Stone Gill–Scandal Beck, Cumbria

[NY 718 038]–[NY 721 044] and [NY 723 041]–[NY 720 055]

Introduction

The Stone Gill-Scandal Beck GCR site is a composite stream section centred on Ravenstonedale village, and extending for approximately 1 km to the north of the village. This site includes arguably the finest available section of the upper part of the Ravenstonedale Group (Stone Gill Limestone and Coldbeck Limestone) and the lower part of the Orton Group (Scandal Beck Limestone, Brownber Formation and Breakyneck Scar Limestone) in north-west England and is one of the most important stratigraphical and sedimentological sections of early Carboniferous (Chadian–early Arundian) age in the Stainmore Basin. In Scandal Beck the section extends from the heart of Ravenstonedale village [NY 7230 0410] to a point close to Hawking Scar (NY 7195 0548; see (Figure 5.8)). The Stone Gill section extends from a point south-west of the village [NY 7180 0377] downstream to its confluence with Scandal Beck [NY 7213 0442] near Coldbeck Bridge. Details of the succession were first described by Garwood (1913, 1916) and later revised by Turner (1950), but attempts to define the position of critical 'series', 'cycle' and 'stage' boundaries in the sequence have so far been without complete agreement (Garwood, 1929; George *et al.,* 1976; Ramsbottom, 1977a; Holliday *et al.,* 1979; Nudds, 1981, 1993). Conodonts recorded from this site enabled Higgins and Varker (1982) to erect a new biostratigraphical zonation scheme for the Ravenstonedale succession. Critical aspects of the sedimentology have been examined by Ashton (1970), Barraclough (1983) and Leeder (1988). Useful reviews of stratigraphy are provided by Johnson and Marshall (1971) and Higgins and Varker (1982). The lithostratigraphical terminology used in this account follows that used on the British Geological Survey map of the Kirkby Stephen district (British Geological Survey, 1997b).

Description

The succession comprises a number of lithostratigraphical units, the nature and limits of which have yet to be precisely defined. Across the site, beds dip gently to the north-east, but the succession is disrupted by faulting and areas of poor exposure. Thus, reported unit thicknesses vary widely (Higgins and Varker, 1982).

The Stone Gill Limestone (*c.* 100–125 m) comprises a varied and extensively dolomitized succession (Figure 5.9), characterized mainly by thinly bedded fine-grained limestones (chiefly carbonate mudstones and wackestones) interbedded with calcareous mudstones and siltstones, and a distinctive fauna and flora. In addition, the lower unexposed beds of this unit (42 m), recorded in a borehole by Holliday *et al.* (1979), contain rare sandstones, seatearths and concentrations of plant debris. In the exposed section (63 m) logged by Higgins and Varker (1982), Garwood (1913, 1916) recorded calcareous algae ('*Solenopora*' *garwoodi*), corals (*Zaphrentis omaliusi, Syringopora, Vaughania cleistoporoides*), brachiopods (*Athyris glabristria, Spiriferina, Spirifer clathratus, Camarotoechia proava*), cchinoids (*Archaeocidaris, Palaechinus*), ostracodes, and sparse plant, sponge (*Hyalostelia*)and nautiloid remains (*Orthoceras*). A number of these fossils appear concentrated within distinctive marker bands, the most obvious of which are the Vaughania Band and Palaechinus Bed recognized by Garwood (1913) near the base of the section [NY 7176 0380]. Higher up in the unit, brachiopod beds containing abundant *Camarotoechia proava* mark the base of Garwood's C. proava Band. At its top is the stromatolitic Spongiostroma Band [NY 7190 0410] which Turner (1950) identified as a convenient boundary between Garwood's (1913) *Solenopora* and *Seminula gregaria* subzones. The location of most of these marker bands is illustrated in (Figure 5.8).

