Fleswick–Saint Bees, Cumbria

[NX 946 132]–[NX 953 118]

Introduction

The coastal cliffs between Fleswick Bay and St Bees Head display an excellent section through the middle part of the St Bees Sandstone Formation, of which this is the type location. The succession is dominated by fine- to medium-grained, cross-bedded sandstones bounded by major erosion surfaces. Conglomerates and mudstones are also present. The St Bees Sandstone formed under fluvial conditions, probably in a major braided river system that flowed NNW as shown by sedimentary structures at the site. In places, the coastline here is approximately parallel to the slope of the Triassic landscape, and therefore the deposits are exposed along the axes of individual channels. This is a superb site for the demonstration of fluvial environments in rocks of Triassic age.

The coastline around Fleswick Bay and St Bees Head has been studied for many years, the first description being by Sedgwick (1832). Subsequent studies include those by Harkness (1862), who formally named the St Bees Sandstone, Eastwood *et al.* (1931), Arthurton and Hemingway (1972), Arthurton *et al.* (1978), Macchi and Meadows (1987), Barnes *et al.* (1994), Jones and Ambrose (1994), and Akhurst *et al.* (1997).

Description

The sea cliffs in the vicinity of St Bees Head and Fleswick Bay are nearly vertical and reach a height of 90 m. At St Bees Head the sediments dip approximately 12° to the SSW or occasionally to the south or south-east. At Fleswick Bay the dip is towards the south-east (Eastwood *et al.,* 1931). The coastal section between Fleswick Bay and St Bees Head forms the St Bees Head Site of Special Scientific Interest (SSSI).

The St Bees Sandstone Formation is well exposed between Barrowmouth and St Bees Head. The underlying St Bees Shale Formation is seen in the Saltom Bay section nearby (see Chapter 2). The overlying Calder Sandstone Formation does not occur at St Bees; it is exposed in the banks of the River Calder but it is best known from boreholes onshore and offshore (e.g. Akhurst *et* ed., 1997).

The basal beds of the St Bees Sandstone Formation consist of red sandstones with a few blue and bluish-grey bands, interbedded with red shales. The sandstones typically show well-defined laminations, often with ripple marks and desiccation cracks; they are generally fine grained and contain angular grains. In some beds coarser material is present, including rip-up clasts of brown shale; these beds typically contain rounded grains (Eastwood *et al.,* 1931). This lower succession has been distinguished as the North Head Member of the St Bees Sandstone Formation (Akhurst *et al.,* 1997, p. 79).

The cliffs and wave-cut platform between St Bees village [NX 958 118] and South Head [NX 952 119] expose a three-dimensional section through the upper part of the St Bees Sandstone Formation. The deposits here consist of micaceous, laminated, and flaggy sandstones, with a few pale green bands and rare brown shales, and show large-scale erosion surfaces, upper-stage plane beds (with primary current lineation), tabular cross-bedding, trough cross-bedding, ripple cross-laminations, and abundant soft-sediment deformation structures (Macchi and Meadows, 1987; (Figure 3.20)). The deformation structures include water-escape features, ranging from over-steepening of foresets to convoluted bedding (Figure 3.21)a. Small-scale slump structures are also exposed, especially towards the edges of the channels.

At St Bees Head, below the lighthouse [NX 940 143], the sequence consists almost entirely of sandstones, with thin beds of conglomerate. The sandstones comprise thick (up to 4 m) units of micaceous, fine- to medium-grained sediment. Sedimentary structures include large-scale cross-beds, erosion surfaces (Figure 3.21)b with associated mudstone-clast conglomerates, and planar beds. The sedimentary structures are arranged in a vague sequence, from planar beds with primary current lineations at the base, through units of tabular planar and trough cross-bedding, to laminations with ripples (Macchi and Meadows, 1987).

A similar sequence of sandstones is seen in the cliffs at Fleswick Bay [NX 946 133]. Additional features here include a cross-section of a small channel at the northern end of the bay and, to the south, gutter casts with flute marks cutting into a thin mudstone bed (Macchi and Meadows, 1987, p. 121).

Palaeocurrent indicators in the St Bees Sandstone Formation indicate a dominant northerly to north-westerly flow and derivation from a source region to the south.

