Cove, Scottish Borders

[NT 785 716]

Introduction

The shore and cliff exposures north and south of Cove [NT 785 716], 10 km south of Dunbar, are the most easterly sections of Lower Carboniferous rocks within the Midland Valley Basin and were deposited in a small fault-bounded sub-basin, the Oldhamstocks Basin, to the south of the line of the Southern Uplands Fault complex (Figure 2.1). The lithological sequence, including parts of the Inverclyde Group and Strathclyde Group (Tournaisian–Asbian), and the fossil content of these beds make them important for correlating sites in Scotland and England. Greig (1988) and Andrews and Nabi (1994) have described the stratigraphy of the site in detail and the latter have provided sedimentological interpretations, which are further amplified in Andrews *et al.* (1991) and Andrews and Nabi (1998). Craig (in Mitchell *et al.*, 1960;in Craig and Duff, 1975), Clarkson (in McAdam and Clarkson, 1986) and Turner (in Scrutton, 1995) have provided guides to the section.

Description

The exposed sequence, comprising the Kinnesswood Formation and Ballagan Formation (Inverclyde Group) and the Gullane Formation and lower part of the Aberlady Formation (Strathclyde Group), is 400 m thick. The lowest parts of the sequence are exposed at Hawk's Heugh on the north-west side of Pease Bay (Figure 2.6) but because of strike faulting the basal parts of the Kinnesswood Formation are not exposed. The Kinnesswood Formation (100 m) consists of red, cross-bedded sandstones and subordinate siltstones with abundant irregular calcrete nodules and layers. The calcretes become increasingly well developed and mature towards the top of the formation (Wright *et al.,* 1993) and there is some later diagenetic replacement of the calcite with silica. Scales of the fish *Holoptychius* have been recorded from this formation but appear to be absent in the uppermost 10 m (Clough *et al.,* 1910).

The basal boundary of the Ballagan Formation has recently been re-defined as the base of silty mudstones, which rest on the highest calcrete, of the Kinnesswood Formation (Andrews and Nabi, 1994). The formation is characterized by nodular dolomitic cementstones interbedded with mudrocks, siltstones and fine sandstones of the Eastern Hole Member (31 m) and the Hurker Member (32 m) separated by the sandstones of the Horse Roads Sandstone Member (23 m). The basal laterally variable parts of the Eastern Hole Member are dominated by mudrocks within which Andrews *et al.* (1991) recognized an inclined erosion surface. The upper sandier parts of the member include a distinctive cementstone breccia, the Eastern Hole Conglomerate, whose sandy matrix also contains abundant plant (Scott and Rex, 1987) and fish remains. One metre higher, a sandy cementstone contains the marine bivalve *Sanguinolites,* fish scales and ostracodes. A marine fauna has also been detected in thin-sections from this bed (Andrews and Nabi, 1994). Palynological preparations from the lower part of the member contain miospores indicative of a Tournaisian age (CM Zone; see (Figure 2.2)) (Clayton, 1985). The Horse Roads Sandstone Member rests erosively on the Eastern Hole Member, and its fine- to medium-grained sandstones show a variety of sedimentary features including cross-bedding, ripple lamination and mudclasts. Wood fragments occur within several of the sandstone beds and one sandstone bed contains *Planolites* burrows. A distinctive feature of this member is the occurrence of large, highly spheroidal carbonate concretions (cannonballs) up to 2 m across. The Hurker Member, marked by the reappearance of the cementstone facies, is less well exposed than the rest of the Ballagan Formation and is disturbed and truncated by a branch of the east–west strike fault known as the 'Cove Fault'. The uppermost bed of the member has been interpreted as a nodular calcrete (Andrews and Nabi, 1998).

