Spittal Shore, Northumberland

[NU 009 511]–[NU 035 481]

Introduction

The Spittal Shore GCR site is a spectacular coastal cliff and foreshore section that extends from a point 2 km south of Berwick-upon-Tweed [NU 0093 5112], 0.6 km north-west of Hud's Head [NU 0135 5076] south-eastwards for a distance of approximately 4.3 km to Far Skerr [NU 035 481]. It provides an almost continuously exposed section of the upper part of the Scremerston Coal Group, the whole of the Lower Limestone Group and most of the Middle Limestone Group (Asbian–Brigantian). This sequence comprises around 450 m of interbedded sandstone, shale and limestone, the proportions of which vary through the succession. The site ranks among the finest late Viséan sections in England, not only because of the quality and completeness of the exposure, but also because of the palaeontological, sedimentological and structural features preserved. Clastic units in particular provide evidence for significant environmental and palaeogeographical changes during late Viséan times, and limestone units represent important lithostratigraphical markers and provide biostratigraphically useful fossils for correlations within the Northumberland Trough and into other areas.

Since the original survey by Gunn (1897), the site has been the subject of numerous geological investigations, principally by Fowler (1926), Frost (1969), Breare (1986), Lees (1991), Reynolds (1992), Frank and Tyson (1995) and Turner and Scrutton (1995). The account below, however, focuses particularly on the work of Reynolds (1992) and Turner and Scrutton (1995). The site and its stratigraphical significance are also discussed in overviews of the Carboniferous rocks of the area (e.g. Johnson, 1980; Johnson *et al.,* 1995).

Description

Structurally, the site can be divided into a number of sections ((Figure 3.30)a). North of Seahouse, the strike roughly parallels the coast, and the rocks dip 30°–60° to the ENE. At Seahouse, a series of minor sharp folds and thrusts are developed, particularly in the Eelwell Limestone, and at Saltpan Rocks the general strike swings round so that the rocks dip gently east. A more open fold structure is recognized in the Sandbanks Limestone between Near Skerr and Far Skerr. As a consequence of this general structure, the succession youngs progressively southwards down the coast. Details of the succession are presented in (Figure 3.30)b.

At the northern end of the site, a 30 m sequence of shale, sandstone, seatearth and thin coal is exposed in the foreshore north of Hud's Head (Figure 3.30)a. These rocks represent the uppermost part of the Scremerston Coal Group, and at the very top a seatearth and 36 cm coal are overlain by the Dun Limestone, defining the base of the overlying Lower Limestone Group (Figure 3.31).

The Dun Limestone is 1.5 m thick and contains a band rich in *Siphonodendron junceum* with large productoid brachiopods and other coral, brachiopod and bryozoan taxa together with 'algal' nodules of the form genus *Osagia* (Frost *et al.,* 1976). The Lower Limestone Group as a whole comprises 150 m (Johnson, 1980; Johnson *et al.,* 1995) to 175 m (Turner and Scrutton, 1995) of 'Yoredale' cycles. The boundaries between cycles are generally taken at the base of marine limestone horizons, the rest of the cycle comprising a coarsening-upward sequence of shales (usually with ironstone bands and nodules), overlain successively by siltstones, sandstones (often with starved ripples towards the base, grading upwards into tabular or lenticular cross-bedded sandstone units) and a seatearth-coal couplet. Variations of this idealized sequence occur throughout the group, but in general, thin and well-spaced coals occur throughout, with thick intervening shales and sandstones, some of which are strongly channelized. The sequence above the Dun Limestone, for example, includes a thick sandstone with intersecting lenticular, fine-grained cross-bedded units near the base, overlain by coarse-grained multistorey sand-bodies with planar cross-stratification developed towards the top. This is overlain in turn by shale, into which a major sandstone-filled channel is cut containing small- to medium-scale trough cross-bedding. A prominent calcrete is developed below the limestone (Woodend Limestone) at the base of the next cycle.

