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## Ballagan Glen, Stirling

[NS 573 797]–[NS 573 804]

### Introduction

Ballagan Glen [NS 573 797]–[NS 573 804] is incised in the southern margin of the Campsie Fells, near Strathblane and about 15 km north of Glasgow. The spectacular exposures in the side of the gorge offer the finest surface section of the Ballagan Formation (Inverclyde Group) in the Campsie district and one of the most significant developments of the Tournaisian 'cementstone' facies in northern Britain. The section also reveals important exposures of the overlying Clyde Sandstone Formation (Inverclyde Group), which lies between the Ballagan Formation and the overlying Clyde Plateau Volcanic Formation (Strathclyde Group). The beds were described by Young (1860) and further details were given by Wallace Young (1867a,b). More recent accounts have been provided by Macgregor *et al.* (1925) and Hall *et al.* (1998).

### Description

The gorge of Ballagan Glen runs steeply south parallel to, but opposite in direction to, the small northerly to north-westerly dip of the Carboniferous strata. The beds of the Ballagan Formation, of which 100 m are present, are dramatically displayed in the steep sides of the glen and in downstream sections (Figure 2.29). The base of the formation is not seen, as at the southern end of the section it is faulted against rocks of the Clyde Plateau Volcanic Formation, which have been downthrown to the south by the Campsie Fault.

The Ballagan Formation, formerly known as the 'Cementstone Group' (Macgregor *et al.*, 1925), consists of rapid alternations of cementstones and mudrocks with some sandstones. Young (1867b) counted over 230 separate beds within the gorge sequence. Thin seams and veins of gypsum are also present. The cementstones are usually thin, 0.04–0.3 m in thickness, and may occasionally be nodular. They are generally aphanitic or structureless in character and are dolomitic limestones or dolomicrites.

The dolomitic nature of the cementstones was first demonstrated by Young (1867a) and has been consistently supported by later analyses (Macgregor *et al.*, 1925; Hall *et al.*, 1998). The mudrocks, which range from fissile shales to more massive mudstones, are also relatively thin, though usually between 0.3 m and 0.6 m in thickness, and these make up about two-thirds of the formation. They are typically calcareous, grey or greenish-grey in colour and contain varying amounts of silt and sand. Desiccation cracks may occur in the mudrocks. In places, both cementstones and mudrocks may have a secondary reddish colour. The few sandstone beds, which are typically 0.6–1 m thick, are white or red in colour and markedly micaceous. These sandstones are bedded and may show ripple marks. In the lowest 10 m of the sequence, sandstones are more abundant and thicker. They appear to represent a transition from the sandstones of the underlying Kinnesswood Formation, although this latter unit is not exposed at Ballagan because of the effects of the Campsie Fault.

The Clyde Sandstone Formation, formerly known locally as the 'Spout of Ballagan Sandstone' (Macgregor *et al.*, 1925), is predominantly a thick (12 m) white siliceous sandstone with little or no mica. Above this, a thinner (2 m) unit of fireclay with coalified rootlets and sandstone is overlain by the lavas of the Clyde Plateau Volcanic Formation. Fossil plants, including a *Lepidodendron* stem and a possible *Stigmaria*, were recorded from this section by Young (1860), but their exact source horizon is unknown.

### Interpretation

Apart from some of the nodular bands, which may be diagenetic precipitates, the cementstones are primary deposits of fine carbonate mud. They and the mudrocks of the Ballagan Formation, both here and elsewhere in Scotland, are interpreted as having been laid down in a wide flat lagoon, or protected coastal flat, with intermittent marine connection

