Burnmouth, Scottish Borders

[NT 971 589]–[NT 958 615]

Introduction

The Burnmouth GCR site is a foreshore section located adjacent to the village of Burnmouth [NT 9540 6095]. It encloses a wave-cut platform that extends some 2.7 km from Burnmouth Bay in the north-west to Lamberton Skerrs in the south-east. This provides near-continuous exposure through more than 600 m of strata that are typical of the Lower Carboniferous deposits of this north-eastern area of the Northumberland Trough (often referred to as the Tweed Basin). The exposed section extends from the upper Old Red Sandstone, through the complete sequence of the Cementstone Group (the best section through this facies anywhere in the Northumberland Trough), into the Fell Sandstone Group. Parts of the Scremerston Coal Group and the Lower Limestone Group are also exposed. This section spans an interval from the Tournaisian through to the Asbian. The site is arguably the most important Tournaisian–Viséan section in the Northumberland Trough, primarily because of the completeness of exposure through Cementstone Group facies which contrast markedly with their more marine equivalents to the west (see Ellery Sike, Birky Cleugh and Whitberry Burn GCR site reports, this chapter) and because of exposure of the contact between the Cementstone Group and the overlying Fell Sandstone Group. Superbly developed sedimentological features demonstrate contrasting styles of fluvial, lacustrine and some deltaic deposition.

Detailed correlation between eastern and western parts of the Northumberland Trough remains problematic and although the stratigraphical terminology applied in the Tweed Basin is somewhat out of step with other areas, the terminology of Fowler (1926) and Greig (1988) is used in this account. Scott (1985), Greig (1988, 1992) and Scrutton and Turner (1995) provide detailed accounts of the geology of this site and much of the description below is based on their reports.

Description

The Lower Carboniferous strata exposed across the foreshore at this site strike northwards more-or-less parallel to the coast and form part of the steep eastward-dipping limb of the northern end of the Berwick Monocline (Figure 3.29). The succession youngs to the east (seawards) and is downthrown by the Boundary Fault (Shiells, 1964) against Silurian or lower Old Red Sandstone strata lying inland to the west. This fault has a slightly sinuous, northward trend and forms a western margin to the Carboniferous outcrop along the full length of this coastal section. Beds adjacent to the fault are often locally overturned; elsewhere the dips in the section vary between vertical and about 70° eastwards.

Another major fault crossing the site is the NE-trending Hilton Bay Fault, which diverges from the Boundary Fault near the centre of Hilton Bay beach. The closure of the Berwick Monocline is exposed near the southern end of the site, in the southern headland of Hilton Bay. The succession is intruded by a number of E–W-trending tholelite and quartz dolerite dykes up to 12 m in thickness (see Greig, 1988, for more details).

At the northern end of the site, near Burnmouth, the basal 50 m of succession is of Old Red Sandstone facies (Figure 3.29). Up to five erosive-based fining-upward sequences are present, each comprising generally red-coloured erosive-based, coarse-grained, trough cross-stratified sandstone, overlain by fine-grained sandstones, siltstones and silty mudstones containing irregular, calcareous cornstone-like layers. The critical few metres of outcrop covering the junction between these rocks and the overlying Cementstone Group is covered by beach material and is rarely, if ever, exposed, but the contact is interpreted as being conformable (Smith, 1968; Scrutton and Turner, 1995).

The Cementstone Group is completely exposed on the foreshore between Burnmouth Bay and Ross Point, and consists of more than 450 m (Greig, 1988; Scrutton and Turner, 1995) of interbedded sandstones, shales and argillaceous dolomites ('cementstones') (Figure 3.29). Sedimentological investigations of the group have been made by Smith (1967) and subsequently by Scott (1971), who recognized two major facies associations. The first association consists of a repeated fining-upward sequence made up of a basal, cross-stratified, fine-grained sandstone unit containing

intraformational clast conglomerates, overlain by an upper unit within which siltstones and mudstones predominate. These fining-upward associations together form almost half of the total thickness of the sequence and they are the major component of the succession in the upper part of the group. The fining-upward sequences are characterized by well-developed, laterally accreted point-bar deposits and fine-grained channel fills. Lag conglomerates occurring in these fluvial sandstones contain intraformational lasts of cementstone, and many such sandstone units cut erosively into underlying cementstone horizons. The second facies association consists of laterally continuous, thinly bedded sandstones (usually < 1 m), silty mudstones and cementstones. These beds are in places mottled and contain modiolid bivalves, ostracodes, burrows (including *Chrondites*)and evidence of bioturbation. This association is particularly evident in the lower part of the group. Cementstone Group sandstones are feldspathic (subarkosic), moderately sorted, often tightly cemented and micaceous. The cementstones are, in the main, argillaceous ferroan dolomites and examples of the various types defined by Belt *et al.* (1967) are readily found within the sequence. In addition, reddened cementstone horizons occur in the upper part of the sequence. Some coarsely crystalline, nodular carbonate horizons have anhydrite inclusions and other mineralogical features indicative of an origin as replacements after nodular anhydrite (Scott, 1986). Scott and Rex (1987) noted the presence of permineralized plant remains (*Lepidodendron calamopsoides* and *Stauropteris berwickense*) in a silty wackestone horizon in the Cementstone Group at this locality.