The Woodend Limestone (2 m) contains a noteworthy coral fauna that is dominated by colonies of *S. junceum* in their growth position, but which also includes *S. martini, Lithostrotion maccoyanum, Dibunophyllum, Caninia* and the calcareous sponge *Chaetetes septosus.* This limestone is overlain by a coarsening-upward cycle ending with the Woodend Coals (Turner and Scrutton, 1995) which probably equate with the Little Howgate Coal of Fowler (1926), shown on the [British] Geological Survey map of the Berwick-upon-Tweed and Norham district (Institute of Geological Sciences, 1977a). About 15 m higher in the sequence, an unfossiliferous limestone described by Scrutton and Turner (1995) as tementstone' and a distinctive 'algal' band with *Somphospongia* cf. *multiformis* occur together with a 4.5 m-thick oil shale containing fish debris, ostracodes and plant fragments (Frost *et al.,* 1976). At least part of this sequence is equivalent to the Doupster Oil Shale (Fowler, 1926; Institute of Geological Sciences, 1977a), but above this point the older description of the sequence (Fowler, 1926; Institute of Geological Sciences, 1977a) differs significantly from more recent accounts. For example, Fowler (1926) claimed that there was a pronounced unconformity in this part of the succession that occurred over much of north Northumberland and which accounted for the absence of the Watchlaw Limestone in the Berwick area. Frost (1969), Johnson (1980), Johnson *et al.* (1995) and Turner and Scrutton (1995), however, indicate that the Watchlaw Limestone (2 m) is present in the Berwick section sandwiched between the Red Shin Sandstone and Maidenkirk Brae Sandstone (see (Figure 3.30)b). A few metres below the Red Shin Sandstone is the distinctive Spirifer Band. Above the Maidenkirk Brae Sandstone, the remaining upper part of the Lower Limestone Group comprises a cyclic siliciclastic succession almost 60 m thick.

The Oxford Limestone (5 m) defines the base of the Middle Limestone Group (250 m). This group is similar to the underlying Lower Limestone Group in that it is made up of a series of 'Yoredale' cycles, but the limestones are thicker and laterally more persistent, and there are some distinctive differences in the siliciclastic facies. Reynolds (1992) discussed the sedimentology of these siliciclastic facies, analysing the seven cycles between the Oxford Limestone and the Eelwell Limestone exposed on Spittal Shore in great detail ((Figure 3.30)b). These cycles are between 8 m and 36 m thick. They commence with a thin shale and are overlain by a marine limestone (mostly skeletal wackestones and packstones). The limestones pass gradually into a black shale at the base of a coarsening-upward clastic interval in which the degree of bioturbation decreases upwards. These sequences have either wave-ripple lamination or storm-influenced structures, including hummocky cross-stratification. In some cycles the top of the coarsening-upward succession is capped by a palaeosol, and this in turn may be overlain by channel sands or by another coarsening-upward cycle. A palaeosol or a coal, overlain by a marine shale, marks the top of a complete cycle. Reynolds (1992) identified a number of distinctive facies In the Spittal Shore sequence: a cross-bedded facies with a range of features, including bipolar opposed palaeoflows and cross-beds with claystone drapes; a heterolithic facies dominated by rippled sandstone and mudstone; a hummocky cross-stratified and a migrating hummocky cross-stratified facies; a climbing-ripple facies; a wave-ripple facies; a plane-laminated facies; a mudstone-free cross-bedded facies; and a microswale facies. He singled out a prominent distributary channel sandstone of his cycle 2 (the cycle containing the Barrasford Limestone) for particular attention (see (Figure 3.32)). The basal 1 m of this erosive-based 5 m-thick unit is dominated by rippled sandstone and mudstone of the heterolithic facies, with rippled sandstone commonly passing laterally into medium-scale trough cross-beds. The central portion of the sand-body is characterized by cross-beds up to 50 cm thick that indicate a palaeoflow to the south. The upper part of the unit is characterized by medium-scale cross-beds with evidence of repeated changes of palaeoflow directed to the north-west and to the south and south-east.

