may include the position of Bannock Limestone B as loose blocks of this, with distinctive laminated intraclasts, can be found in the Bannock Burn a short distance above Todholes Ford [NS 754 878]. In the same vicinity there are blocks of sandstone with large plant fragments, which appear to have come from the sequence above the Murrayshall Limestone. The plant fossils recorded by Kidston (1884) probably also came from this part of the sequence.

Interpretation

The locality lies on the eastern flank of the complex volcanic area of the Campsie and Touch Hills. The succession provides significant information about the overlap of these largely basaltic volcanic rocks by later beds of the Kirkwood Formation and Lawmuir Formation and the lower part of the Lower Limestone Formation. After the eruption of the Clyde Plateau Volcanic Formation there was a prolonged period of weathering and erosion, and the earliest bedded strata, the volcanic detritus of the Kirkwood Formation, are almost entirely derived from the reworking of highly weathered lava. The boundary between the Kirkwood Formation and Lawmuir Formation is recognized to be highly diachronous regionally (Browne *et al.,* 1999) and the basal beds of the Lawmuir Formation at Todholes are considerably younger than the basal beds in the Paisley region (Hinman *et al.,* 1920; Macgregor *et al.,* 1925). The overlying beds of the Lawmuir Formation are deposited in a cyclical sequence and although the marine units provide no evidence to suggest that the sediment was derived directly from the underlying volcanic complex, some of the sandstones and siltstones do appear to include some weathered volcanic material. This emphasizes the progressive and temporally prolonged nature of the overstep of the Clyde Plateau Volcanic Formation.

The first marine horizon recognized at Todholes, Bannock Limestone G, is thinner than at Touchadam (see GCR site report, this chapter), and dies out completely within the Todholes outcrop, a feature that underlines the ancient palaeotopography of the region with an eastward-dipping palaeoslope extending from the Clyde Plateau lava pile down into the Stirling–Clackmannan Basin. With its content of corals and gigantoproductids this limestone strongly resembles the Hollybush Limestone of the Paisley district with which it is correlated (Dinham and Haldane, 1932; Francis *et al.,* 1970). Bannock Limestone E and F also show features reflecting this palaeoslope. At Todholes it is predominantly a shelly brachiopod limestone but at the most easterly outcrop a goniatite-bearing facies occurs similar to the goniatite–Lingula facies of the equivalent horizon in the more basinward locality of Touchadam. Thus the facies change reflects changes with water depth. This horizon is correlated with the Blackbyre Limestone of the Paisley district (Dinham and Haldane, 1932; Francis *et al.,* 1970).

The palaeosol development that affects the upper part of the combined Bannock Limestone E and F is a widespread feature of the strata between the Blackbyre Limestone and the Hurlet Limestone and representative of a disconformity that can be traced throughout the Midland Valley (Whyte, 1983; Wilson, 1989). At Todholes, palaeosol features are well developed but nearby at Touchadam the combined Bannock Limestone E and F is not modified by soil-forming processes but is overlain by a thick marl that has no equivalent at Todholes. This marl may have some volcanic detrital content and may indicate that weathered volcanic material was again being reworked during this interval.