The Burnmouth site is one of very few localities that expose the contact between the Cementstone Group and the overlying Fell Sandstone Group. This contact is an undulating erosion surface, in places cutting down 2–3 m. The Fell Sandstone Group is exposed across a smooth wave-cut platform scoured out of an essentially uniform, fine- to medium-grained, cross-stratified sandstone, which contrasts with the much more Irregular platform cut into the more variable uppermost beds of the Cementstone Group. The Fell Sandstone Group is best exposed in the vicinity of the Maidenstone Stack, where it is made up of about 80 m of yellow-coloured sandstone with a few thin mudstone partings. The sequence also contains some interbedded units of red-coloured and sometimes mottled, ripple-laminated siltstones averaging 2–3 m in thickness. Petrologically, the Fell Sandstone Group is quartzose (mostly quartz arenite), poorly sorted, with moderate to good porosity and virtually no mica.

At Hilton Bay, the south-easterly downthrow of the Hilton Bay Fault brings in the junction between the Scremerston Coal Group and the Lower Limestone Group, with beds of the latter group cropping out over Lamberton Skerrs. Only the upper part of the Scremerston Coal Group and the lower 50 m of the Lower Limestone Group are exposed (Greig, 1988). The Scremerston Coal Group outcrop comprises at least 20 m of interbedded fine sandstones and shales, with at least 12 thin coal seams present. Channel sandstones, up to 14 m in thickness, produce rapid lateral facies changes. Overlying the Scremerston Coal Group is the Lamberton Limestone, a horizon correlated with the Dun Limestone of northern Northumberland (Fowler, 1926), which In this area defines the base of the Lower Limestone Group. This horizon is about 1.2 m thick, dark grey, shaly in part, and contains colonial corals including *Lithostrotion,* gigantoproductids, *Girvanella* and crinoid columnals. The limestone is immediately overlain by a grey shale with small, isolated, lens-like colonies of *Lithostrotion* near the base, and is eventually succeeded by a prominent red cross-bedded sandstone approximately 45 m thick (Greig, 1971).

Interpretation

A Tournaisian age for the Old Red Sandstone at this site is indicated by unpublished spore evidence (Leeder, 1974b). These rocks reflect deposition in a continental alluvial setting with fluvial channel sandstones and fine-grained fluvio-lacustrine deposits containing calcretes.

The lack of diagnostic macrofossils in the Cementstone Group also creates difficulties with age assignment, but laterally equivalent strata from the uppermost part of the group have yielded miospore floras of the Pu and TC zones (Neves *et al.,* 1973) which suggest a Chadian to Asbian age range (see (Figure 1.4), Chapter 1). The Cementstone Group strata were deposited in a coastal plain, fluviatile environment crossed by meandering channel systems. Palaeocurrent data indicate that flow was towards the southwest (Scrutton and Turner, 1995). Shallow lakes were present, which may intermittently have had connections to brackish or marine conditions to the south-west (Scott, 1971). The nodular carbonate horizons with replacements after nodular anhydrite provide direct evidence of evaporate formation within the group and add support to a hypersaline origin for the cement-stones (Scott, 1986).