Some of the limestone units of the Middle Limestone Group are also quite distinctive, and have been correlated over considerable distances. The Oxford Limestone is poorly fossiliferous, but for the occurrence of nodular algal structures with crinoid stem cores coated by red 'haloes' containing *Girvanella* (Frost *et al.,* 1976). The Eclwcll Limestone (8 m) is easily distinguished by its prominent fauna of large *Gigantoproductus* and corals Including *S. junceum.* A layer of spiriferoid brachiopods occurs near the top of the unit. The limestone is also locally dolomitized, brown weathering and vuggy. Overlying a thin sulphurous coal, the Acre limestone (4.5 m) is of a similar character, containing a rich coral–brachiopod fauna, crinoid remains and small algal nodules. Towards the top of the sequence, and the southern end of the site, the Sandbanks Limestone is made up of a series of thin limestone beds with shaly partings. In addition to layers with abundant brachiopods, and prominent solitary corals (mainly *Aulophyllum pachyendothecum,* with rarer *Palaeosmilia murchisoni*)excellent examples of the trace fossil *Zoophycos* occur, and the top of the unit contains characteristic dark-brown chert nodules. The sandstones beneath the Sandbanks Limestone also have a well-preserved ichnofauna including *Diplocraterion* and the beaded burrow *Eione moniliforme.* Further details of the distribution of trace-fossil assemblages in this section are presented by Lees (1991).

Interpretation

Like much of the sedimentary fill of the Northumberland Trough, the sequence exposed at Spittal Shore reflects the interplay of fluviodeltaic and shallow marine depositional systems. The gross changes in the proportions of limestone, sandstone and shale from the Scremerston Coal Group, through the Lower Limestone Group and into the Middle limestone Group record a gradual increase in marine influence and a decrease in periods of emergence. The coarsening-upward siliciclastic sequences of the Lower Limestone Group reflect delta progradation, with the development of facies characteristic of interdistributary bay, distributary channel and floodplain environments reflecting the 'classic' interpretation of 'Yoredale' cycles in the Carboniferous System of the UK. A somewhat different interpretation was envisaged by Reynolds (1992) for the Middle Limestone Group in which tidal distributary channels developed, and storm and wave processes dominated the delta fronts. In more detail, the thin shale at the base of each cycle records the gradual flooding of the lower delta plain (represented by the underlying palaeosol), and the succeeding limestone represents the withdrawal of clastic supply. The gradual resumption of clastic input is marked by the transition into bioturbated shales, the upward decrease in bioturbation in the siliciclastic phase of the cycle reflecting progressively higher sedimentation rates and lower salinities. The coarsening-upward sequences record the gradual infilling of protected marine embayments where ripples dominated, followed by progradation of storm-dominated shoreline deposits with hummocky cross-stratification (hummocky cross-stratified facies and climbing-ripple facies reflecting storm activity). The wave-ripple facies, plane-laminated facies, mudstone-free cross-bedded facies and micro-swale facies of Reynolds (1992) reflect periods of wave-dominated sedimentation. The channel of cycle 2 described briefly in the preceding section provides important evidence for tide-dominated sedimentation, the upper part of the unit recording the alternating palaeocurrent directions of the ebb and flood tides.