Overlying the Spongiostroma Band, the Coldbeck Limestone (*c.* 80 m) extends downstream to a prominent algal band beneath Coldbeck Bridge [NY 7209 0435]. Turner (1950) suggested that approximately 30–35 m of this succession had been removed by faulting. The formation is dominated by limestones (carbonate mudstones) and is distinguished from the underlying unit by the occurrence of abundant nodular and laminated algal horizons, and a sparser macrofauna. Dolomitized limestones, minor shale developments, *Composita gregaria* and rhynchonellids also occur (Turner, 1950; Ramsbottom, 1974; Higgins and Varker, 1982). The algal band beneath Coldbeck Bridge was originally used by Mitchell

(1972) to define the position of the Tournaisian–Visean boundary; and later by Ramsbottom (1973, 1974) to mark the junction between the first and second 'major cycles' of sediment deposition he recognized in the Ravenstonedale succession. For a short period, the same band was also used by George *et al.* (1976) to define the boundary between the Courceyan and Chadian stages (see 'Interpretation' below). This band does not, however, equate with the algal layer described by Turner (1950) which appears to lie slightly lower in the sequence. The varied lithofacies and restricted biofacies of both the Stone Gill Limestone and the Coldbeck Limestone indicates that these deposits most probably formed in very shallow water under hypersaline conditions at the head of the Stainmore Basin as nearshore, tidal-flat sediments (Ramsbottom, 1974; Mitchell, 1978; Barraclough, 1983).

North and east of Coldbeck Bridge the Scandal Beck Limestone (*c.* 100–125 m) continues the sequence to the base of the Brownber Formation (formerly the Brownber Pebble Bed). The lower part of the Scandal Beck Limestone is well exposed south of the Stone Gill–Scandal Beck confluence, but up sequence the exposure deteriorates. The unit comprises fine-grained bioclastic limestones (some dolomitized) with thin calcareous mudstone interbeds and a sparse microfauna. The Thysanophyllum Band (Garwood, 1913), characterized by the late Chadian coral *Dorlodotia pseudovermiculare,* occurs near the top of this unit at a level where marine faunas appear to become more common in the sequence. However, the occurrence of '*Thysanophyllum*' well below the level of the Thysanophyllum Band has also been reported by Turner (1948, 1950) from Garwood's (1913) 'Globosus/fawcettensis Beds'. The outcrop of the Thysanophyllum Band is significantly displaced (close to Coupland Sike and Breakyneck Scar) by a NNE–SSW-trending fault that crosses Scandal Beck at [NY 7193 0528] (Figure 5.8).

The Brownber Formation comprises 4–6 m of calcareous sandstone and, in its upper part, quartz pebbles are common. The unit is a useful lithostratigraphical marker within the Ravenstonedale succession. A more complete description of the Brownber Formation is given by Barraclough (1983) who, along with Leeder (1988), regarded it as a shoreline (beach) deposit. Above this unit, discontinuous outcrops of fossiliferous and bioclastic limestones with a rich marine fauna belonging to the lower part of the Breakyneck Scar Limestone complete the sequence.

Interpretation

Although very little modern sedimentological work has been published, Barraclough (1983) suggested that the sequence was deposited towards the margin of the Stainmore Basin in a variety of marginal marine and offshore marine environments. The lower part of the succession (Stone Gill Limestone and the lower part of the Scandal Beck Limestone) was interpreted as a complex succession of tidal-flat cycles (with algal marsh, channel and pond deposits) while the upper part of the succession (the upper part of the Scandal Beck Limestone to Breakyneck Scar Limestone) was regarded as largely shallow, sub-tidal and offshore marine deposits. The transition from tidal-flat to open marine facies noted by Barraclough (1983) occurs below the Brownber Formation and close to the position of the Thysanophyllum Band. This transgressive event brought an end to the extensive phase of tidal-flat sedimentation that characterized the early Carboniferous history of the Stainmore Basin. Evidence of increased water depths at this level is provided by Higgins and Varker (1982) who recorded shallow subtidal and intertidal conodont faunas from the lower part of the succession (Stone Gill Limestone to lower Scandal Beck Limestone) which were joined by deeper-water forms only in the Breakyneck Scar Limestone.