Interpretation

The St Bees Sandstone Formation was deposited under fluvial conditions (Akhurst *et al.,* 1997, pp. 81–3). The underlying St Bees Shale Formation was deposited in a mudflat environment as wind-borne dust and sheetflood detritus, with periodic establishment of evaporitic conditions. The transition to the North Head Member of the St Bees Sandstone Formation was marked by a continuation of the sheetflood facies, and the introduction of river-borne debris from the south (Figure 3.22)a. Higher in the formation, deposits of this fluvial system progressively evolve from sheetflood sediments to thin, single-storey channel sandstones interbedded with overbank mudstones that, in turn, pass upwards into multi-storey channel sandstones. The dominant direction of river flow was towards the north-west. The range of palaeocurrent directions is limited, and there is little evidence of lateral accretion bedforms, both of which suggest that the channels were relatively uniform in direction. Overall, the facies is interpreted as produced by a sandy, low-sinuosity, braided river system (Figure 3.22)b.

Variations in the flow of the rivers are reflected in cyclical deposits seen in the cliffs between St Bees and Fleswick, with each cycle deposited in conditions of declining flow energy (Macchi and Meadows, 1987). Re-activation surfaces within the sandstone units indicate that the river was subject to frequent periods of flooding. An idealized sequence begins with a conglomeratic lag deposit overlying an erosion surface. The lag deposit is overlain by a plane-bedded sandstone with primary current lineation, a bed-form feature characteristic of high-flow regimes that probably occurred during flooding events. Above the plane bedded units are planar-tabular and trough cross-bedding, structures formed during moderately high-flow rates, and representing the migration of transverse linguoid channel bars. The tabular planar cross-beds were deposited in large transverse bars on the river bed. As the floodwaters declined these bars caused the river to split into many smaller channels, producing a braided profile. The trough cross-bedding was produced in the braided channels, and represents small dunes with curved crests that migrated around the larger transverse bars. At the top of these sequences are laminated beds that commonly show ripples, indicative of lower energy-flow conditions.

This idealized sequence is not always encountered. For example, some of the thicker sandstone units reflect several floods within the same channel, in the form of planar beds of the upper flow regime, with primary current lineations, alternating with planar cross-bedding (Macchi and Meadows, 1987, p. 117).

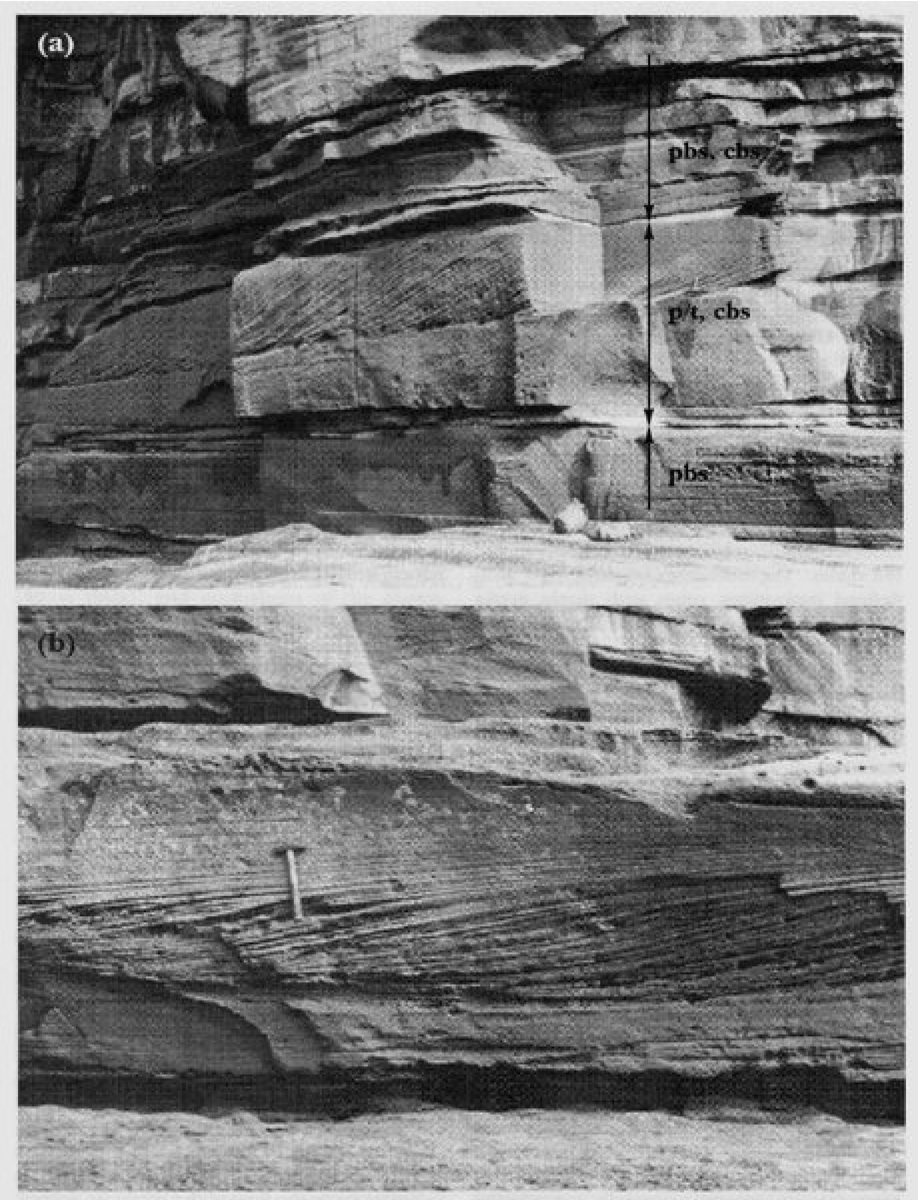
The section between St Bees and South Head shows evidence for small pools or areas of low flow velocity between the major transverse bars. Within the pools, fine-grained micaceous sandstones were deposited in rippled beds. Mudstone drapes are often preserved overlying the ripples (Macchi and Meadows, 1987). The fine-grained units sometimes show evidence of emergence and desiccation and possible local development of aeolian dunes (Figure 3.22)b.

