Saltom Bay; Cumbria

[NX 958 159]–[NX 957 155]

Introduction

The foreshore at, and adjacent to, Saltom Bay provides the best exposure of the Permian succession in west Cumbria. A basal breccia, the Brockram, rests unconformably on the Whitehaven Sandstone Formation (Carboniferous), and passes upwards into the St Bees Evaporite Formation, represented by the Saltom Dolomite, a marine carbonate. The overlying St Bees Shale Formation was deposited in a mudflat environment, and is succeeded by the St Bees Sandstone Formation (?Lower Triassic Series), which represents a range of fluvial environments. This site has the best exposure of the Permian succession of west Cumbria, and it is critical for understanding the geology of the extensive contiguous offshore Irish Sea Basin.

The first description of the geology of the region was published by Sedgwick (1832), and later accounts include Binney (1855), Harkness (1862), Smith (1924), Eastwood *et al.* (1931), Meyer (1965), Arthurton and Hemingway (1972), Macchi and Meadows (1987), and Akhurst *et al.* (1997).

Description

The exposures at Saltom Bay form part of the St Bees Head Site of Special Scientific Interest (SSSI), which comprises five GCR sites — essentially the same area has been selected independently for both its marine Permian (Smith, 1995) and red bed features, and the continuation to St Bees Head has been selected for its Triassic red beds (see Chapter 3); the Westphalian' and 'Quaternary of Cumbria' GCR Blocks are also represented here.

Sedimentology

The Permian section in Saltom Bay (Figure 2.17) comprises (Akhurst *et al.,* 1997, p. 67):

Sherwood Sandstone Group (Lower Triassic Series)

St Bees Sandstone Formation

Cumbrian Coast Group (?Upper Permian)

St Bees Shale Formation

St Bees Evaporite Formation (includes Saltom Dolomite)

Appleby Group (?Lower Permian)

Brockram (= Basal Breccia)

Whitehaven Sandstone Formation (Upper Carboniferous)

The Whitehaven Sandstone Formation (Westphalian C–D) is a trough-cross-bedded sandstone unit with reddish or purplish stains. The joints have been widened and infilled with material from the overlying Brockram.

The Brockram rests unconformably upon the Whitehaven Sandstone; it ranges from 1.5 to 3 m in thickness, and thins towards the south-west, where, at low water, it is seen to be only 0.2 m thick (Eastwood *et al.,* 1931). The unit is much thicker offshore, reaching 150 m in some boreholes (Akhurst *et al.,* 1997). The Brockram is a coarse, poorly bedded to moderately sorted, generally massive, matrix- or clast-supported breccia. Clasts range from granule to cobble grade, but

are mostly pebble-sized. Many of the clasts are local in origin and are subangular to angular; rounded to subrounded clasts are rare. The clasts consist of Carboniferous sandstone, siltstone, and limestone, and Ordovician slates, sandstones, vein quartz, tuffs, and lavas. The lower parts of the breccia contain abundant quartz sandstone matrix, while the upper parts show evidence of reworking, followed by cementation with dolomite (Macchi and Meadows, 1987). Sedimentary structures are generally limited to poorly developed bedding, although there are patches of low-angle cross-bedding and clast imbrication. The top surface of the breccia is marked by vertical cracks that form large polygons infilled with fine- to medium-grained sand (Arthurton and Hemingway, 1972). The Brockram is laterally equivalent to the Collyhurst Sandstone Formation of the offshore East Irish Sea Basin (Jackson *et al.,* 1987, 1995; Akhurst *et al.,* 1997), the two units being included in the Appleby Group.

The Brockram is succeeded by the marine St Bees Evaporite Formation, which has been described in the GCR volume *Marine Permian of England* (Smith, 1995, pp. 15–18). At Saltom Bay only part of this formation, the Saltom Dolomite, formerly known as the 'Magnesian Limestone' (Arthurton and Hemingway, 1972), is exposed. The lowest metre of the basal division of this unit, a shelly dolomite, contains fragments of the underlying breccia, which were incorporated during a phase of sediment reworking (Figure 2.18).