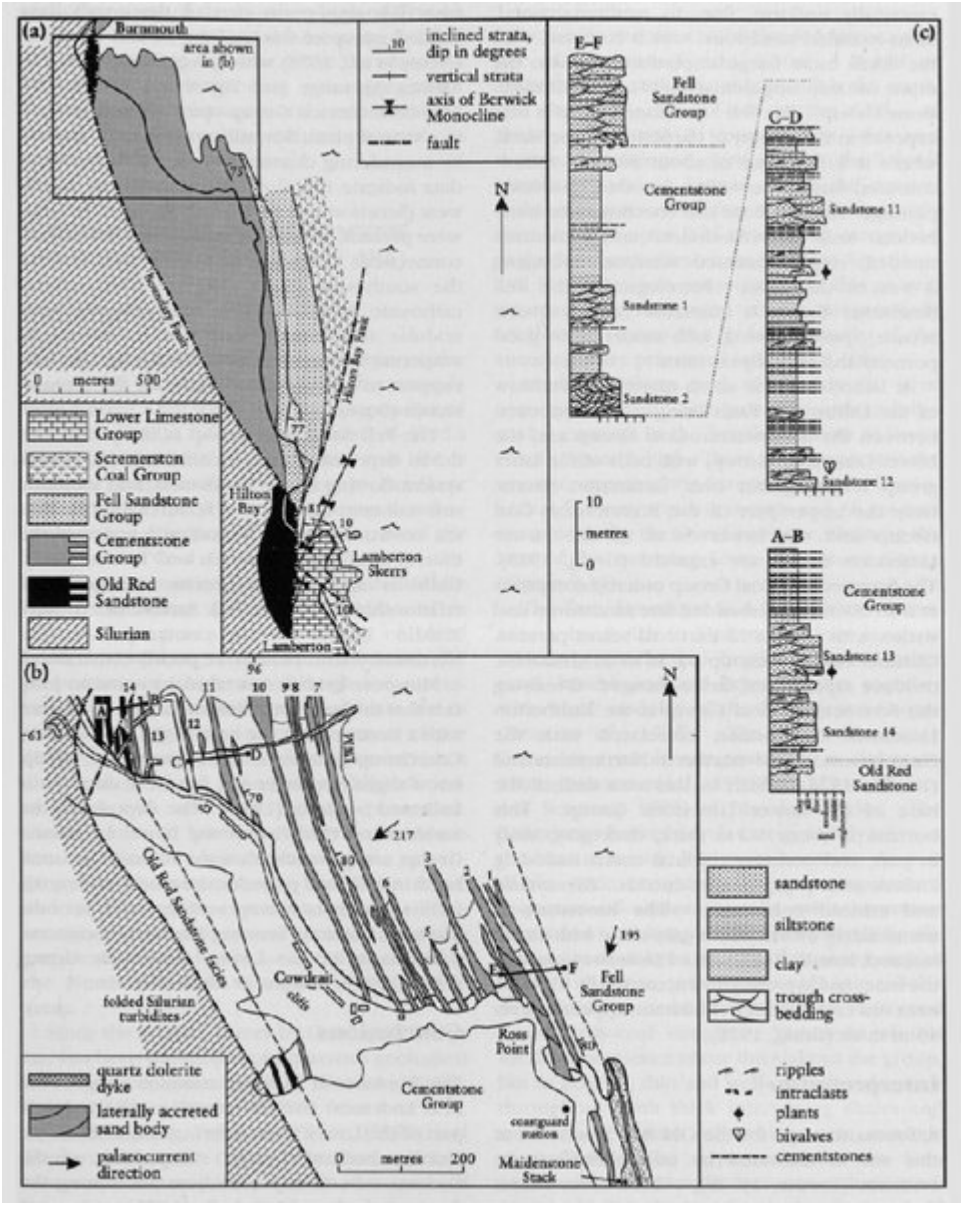
The Fell Sandstone Group is the product of fluvial deposition by a perennial braided stream system flowing to the south-west, and localized soft-sediment deformation features indicate that the environment was tectonically active at the time of deposition (Scrutton and Turner, 1995). Both its age and its precise stratigraphical relationship to other Fell Sandstone Group–Middle Border Group outcrops in the Northumberland Trough are poorly constrained.

Miospore evidence is taken by some to indicate that the base of the Asbian Stage is correlated with a horizon near the base of the Scremerston Coal Group (Wilson, 1974; Johnson *et al.,* 1995), but a slightly younger age for these deposits is indicated by Greig (1988). The deposits of the Scremerston Coal Group and Lower Limestone Group are generally thought to have accumulated in a deltaic palaeoenvironment with coals forming in delta-swamp settings, and periodic marine incursions forming limestone horizons, particularly in the Lower Limestone Group (Smith, 1967; Johnson *et* al., 1995).