The St Bees Sandstone is unfossiliferous, and cannot be dated directly or precisely. It is assumed to be of Early Triassic age. It conformably overlies the St Bees Shale, a lateral equivalent of the Eden Shale and Manchester Marl formations (Figure 3.19) that contain a late Permian microflora and fauna. It passes laterally southwards into the Chester Pebble Beds Formation, which is overlain by the Wilmslow Sandstone Formation, and that by the Helsby Sandstone Formation, which has yielded miospores indicative of a Mid Triassic, Anisian, age (Warrington *et al.,* 1999).

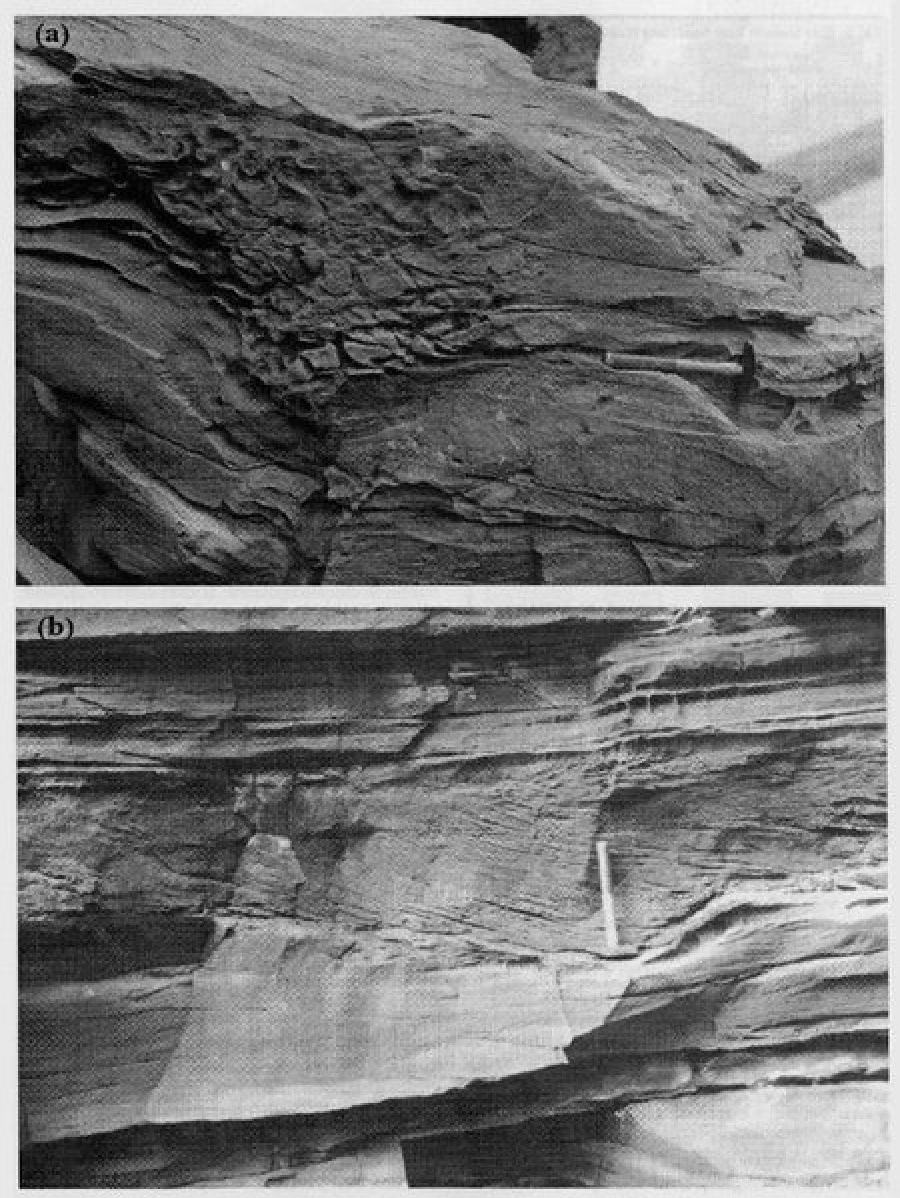
Conclusions

The cliffs, wave-cut platform and foreshore around St Bees and Fleswick Bay provide excellent three-dimensional exposures of the St Bees Sandstone Formation, of which this is the type location. This outcrop allows detailed study of the bedforms of a braided river system that was prone to periods of violent flooding. The extensive exposure enables single channels to be traced downstream for many hundreds of metres. The site is critically important in showing the nature of beds of the presumed Permian Triassic transition, and the character of the Sherwood Sandstone Group on the northern flank of the East Irish Sea Basin.