The St Bees Shale Formation at Saltom Bay comprises a few metres of reddish siltstones and mudstones with some beds of fine-grained, calcareous sandstone. The sediments are commonly cross-laminated, and also display load casts, slumps, and desiccation cracks; they include gypsum nodules and veins, mudstone rip-up clasts, and a few rock fragments (Arthurton and Hemingway, 1972). The top of the formation is placed below the first significant sandstone bed of the St Bees Sandstone Formation (Barnes *et al.,* 1994), and the contact appears to be gradational. The St Bees Shale Formation and its offshore equivalent, the Barrowmouth Mudstone Formation, is better represented in boreholes (Akhurst *et al.,* 1997).

Palaeontology

The Brockram has not yielded fossils. The Saltom Dolomite, representing the St Bees Evaporite Formation, contains a fauna of bivalves (Pattison, 1970), including *Bakevellia binneyi, Permophorus costatus,* and *Schizodus obscurus.* Miospores have been recovered from the basal unit in this formation; these include *Falcisporites zapfei, Klausipollenites schaubergeri,* and *Taeniaesporites labdacus,* and indicate a Late Permian age (Warrington in Arthurton and Hemingway, 1972).

Interpretation

Detailed mapping, and borehole information from onshore and offshore areas, allowed Akhurst *et al.* (1997) to compile a schematic cross-section of the Permian succession of the East Irish Sea–west Cumbria coast area (Figure 2.19). The Carboniferous basement formed a surface that was undergoing faulting and differential uplift and subsidence as the Brockram was deposited. This explains the great variations in thickness of this unit, from less than 1 m in places to 150 m in some boreholes. The Brockram is succeeded by evaporite, carbonate, and breccia units in different parts of the basin.

The marine units are partly laterally equivalent to the St Bees Shale Formation, which also overlies them. The lower Triassic St Bees Sandstone Formation (basal unit, the North Head Member) succeeds the Permian uniformly across the basin.

The reddening of the Carboniferous Whitehaven Sandstone Formation, at the base of the succession, was probably caused by deep weathering during arid early Permian times when the contemporary water table would have been at a low level (Jackson *et al.,* 1987).

The Brockram has been interpreted as the deposits of a series of alluvial fans comprising material eroded and transported from the Carboniferous uplands to the east (Figure 2.20)a. Syndepositional faulting maintained those uplands and produced the differences in relief necessary for the accumulation of large alluvial fans. The textures and sedimentary structures of the Brockram show that it formed in alluvial fans comparable with those now forming from debris-flow processes. The debris flows followed periods of heavy rainfall that created flash floods and resulted in rapid erosion and

transport of debris from upland areas. Finer-grained sediments indicate waning flood conditions.