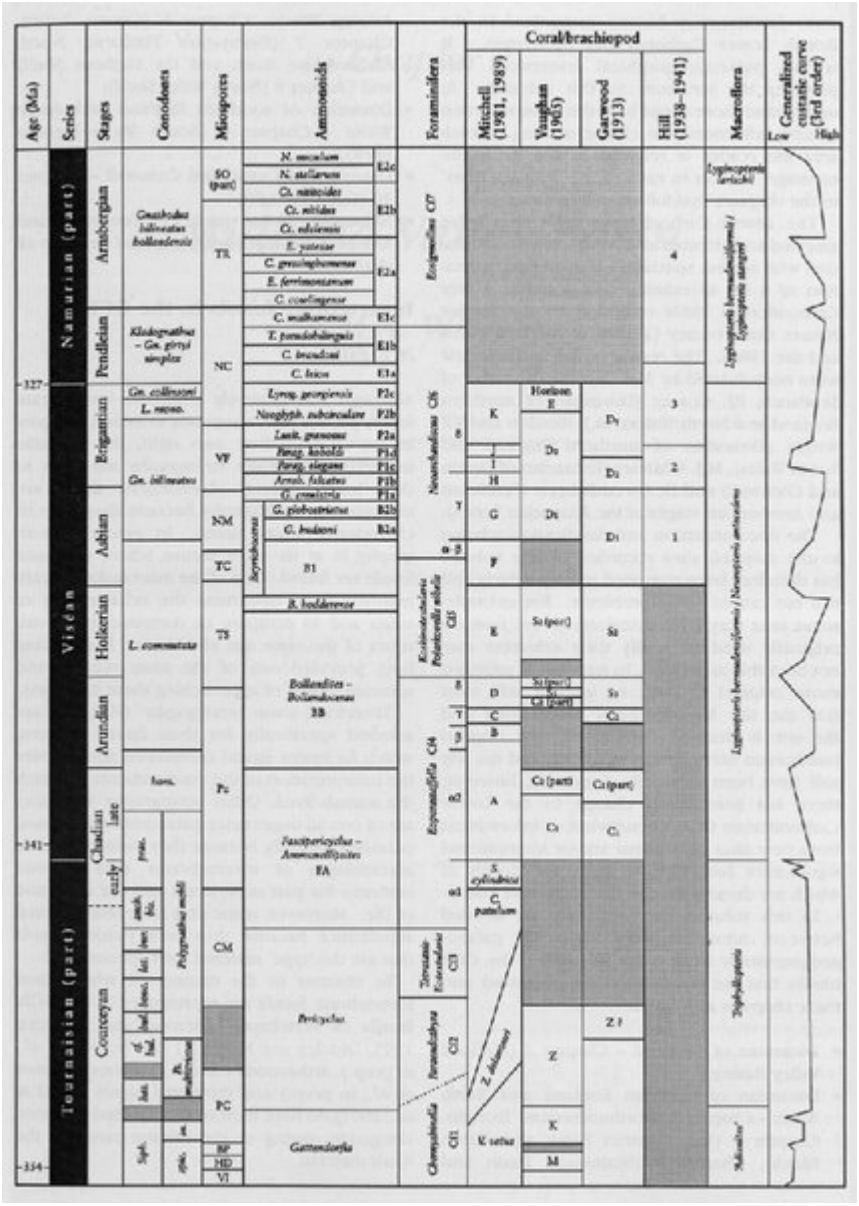
Conclusions

The Burnmouth GCR site contains some of the best and most complete sections of the lower part of the Lower Carboniferous sequence in the Northumberland Trough. Exposures of the Cementstone Group seen here are among the finest examples of Lower Carboniferous coastal plain, fluvial and lacustrine facies associations anywhere in Britain. Also exposed are several important stratigraphical boundaries that are rarely seen elsewhere. The site is situated between the Midland Valley Basin to the north and other parts of the Northumberland Trough to the south and west, and this location, coupled with the quality of exposure, make Burnmouth a key site for understanding palaeogeography, depositional environments and basin evolution during the Tournaisian–Asbian interval in northern Britain.

References



(Figure 3.29) The Lower Carboniferous geology of the Burnmouth GCR site. (a) Simplified geological map after Smith (1967). (b) Detailed geological map, and (c) sedimentary log, after Scrutton and Turner (1995).



(Figure 1.4) Chronostratigraphical and biostratigraphical classification schemes for the Lower Carboniferous Subsystem. After Riley (1993, fig. 1) with additional information for the Pendleian and Arnsbergian stages supplied by the same author. Absolute age data from Guion et al. (2000) based mainly on information by Lippolt et al. (1984), Hess and Lippolt (1986), Leeder and McMahon (1988) and Claoue-Long et al. (1995). Ammonoid abbreviations used in this figure: N. — Nuculoceras; Ct. — Cravenoceratoides; E. — Eumorphoceras; C. — Cravenoceras; T. — Tumulites; Lyrog. — Lyrogoniatites; Neoglyph. — Neoglyphioceras; Lusit. — Lusitanoceras; Parag. — Paraglyphioceras; Arnsb. — Arnsbergites; G. — Goniatites; B. — Bollandoceras. Conodont abbreviations used: Gn. — Gnathodus; Gn. collinsoni — Gnathodus girtyi collinsoni; L. mono. — Lochriea mononodosa; L. — Lochriea; horn. — Gnathodus homopunctatus; prae. — Mestognathus praebeckmanni; and,. — Scaliognathus anchoralis; bis. — Polygnathus bischoffi; bur. — Eotaphrus burlingtonensis; lat. — Doliognathus latus; bout. — Dollymae. bouckaerti; bul. — Eotaphrus bultyncki; has. — Dollymae bassi; siph. — Siphonodella; Ps. — Pseudopolygnathus; in. — Polygnathus inornatus; spit. — Polygnathus spicatus. Stipple ornament shows interzones (conodonts and miospores) or non-sequences (brachiopods).