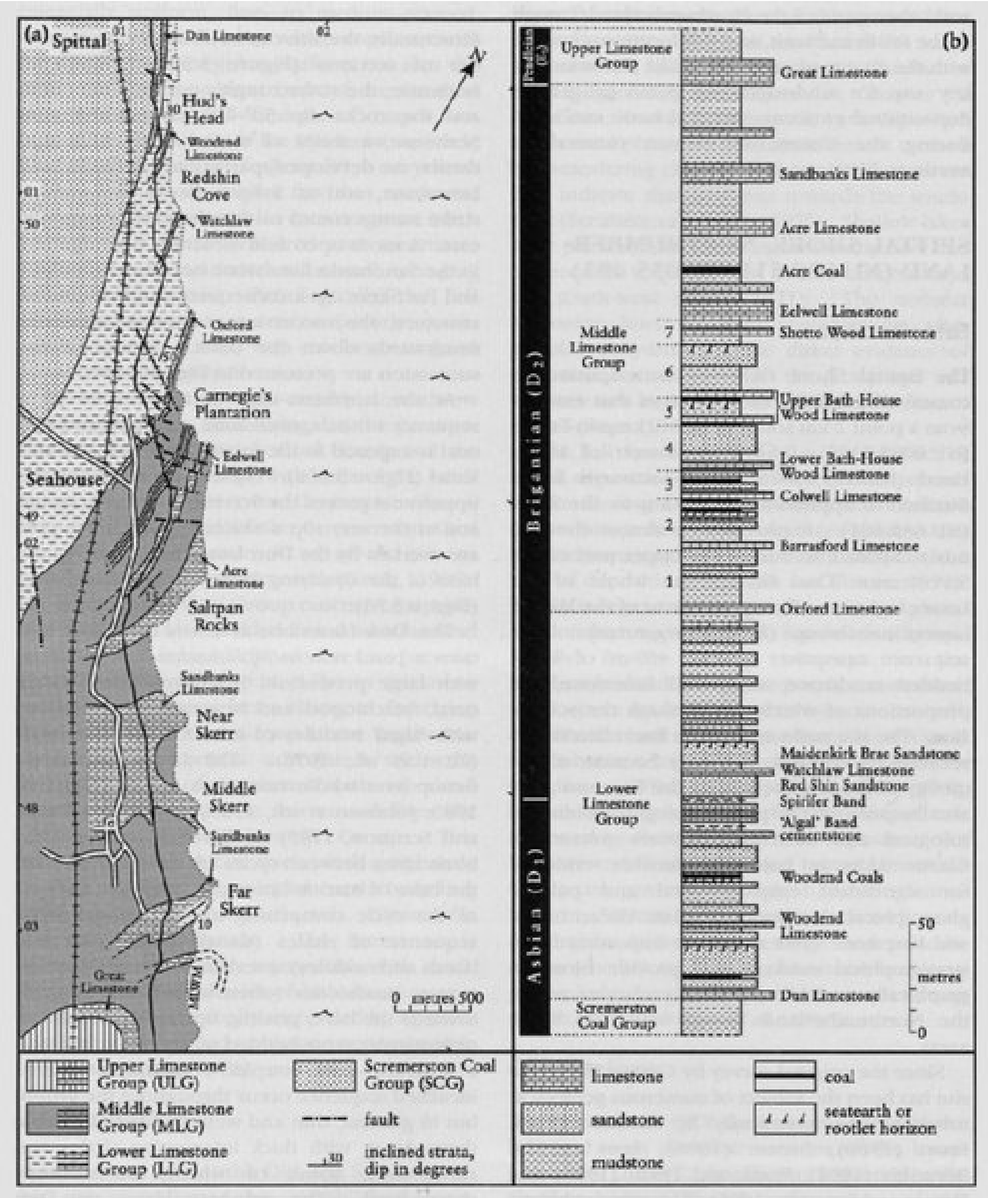
Although the Spittal section contains a rich and varied suite of lithofacies, it is also rather poorly fossiliferous and this has caused problems in correlating the section into neighbouring areas of the Northumberland Trough (Figure 3.5) and Midland Valley Basin. Early workers (Miller, 1887; Fowler, 1926, 1936) regarded the Dun limestone as the equivalent of the Redesdale Limestone in south Northumberland (see Redesdale GCR site report, this chapter) but subsequent [British] Geological Survey mapping and micropalaeontological evidence indicated that the former was likely to be some 150–170 m above the latter (Frost *et al.,* 1976; Frost and Holliday, 1980). In addition, Frost and Holliday (1980) correlated the Spirifer Band with the Low Tipalt Limestone. This established the local base of the Brigantian Stage, as the Low Tipalt Limestone is correlated with the Peghorn Limestone, the base of which defines the base of the stage (George *et al.,* 1976; Frost and Holliday, 1980; see Tipalt Burn GCR site report, this chapter, and Janny Wood GCR site report, Chapter 5). George *et al.* (1976) and Johnson *et al.* (1995) seem to indicate a Peghorn–Low Tipalt–Watchlaw correlation. The Spittal section is also believed to equate in part with the Upper Liddesdale Group succession exposed at Penton Linns (see GCR site report, this chapter; and (Figure 3.5).