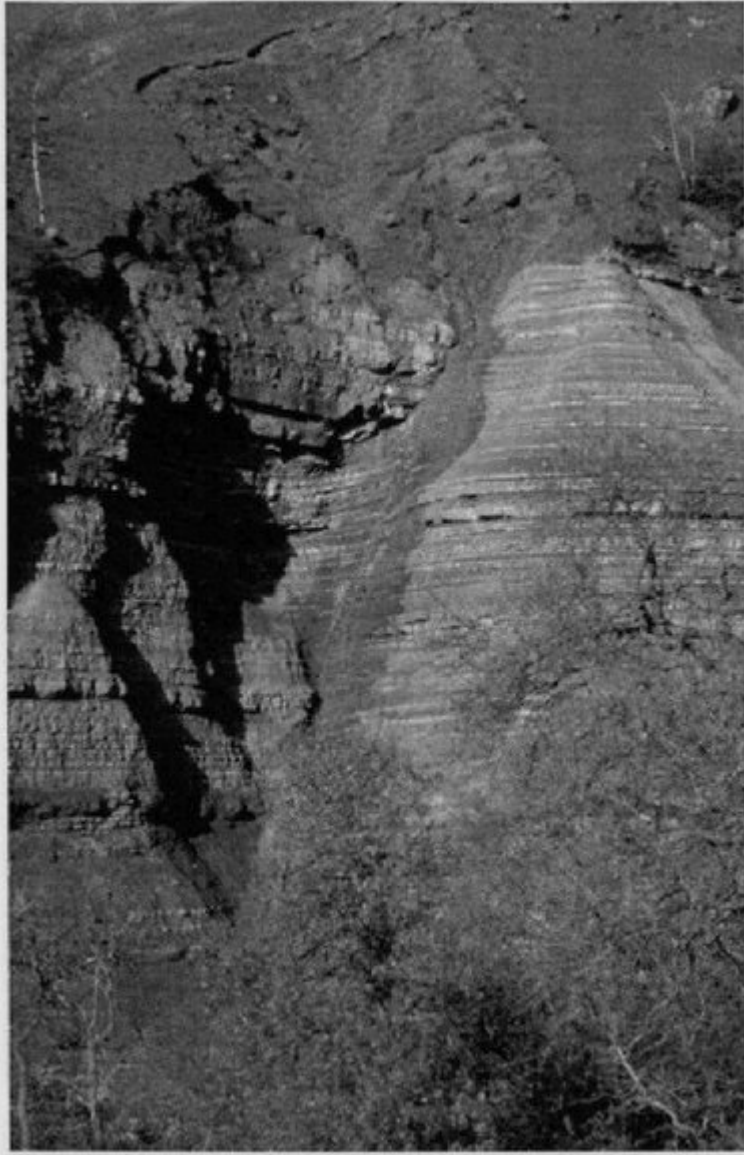
and varying salinity (Macgregor *et al.*, 1925; Macgregor, 1930; Belt *et al.*, 1967; Whyte, 1994; Hall *et al.*, 1998). The dolomitic character of the cementstones, the presence of desiccation cracks and the occurrence of gypsum all indicate hypersaline conditions and an arid to semi-arid climate (Belt *et al.*, 1967). Macgregor *et al.* (1925) discussed the origin of the rhythmic alternation between cementstones and mudrocks and related these respectively to drier and wetter conditions. They rightly dismissed a seasonal cycle for the origin of the rhythms and suggested a geographical rather than a climatic oscillation as the underlying cause. The case for climatic variation, however, needs to be reconsidered as the scale of the rhythms and the varying thickness of cycles and their component elements might well reflect a climatic response to orbital forcing and Milankovitch-type cyclicity (House, 1995).

The sporadic sandstones may represent either small channel systems or more widespread sheet-flood deposits. The thicker sandstones towards the base of the sequence are of fluvial origin and indicate that there is a transition from the fluvial-dominated successions of the Kinnesswood Formation into the Ballagan Formation. The sandstones of the Clyde Sandstone Formation indicate a relatively abrupt return to fluvial deposition that may be related to a phase of uplift and rejuvenation of the hinterland prior to the eruption of the Clyde Plateau Volcanic Formation (Hall *et al.*, 1998; Browne *et al.*, 1999). The carbonaceous fireclays at the top of the Clyde Sandstone Formation reflect extensive plant colonization and indicate a change to a more humid climate.

## Conclusions

The Ballagan Glen GCR site is the classic section of the Ballagan Formation (Inverclyde Group, Tournaisian) and Young (1860) refers to it as 'presenting one of the grandest specimens of stratification to be witnessed in this countryside'. Although the type section for the formation has recently been re-defined in a borehole section (Browne *et al.*, 1999) Ballagan Glen remains the surface exposure that typifies this lithostratigraphical unit. The sequence is dominated by cementstone-shale alternations, whose cyclical nature probably reflects climatic change in an arid to semi-arid environment. Significantly, features of the overlying Clyde Sandstone Formation (Inverclyde Group) indicate not only a phase of uplift and rejuvenation, but also a change to a more humid environment.

## [References](#)



*(Figure 2.29) General view of the Inverclyde Group (Tournaisian) section at the Ballagan Glen GCR site showing alternating beds of the Ballagan Formation (mainly cementstones and mudstones and a few sandstone bands) overlain at the top of the cliff by the Clyde Sandstone Formation. A prominent fault (top centre-right to bottom centre-left) downthrows to the left. (Photo: C. MacFadyen.)*