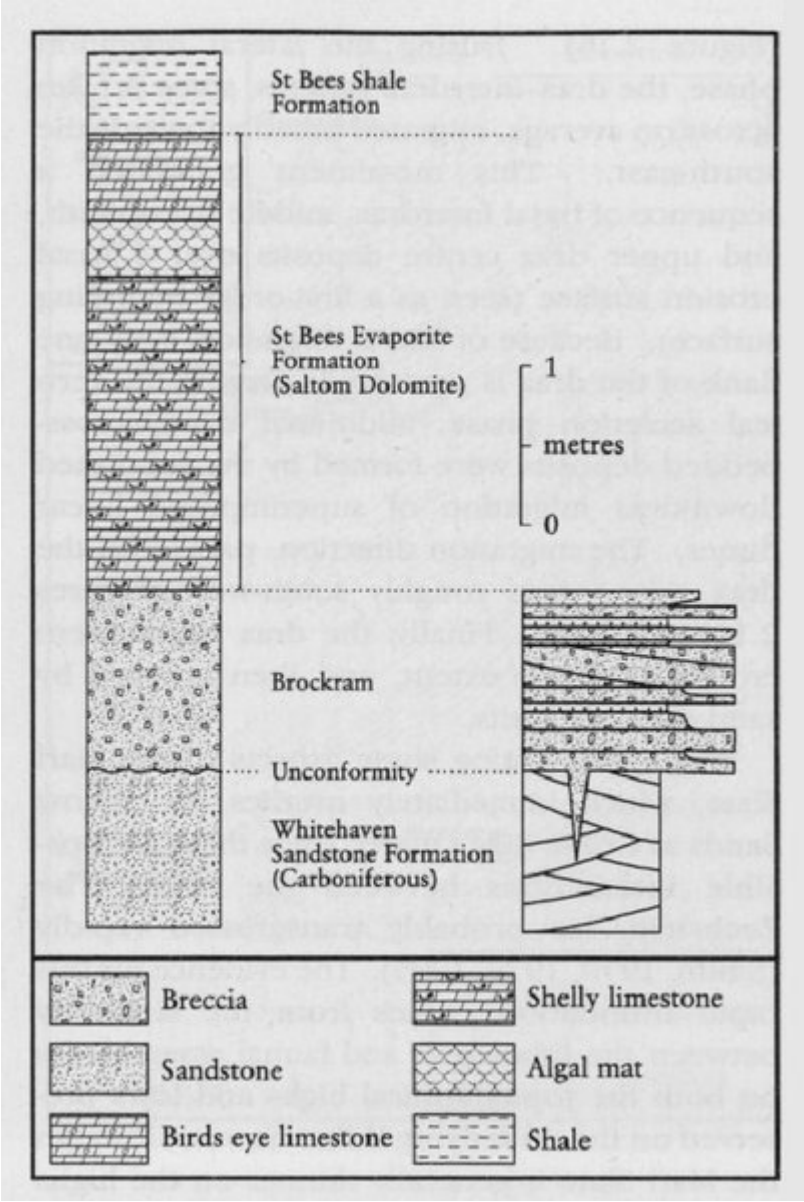
The Saltom Dolomite of the St Bees Evaporite Formation represents the initiation of a marine transgression, with carbonate sedimentation on a shallow coastal shelf that supported a restricted marine bivalve fauna. These marginal carbonates are succeeded by the St Bees Shale Formation, comprising fine-grained clastic material presumably washed in from the basin margins. Rising sea level then led to the deposition of dolomite. Later, halite and anhydrite were deposited in the centre of the basin. Alluvial fans prograded into the basin from its margins throughout this marine phase (Figure 2.19).

The St Bees Shale Formation represents a reversion to continental conditions. The depositional environment was essentially a mudflat with slow accretion of sediment transported by wind and sheet floods (Figure 2.20)b. The occurrence of small pools of water is recorded by evidence of minor wave influence. The mudflats dried out from time to time, producing mud cracks and evaporites. Coarse-grained alluvial fans built up around the margins of the basin.