Structurally, the minor folds and thrusts in the area of Seahouse have recently been interpreted as part of the synclinal member of a monoclinal fold pair, thus establishing the easterly vergence of the 'Berwick Monocline'. This suggests that the formation of the Berwick Monocline was controlled by strength and density contrasts within the Caledonian basement (Roper, 1997).

Conclusions

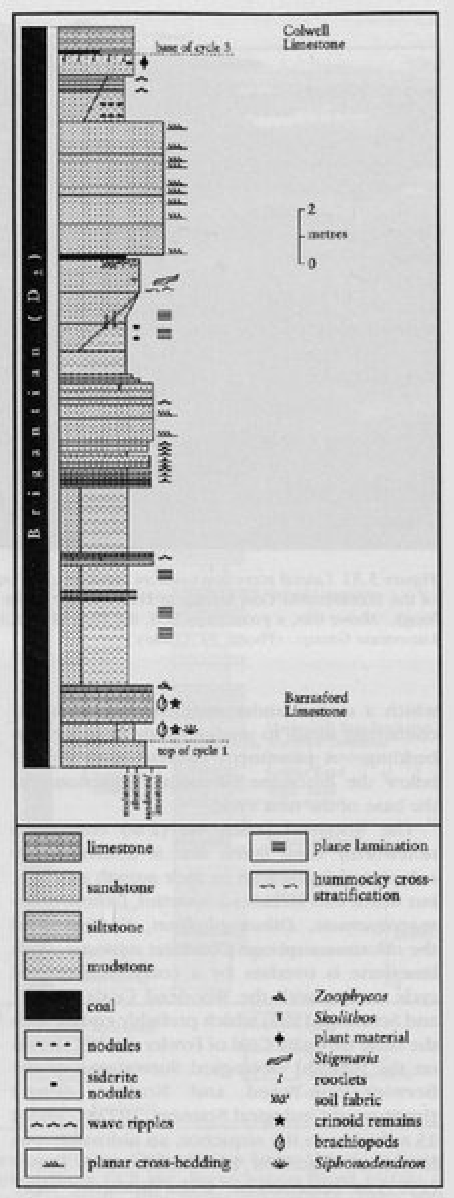
The Spittal Shore GCR site contains one of the finest late Viséan sections in England. The exposed succession preserves important evidence of changing palaeoenvironments and of secular trends in delta-marine interactions during Asbian and Brigantian times. The site contains good examples of 'Yoredale' cycles, with well-developed sequences reflecting tide-, wave- and storm-influenced deltaic deposition. They provide important reference sections against which other 'Yoredale' cycles may be compared for such influences. Several of the limestones of the Lower Limestone Group and Middle Limestone Group contain well-preserved and diverse faunas, some of which are used as important lithostratigraphical marker horizons of regional significance in correlations across the Northumberland Basin and into the areas beyond.

[**References**]