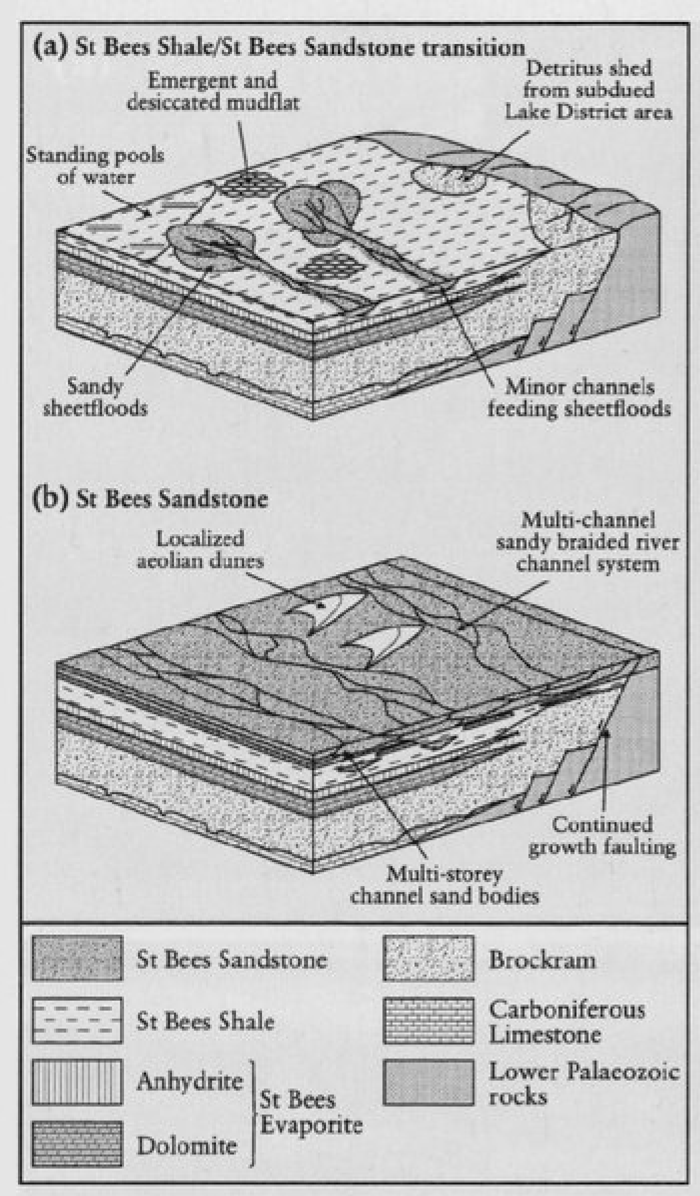
References



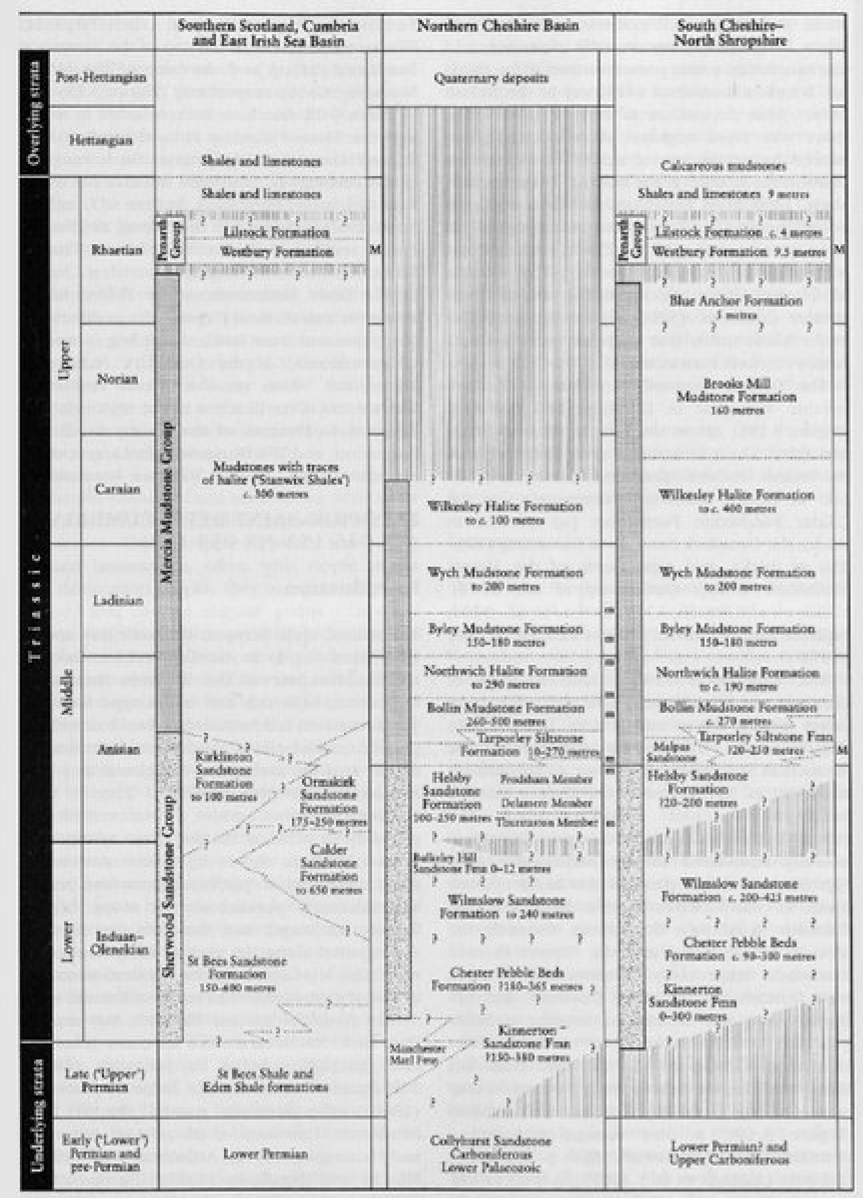
(Figure 3.20) The Lower Triassic St Bees Sandstone Formation at St Bees Head on the Cumbrian coast showing vertical profiles through transverse bars. (a) Plane-bedded sandstones (pbs) overlain by planar/tabular cross-bedded sandstones (p/t, cbs), and then more plane-bedded and cross-bedded sandstones (pbs, cbs) with multiple erosion surfaces; rucksack for scale. (b) Multiple cross-bedded units and a large sinusoidal bedform with re-activation surfaces. (Photos: P Turner.)



(Figure 3.21) The Lower Triassic St Bees Sandstone Formation at St Bees Head on the Cumbrian coast. (a) Cross-bedded sandstones that have been distorted shortly after deposition. (b) A scour-and-fill structure, in which cross-bedded sandstones occupy a hollow eroded into the underlying sandstones. (Photos: P Turner.)



(Figure 3.22) Depositional models for the St Bees Shale and the St Bees Sandstone formations, showing major sediment types, and proposed sedimentary environments. (After Akhurst et al., 1997.)



(Figure 3.19) Stratigraphical columns for the Triassic successions of southern Scotland and Cumbria, and the East Irish Sea and Cheshire Basin areas. M, macrofossils; m, microfossils. Based on Warrington et al. (1980), Jackson et al. (1987), Wilson (1993) and Ivimey-Cook et al. (1995), Jackson and Johnson (1996), Akhurst et al. (1997) and Warrington (199713).