Conclusions

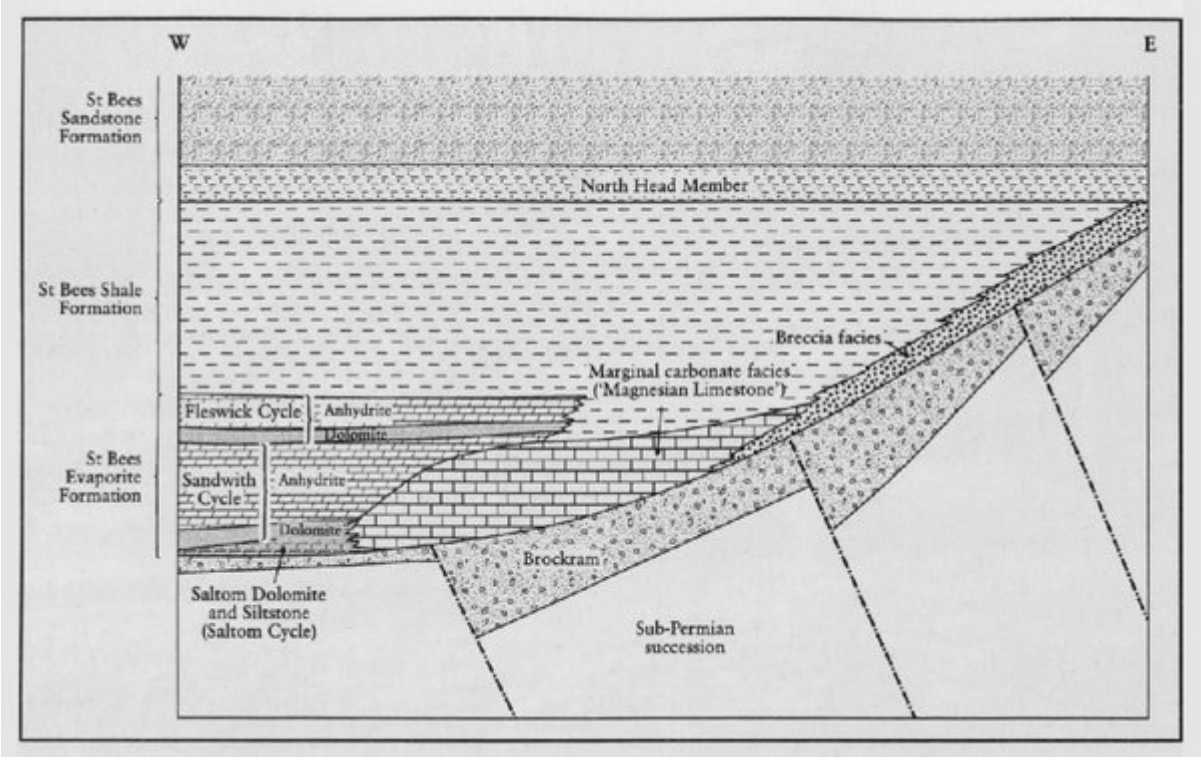
The sediments exposed in the cliffs and on the wave-cut platform at Saltom Bay are Permian in age, and include the Brockram, the St Bees Evaporite Formation, the St Bees Shale Formation, and the lower beds of the St Bees Sandstone Formation. This is the best exposure through the Permian succession in west Cumbria and it illustrates a major change in palaeoenvironment, from terrestrial piedmont breccias to marine carbonate shoals, following a marine transgression, and then a reversion to continental conditions. The Saltom Bay section is critical for understanding of the Permian history of the Irish Sea Basin, and for broad-scale palaeogeographical reconstruction.