Subsequent to Garwood's (1913) original description of the section, the site became the subject of a long and still ongoing debate regarding the placement of critical stratigraphical boundaries. Early discussions focused attention on the location of the Tournaisian–Viséan boundary (Johnson and Marshall, 1971) while later workers (after Ramsbottom, 1973; George *et al.,* 1976) attempted to define the position of the Courceyan–Chadian and Chadian–Arundian stage boundaries.

Initially, Garwood (1913) assigned the whole of the Stone Gill-Scandal Beck section to the Tournaisian Series and, more specifically, to the *Athyris glabristria* Zone, but subsequently he concluded that the Tournaisian–Viséan boundary was best placed at the level of the Thysanophyllum Band (Garwood, 1929).

Since then, the position of this boundary, and the Courceyan–Chadian stage boundary with which it was once broadly equated, has been moved to a lower position within the sequence, largely on the basis of micropalaeontological evidence. Thus, Holliday *et al.* (1979) tentatively positioned the Courceyan–Chadian stage boundary within the Shap Conglomerate (i.e. below the level of the Stone Gill Limestone and outside of the limits of the Stone Gill–Scandal Beck section) and this view is followed in the present account (see (Figure 5.3)).

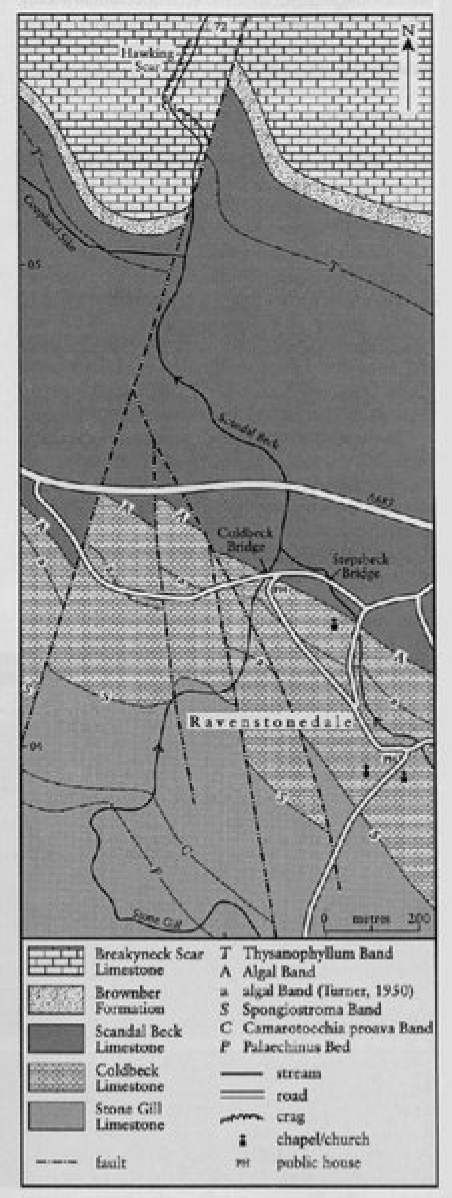
Following this trend and the discovery of the Arundian coral *Dorlodotia briarti* towards the top of the Scandal Beck Limestone, Nudds (1981) tentatively suggested the lowering of the Chadian–Arundian boundary from its original position 20 m below the Brownber Formation (George *et al.,* 1976) to the base of the Scandal Beck Limestone. Later, Riley (in Nudds, 1993) argued that, since the Scandal Beck Limestone is devoid of archaediscid foraminifera, the entire unit must be of late Chadian age. However, this view was challenged by Nudds (1993) who noted, in the upper part of the unit, the occurrence of *D. briarti* in prolific association with *Siphonondendron martini* — a form that is known to have made its first entry in the Arundian Age (Nudds, 1980; Mitchell, 1989; Riley, 1993). Nudds (1993) therefore maintained an early Arundian age for the upper Scandal Beck Limestone, as originally suggested by George *et al.* (1976).