The Gullane Formation is represented in the Cove section by two members, the Kip Carle Member (49 m) and the Heathery Heugh Sandstone Member (65 m). The Kip Carle Member, which is also the lowest unit in the Strathclyde Group, is distinguished by the appearance of thick sandstones with associated coals and carbonacous mudrocks, which become more prominent in the upper part of the member. As this lithofacies develops, the cementstones of the

underlying Ballagan Formation disappear. The sandstones may have basal erosion surfaces and contain cross-bedding, soft-sediment deformation, ripple marks and shrinkage cracks. Rootlet beds containing *Stigmaria* also occur and there is an abundance of other carbonized plant material. Ironstone nodules occur in some of the mudstones, and pyrite is commonly present. Bivalves and ostracodes have also been recorded from this part of the section. The Heathery Heugh Sandstone Member is predominantly composed of thick- to medium-bedded sand stones. These are generally of medium grain-size, but coarser bands occur and there are interbedded mudstones in places. The sandstones are marked by planar and trough cross-bedding and in places there is extensive convolution of the bedding. Desiccation structures and bioturbation are also present. Root beds occur rarely, but one horizon is well known for its plant remains (Scott *et al.,* 1984).

The succeeding Cove Harbour Member (77 m) of the Aberlady Formation (Figure 2.7) contains a mixed assemblage of thin- to medium-bedded sandstones, siltstones and mudrocks with associated ironstones and root beds. The most important elements within this member are the Cove Lower Marine Band at the base, the Cove Upper Marine Band about 20 m above the base, and the Cove Oil Shale about 60 m above the base. The two marine bands are exposed within Cove Harbour. Faunal lists (Wilson, 1954; Wilson, 1974) have been summarized by Greig (1988) and show that these horizons are of Asbian age. The Cove Oil Shale is exposed on the foreshore to the north of the harbour and is a thin brownish shale with pyrite, plant material, including *Sphenopteris* fronds, and fish remains. In the uppermost parts of the member above the oil shale there are some carbonate units interpreted as caicretes (Andrews and Nabi, 1998). The overlying Bilsdean Sandstone Member marks a return to predominantly sandstone deposition, but only the basal few metres of this lie within the site.

Interpretation

The section at Cove is the only well-exposed sequence of lowermost Carboniferous rocks within the Cockbumspath Outlier. These rocks were deposited in a small depositional basin (Oldhamstocks Basin) to the south of the Southern Uplands Fault and on the flanks of the Southern Uplands Massif. The section shows extremely clearly the transition from the palaeosols and fluvial strata of the Kinnesswood Formation to the lake precipitates and floodplain deposits of the Ballagan Formation. The lithological changes from the Ballagan Formation to the wetter and swampier floodplain environments of the Kip Carle Member and the marine-influenced coastal floodplains of the Cove Harbour Member are also uniquely well displayed. The sequence is punctuated by several developments of fluvial channel sandstones, often with erosive bases, and the erosion surface within the Eastern Hole Member has been interpreted as a terrace cut into floodplain strata (Andrews *et al.,* 1991). The sequence thus contains crucial evidence of palaeoenvironmental and climatic change in the Lower Carboniferous sequence and of the derivation of sedimentary materials.