References

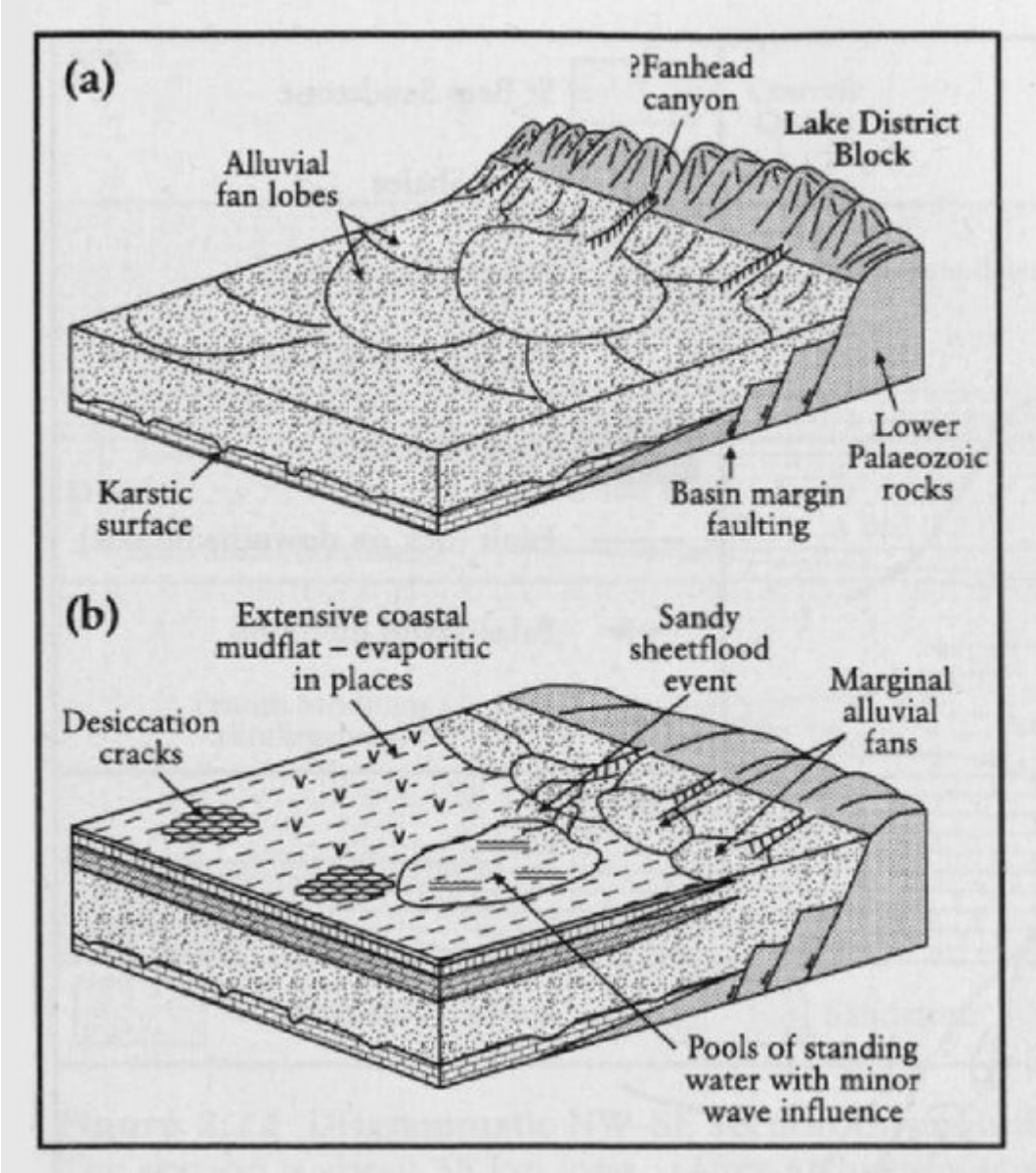


(Figure 2.17) Simplified sedimentary log of the succession at Saltom Bay, with the Permian Brockram resting unconformably on the Carboniferous White-haven Sandstone Formation and succeeded by the St Bees Evaporite and St Bees Shale formations. A graphical facies log of the Basal Breccia is shown. Note the deep, weathered fissure in the top of the sandstone filled with brockram. (After Macchi and Meadows, 1987.)

(Figure 2.18) The Saltom Dolomite of the St Bees Evaporite Formation resting on the uneven top surface of the Brockram, at the south-west end of Barrowmouth Beach, Saltom Bay. The hammer is 0.33 m long. (Photo: D. B. Smith.)



(Figure 2.19) Diagram of stratigraphical relationships of the sub-Permian strata, and the Permian Brockram and higher breccia fades and basinal marine deposits in the Appleby and Cumbrian Coast groups, west Cumbria. (After Akhurst et al., 1997.)



(Figure 2.20) Block reconstructions of major sedimentary environments represented by (a) the Brockram, and (b) the St Bees Shale Formation. (From Akhurst et al., 1997.)