After the publication of Ramsbottom's (1973) synthesis of Dinantian stratigraphy, the Stone Gill–Scandal Beck section became a test bed for Ramsbottom's contention that Lower Carboniferous successions could be subdivided into a number of major eustatically generated sedimentary cycles, the boundaries between which he believed were defined by sedimentological and palaeontological features indicative of regression and transgression (Barraclough, 1983; Leeder, 1988). In this context, Ramsbottom (1973) regarded the algal band at the top of the Coldbeck Limestone as the terminal regressive phase of his 'Major Cycle 1', between his 'Major Cycles 1 and 2' (later the D2a–D2b mesothemic cycle boundary; Ramsbottom, 1977a) and the Brownber Formation as a similar regressive interval that marked the Major Cycle 2/3 boundary. However, detailed facies analysis by Barraclough (1983) indicated that the algal band at the top of the Coldbeck Limestone was a relatively insignificant component of a more extensive cyclic peritidal sequence (the Stone Gill Limestone to lower Scandal Beck Limestone interval) within which there was no sign of any significant transgression or regression, and that the Brownber Formation occurred in the middle of a transgressive marine sequence rather than at its base. Furthermore, the more significant and most obviously transgressive facies change in the sequence (the transition from peritidal to open marine facies within the Scandal Beck Limestone) was not identified as a potential cycle boundary by Ramsbottom (1973, 1974). Leeder (1988) concluded that Barraclough's work and refinements to the biostratigraphy provided evidence that cast doubt on the reality of Ramsbottom's major cycles and suggested that attempts to correlate them worldwide (Ross and Ross, 1985) were therefore ill-founded.