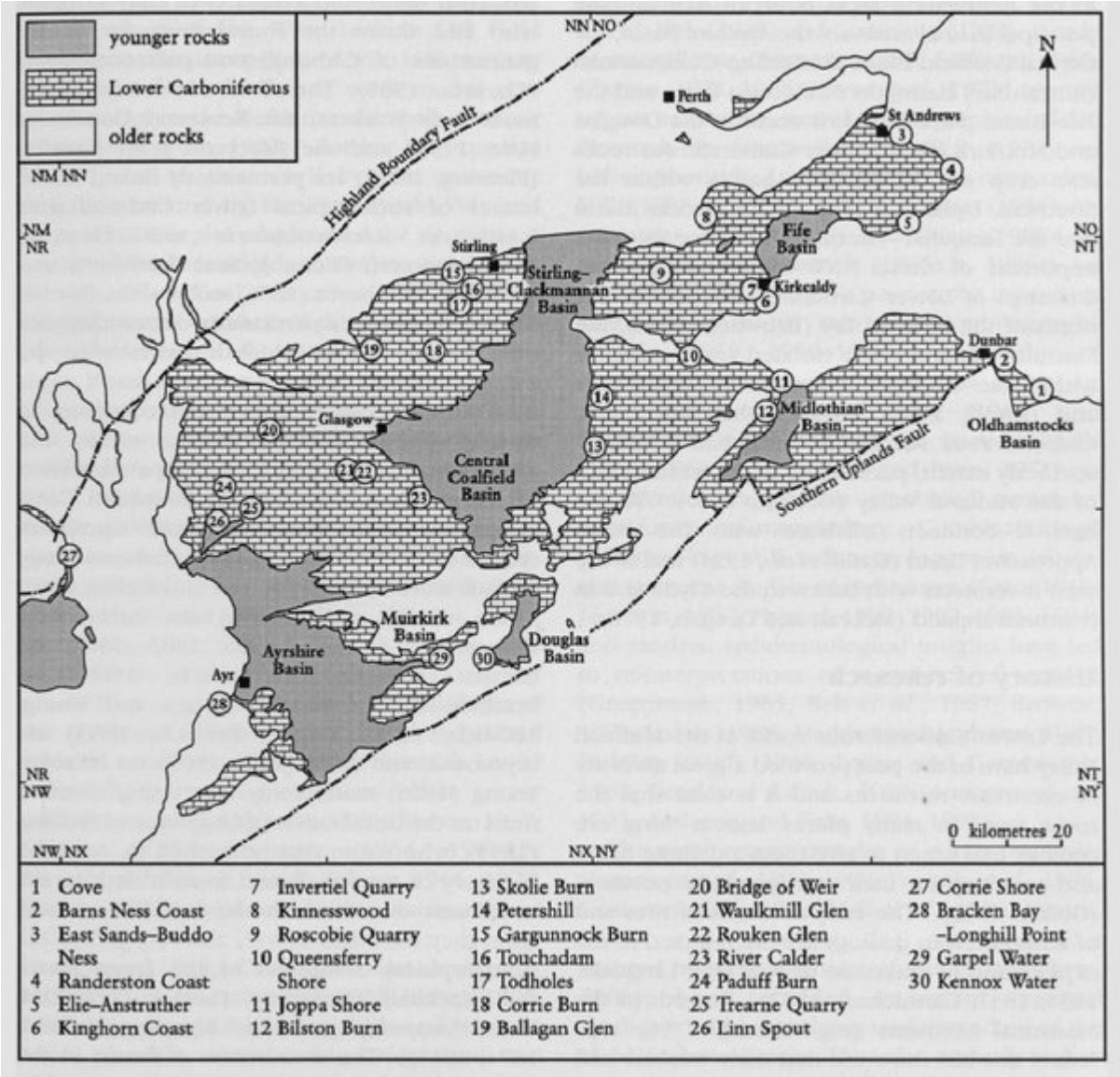
The section at Cove is critical in the correlation of Scottish and English successions. The correlation of the Cove Marine Bands with the MacGregor Marine Bands of the Lothians and Fife (Wilson, 1974, 1989) and with the Lamberton Limestone and Dun Limestone of Northumberland (Wilson, 1954) are a particularly important link between the two areas based on faunal evidence (Wilson, 1954; Greig, 1988). The composition of the faunas indicates an Asbian age (Wilson, 1989). Asbian goniatites have been found at this horizon in a nearby stream exposure (Currie, 1954). In addition, the carbonaceous beds of the Kip Carle Member can be equated with the Scremerston Coal Group of Northumberland (Greig, 1988), and the calcretes in the Cove Harbour Member have been compared to units in the Sandy Craig Formation of East Fife (Andrews and Nabi, 1994, 1998) and provide evidence of a semi-arid phase within what is a generally humid interval. Palynological work and the dating of the basal beds of the Ballagan Formation (Clayton, 1971; Neves *et* al., 1973) contribute to this biostratigraphical evidence, and the position of the base of the Carboniferous System is further constrained by the records of the Devonian fish *Holoptychius* (Clough *et al.,* 1910).