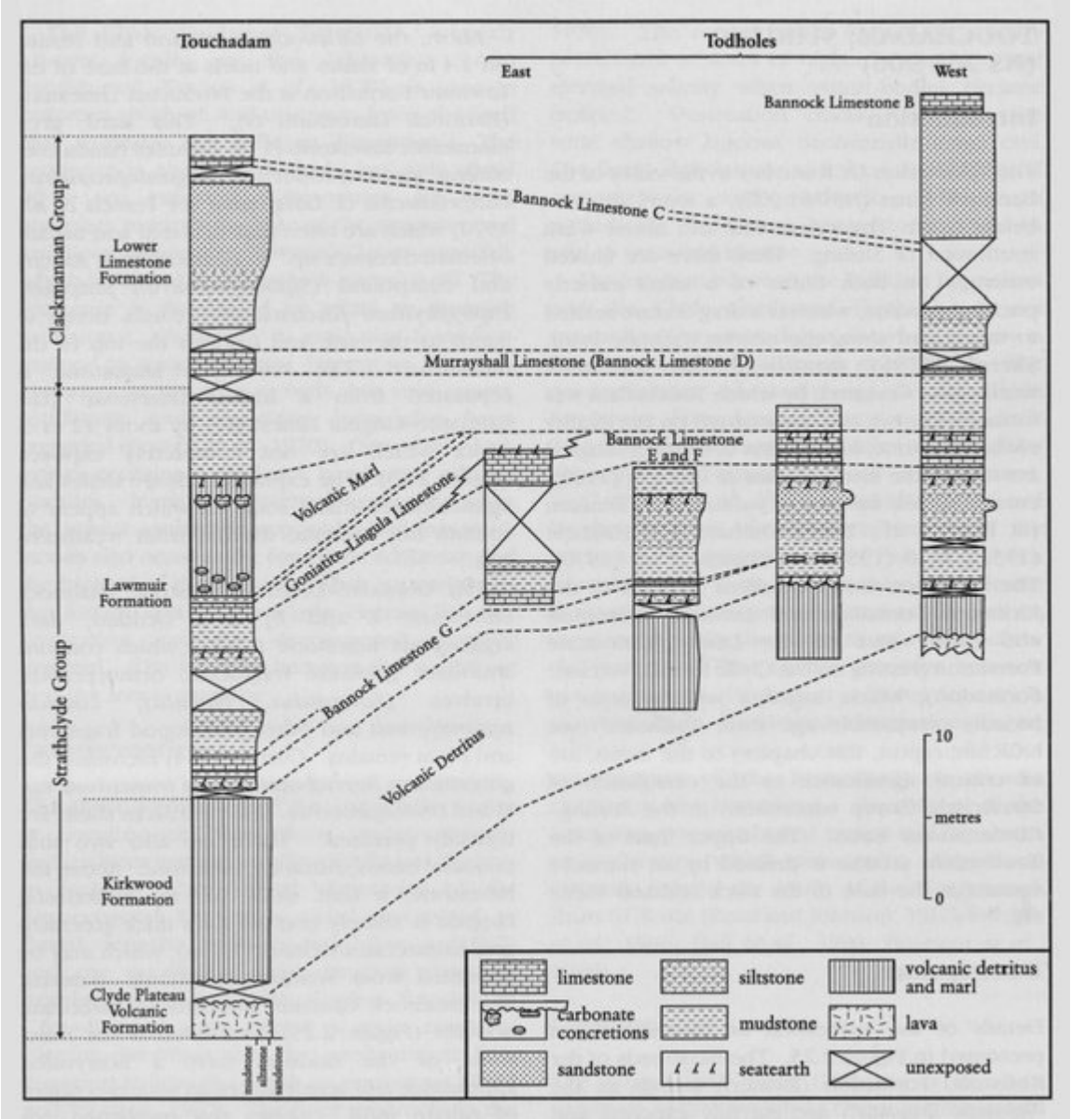
The overlying Bannock Limestone D is correlated with the Hurlet Limestone, and the shales at its base (Francis *et al.,* 1970) include elements of the Macnair Fauna, which are typically found at this horizon (Wilson, 1989). The base of the Hurlet Limestone is the marker for the base of the Lower Limestone Formation. Bannock Limestone C has no equivalent in the Paisley area as marine conditions at this horizon did not penetrate to that area. It is equivalent to the Shields Bed of Campsie and Corrie Burn and the Craigenhill Limestone of Carluke (Dinham and Haldane, 1932; Francis *et al.,* 1970; Wilson, 1989). Its occurrence at Todholes provides valuable information on the distribution of this restricted horizon. Bannock Limestone B is equivalent to the lower leaf of the Blackhall Limestone of Paisley (Dinham and Haldane, 1932; Francis *et al.,* 1970) and also provides valuable information on the distribution and character of this more lagoonal facies of the limestone.

Conclusions

Together with Touchadam, the sections at Todholes were described by Dinham (in Flett *et al.,* 1927) as 'the finest sections of Carboniferous rocks in the district'. As well as forming a vital reference section for the Kirkwood Formation and Lawmuir Formation and the lower parts of the Lower Limestone Formation on the western side of the Stirling–Clackmannan Basin, this is an outstanding locality for understanding both local and regional facies variations. This is particularly well illustrated by the contrasting styles of sedimentation evident at this site and the Touchadam site. For example, features indicative of shallow-water deposition and emergence (palaeosols) recognized at specific levels in the succession at Todholes are absent from their time-equivalent horizons at Touchadam.

References

(Figure 2.27) General view of the Bannock Burn at the Todholes GCR site showing outcrops of Lawmuir Formation (Brigantian) including Bannock Limestone F and underlying beds. (Photo: M.A. Whyte.)



(Figure 2.25) Comparative sections of strata at the Touchadam and Todholes GCR sites showing the correlation of the principal lithostratigraphical units. Note that the sections at Todholes are each approximately 100 m apart and some 3 km to the south of Touchadam. Based on various sources and including information from Francis et al. (1970).