Conclusions

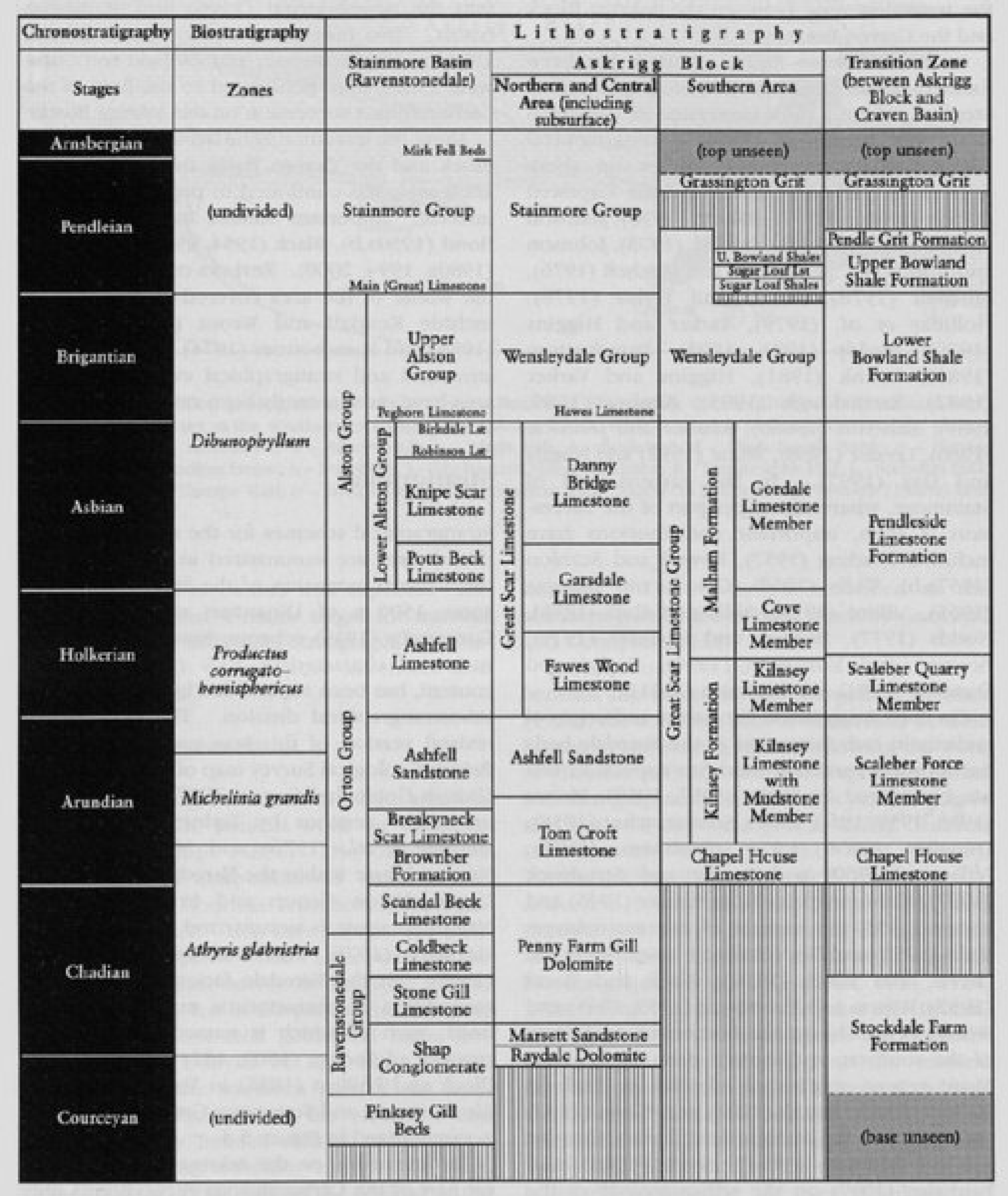
This site provides a near-continuous section from the Stone Gill Limestone through to the Breakyneck Scar Limestone, one of the most extensive and complete sections of Lower Carboniferous (Chadian-early Arundian) age in northern England. With its varied macrofossil and microfossil assemblages and a diverse array of sedimentary features, the section is vital to the understanding of the stratigraphical and palaeogeographical evolution of the Stainmore Basin. Barraclough (1983) suggested that the lower part of the succession (Stone Gill Limestone to lower Scandal Beck Limestone) was deposited close to the head of the Stainmore Basin in a range of shallow, quiet-water, marginal marine environments similar to those of modern (Bahamian) tidal-flat areas, and that the upper part of the succession (upper Scandal Beck Limestone to Breakyneck Scar Limestone) was deposited in a more open marine environment. Uncertainties relating to the position of the Courceyan–Chadian boundary, the Chadian–Arundian stage boundary and the poor definition of lithostratigraphical (rock) units highlight the potential of this site in future research.

References



(Figure 5.8) Simplified geological map of the Stone Gill–Scandal Beck section. Based on Garwood, 1913; Turner, 1950; Higgins and Varker, 1982; Institute of Geological Sciences, 1972. The lithostratigraphical terminology derives from the geological map of the Kirkby Stephen district (British Geological Survey, 1997b).

(Figure 5.9) General view of the peritidal and partially dolomitized beds of the Stone Gill Limestone (Chadian) at Stone Gill, Ravenstonedale. (Photo: P.J. Cossey.)



(Figure 5.3) Simplified stratigraphical chart for the Lower Carboniferous sequence of the Askrigg Block and Stainmore Basin. Compilation based upon and modified after George et al. (1976), Dunham and Wilson (1985), Arthurton et al. (1988), British Geological Survey (1997b,c), and Mundy (2000). Zonal biostratigraphy (Chadian–Brigantian only) after Garwood (1913). For further details of the Wensleydale Group, Upper Alston Group and Stainmore Group successions, see (Figure 5.4). Areas of vertical ruling indicate non-sequences. Not to scale.