Conclusions

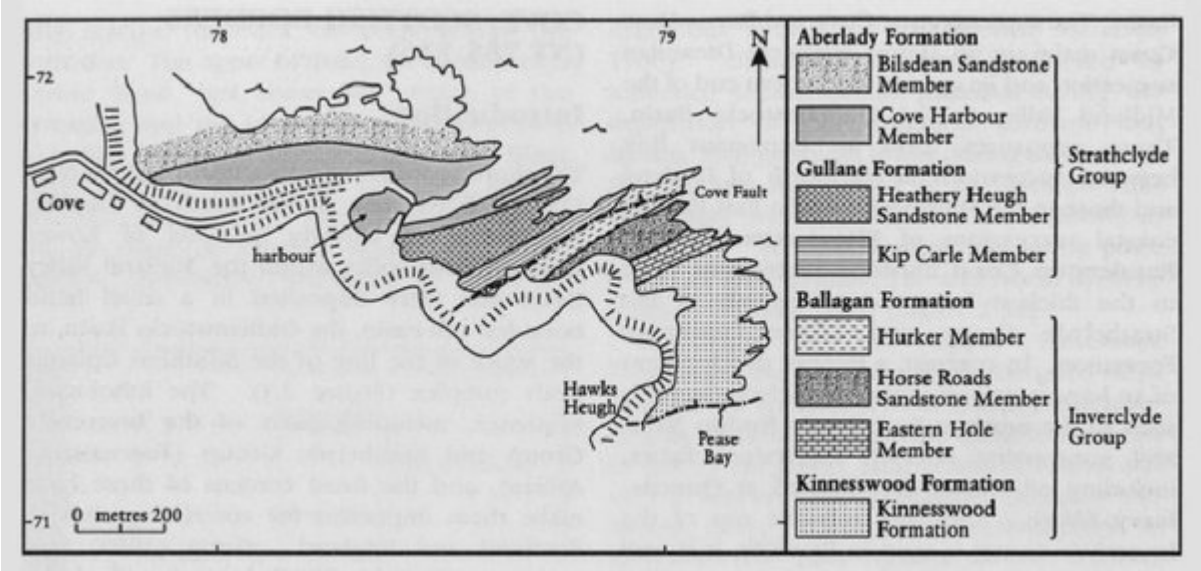
The Cove GCR site is important as it allows a well-exposed, major Carboniferous section to be examined with representatives of the Inverclyde Group (Kinnesswood Formation and Ballagan Formation) and Strathclyde Group (Gullane Formation). The junction between the Kinnesswood Formation and Ballagan Formation, which is apparently conformable, has been dated palynologically as late Tournaisian in age and the base of the Carboniferous System

probably lies within the Kinnesswood Formation. Higher beds consist of clastic deposits (sandstones and mudrocks), including representatives of the Scremerston Coal Group and, above, the Cove Marine Bands and associated strata. The sedimentology of these beds provides a unique insight into the interaction between fluvio-deltaic environments and palaeoclimatic changes within the Oldhamstocks Basin. The marine faunas and the biostratigraphically useful fossil spores make this a vital section in correlating sites in Scotland and England.