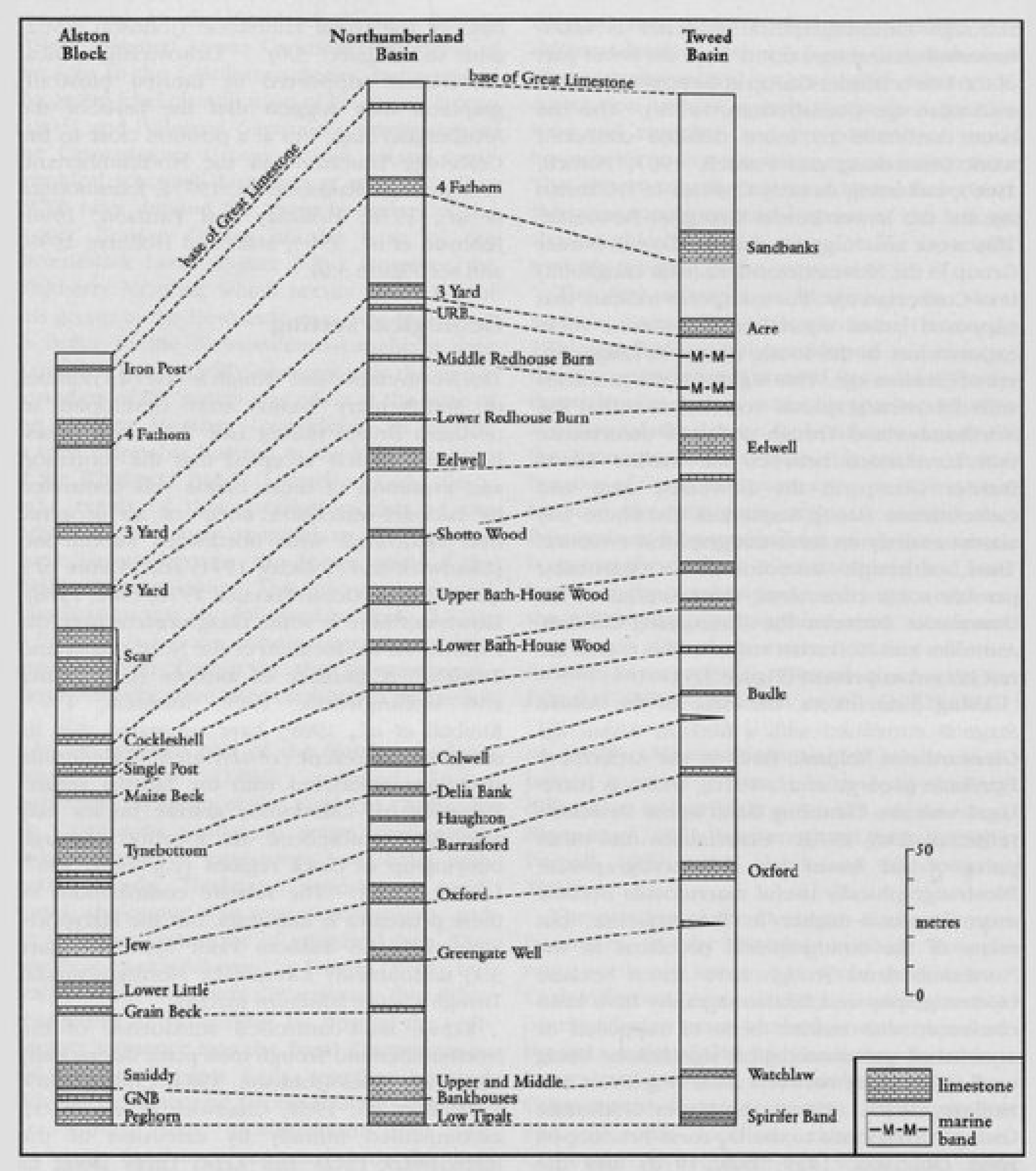


(Figure 3.30) (a) Simplified geological map and (b) section of Lower Carboniferous Lower Limestone Group to Middle Limestone Group strata exposed at the Spittal Shore GCR site, Berwick-upon-Tweed (details of the Scremerston Coal Group and Upper Limestone Group omitted). After Turner and Scrutton (1995), with additional section details from Frost (1969) and Reynolds (1992). Numbers in (b) relate to cyclothemic sedimentary cycles identified in the Middle Limestone Group beds by Reynolds (1992).

(Figure 3.31) Lateral accretion surfaces (epsilon cross-bedding) in fluvio-deltaic channel sandstones near the top of the Scremerston Coal Group at Hud's Head in the Spittal Shore section (the hammer, for scale, is 30 cm long). Above this, a prominent bed, the Dun Limestone (1.5 m thick), marks the base of the overlying Lower Limestone Group. (Photo: P.J. Cossey.)



(Figure 3.32) Graphic log of Middle Limestone Group (Brigantian) sedimentary cycle 2 at the Spittal Shore section. After Reynolds (1992). See text for further details.



(Figure 3.5) Stratigraphy of the Upper Liddesdale Group (Brigantian, D_2) limestones from the Alston Block to the Northumberland Basin and the Tweed Basin. (GNB — Girvanella Nodular Bed; URB — Upper Redhouse Burn.) After Frost and Holiday (1980).