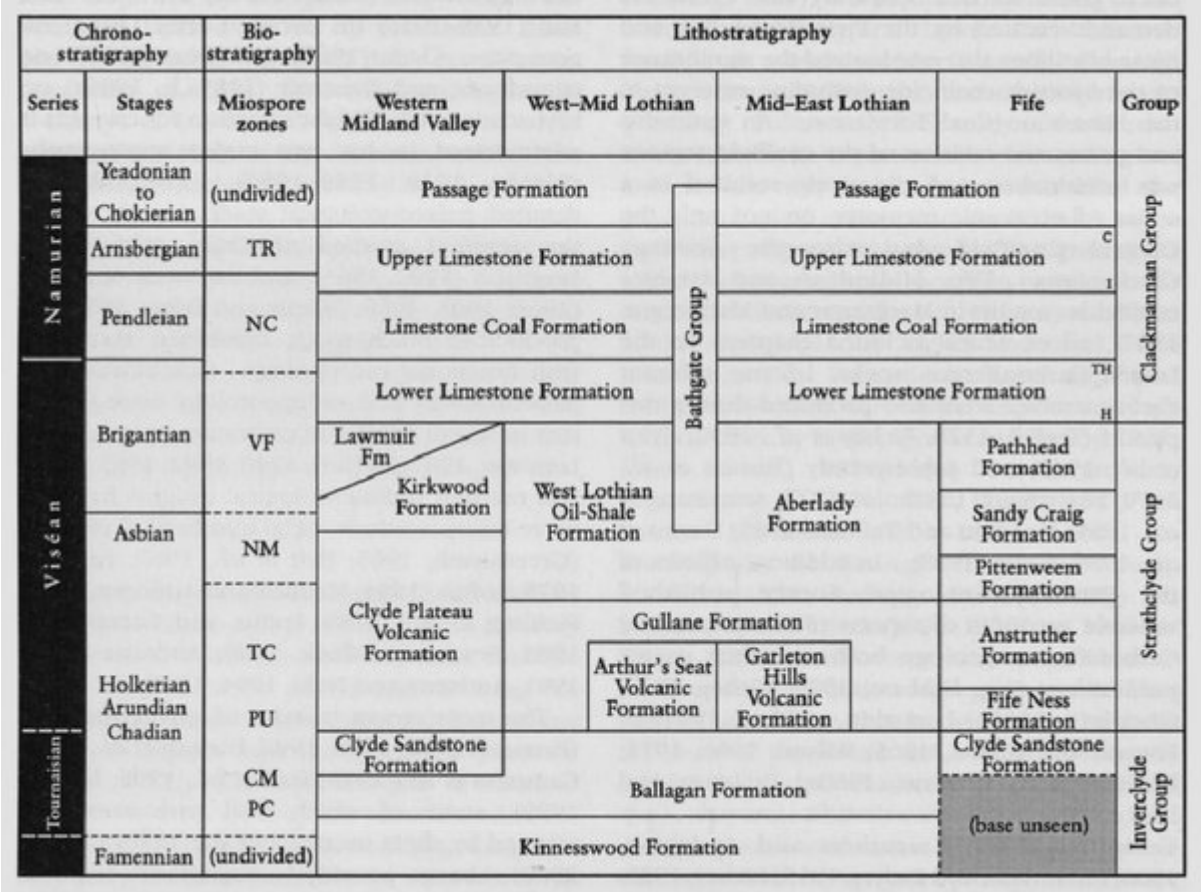
References



(Figure 2.1) Geological map of the Midland Valley Basin showing the distribution of Lower Carboniferous outcrops, sedimentary basins and the location of GCR sites described in the text. Based on information from [British] Geological Survey maps of the area (principally Institute of Geological Sciences, 1979a).



(Figure 2.6) Geological map illustrating the distribution of Lower Carboniferous rocks at the Cove GCR site. Based on Craig and Duff (1975) and Andrews and Nabi (1994).



(Figure 2.2) Simplified Lower Carboniferous stratigraphical chart for the Midland Valley of Scotland. Note that below the Brigantian Stage, the position of stage boundaries is uncertain and that below the NM miospore zone only recorded zones are indicated. (H — Hurlet Limestone; TH — Top Hosie Limestone; I — Index Limestone; C — Castlecary Limestone.) The Bathgate Group comprises the Salsburgh Volcanic Formation, the Bathgate Hills Volcanic Formation and the Kinghorn Volcanic Formation. Based on various sources and including information from Whyte (1981), Chisholm et al. (1989) and Browne et al. (1996, 1999).

(Figure 2.7) Outcrops of the lower part of the Cove Harbour Member (Aberlady Formation) east of Cove Harbour. The topmost beds of the underlying Heathery Heugh Sandstone Member (Gullane Formation) can be seen in the near cliffs to the right. The large block (lower centre) is approximately 0.8 m long. (Photo: M.A. Whyte.)