Three Cliffs Bay, Gower, West Glamorgan

[SS 529 877]–[SS 536 880]

Introduction

The Three Cliffs Bay GCR site is a large coastal site ([SS 529 877]–[SS 536 880]), situated south of the hamlet of Penmaen on the Gower Peninsula. It offers an outstanding and almost unbroken Courceyan–Holkerian section extending from the base of the Shipway Limestone (Penmaen Burrows Limestone Group) to the Hunts Bay Oolite. It provides one of the finest sites in Britain, not only for examining this stratigraphical interval, but also for the study of limestones in general. The detail visible in many of the outcrops, particularly those in the lower part of the succession, is unsurpassed in Britain, giving many important insights into the controlling factors of limestone deposition. As a result, many papers have been written on this section and the quality of exposure will allow this section to be a focus for future research. This gives the section international significance as a model for the interpretation of early Carboniferous limestones and for ramp deposits of other ages. Of particular significance are the exposures of storm bedding preserved in the Shipway Limestone, the fossil soil and related exposure features at the top of the Caswell Bay (Gully) Oolite, and the Caswell Bay Mudstone–High Tor Limestone transgressive barrier shoreline succession. Detailed descriptions of parts of the succession are to be found in Dixon and Vaughan (1911), George (1978b), Wu (1982), Simpson (1985b), Ramsay (1987) and Faulkner (1988). The stratigraphical divisions were revised by the [British] Geological Survey (Institute of Geological Sciences, 1973) and George *et al.* (1976).

Description

This extensive section (see (Figure 9.20)) begins in cliffs to the west of the sand dunes behind the main beach area. The lowest exposed units belong to the Penmaen Burrows Limestone Group (Institute of Geological Sciences, 1973; George *et al.,* 1976), for which this is the type section. This is a major unit which correlates with the Black Rock Limestone Group of the Bridgend, Cardiff (Figure 9.2) and Bristol areas. The underlying Cefn Bryn Shales are not exposed. The first limestone outcrops are the Shipway Limestone (Institute of Geological Sciences, 1973; George *et al.,* 1976), which contains a variety of matrix-rich bioclastic limestones with trace fossils, and which were described in considerable detail by Wu (1982), Faulkner (1988), with additional information given by Wright (1986a) and Ramsay (1987). The main fauna consists of brachiopods, crinoids and bryozoans. Faulkner (1988) identified five lithofacies types within this unit, including graded beds and hummocky cross-stratification. Trace fossils include *Zoophycos, Planolites, Chrondites,* rare *Rhizocorallium* and common escape burrows. Truncated vertical burrows filled with coarse shell material also occur. The Shipway Limestone is here some 47 m thick (Faulkner, 1988), and is the equivalent of the Barry Harbour Limestone in the Cardiff area, which is dated as Courceyan in age (*Siphonodella-Pseudopolygnathus multistriatus* Interzone; Waters and Lawrence, 1987).

Overlying these bioclastic limestones is a partially dolomitized, reddened oolitic–bioclastic unit (*c.* 4 m), which has been regarded as the Brofiscin Oolite (Faulkner, 1988), a widespread unit in the Vale of Glamorgan (Waters and Lawrence, 1987; Wilson *et al.,* 1990). *It* has been discussed by Burchette *et al.* (1990), and exhibits trough cross-bedding, with vadose cements preserved in its uppermost part. This unit is repeated by a thrust some distance along the cliff to the south-west. The contact with the bioclastic limestones of the Shipway Limestone is in a recess In the cliff face but the oolite appears to be sharp based. No clasts of the underlying limestones have been found in the Brofiscin Oolite. This unit is sharply overlain by the Tears Point Limestone, a package (*c.* 60 m) of muddy, highly crinoidal limestones, described by Ramsay (1987) and Faulkner (1989a). The upper part of the Penmaen Burrows Limestone Group, arguably part of the Tears Point Limestone, was named the 'Langland Dolomite' by the [British] Geological Survey (Institute of Geological Sciences, 1973). This is a fine-grained replacive dolomite. The age of the upper part of this group has been determined at nearby Tears Point (Mitchell *et al.,* 1986) as being late Tournaisian–early Viséan in age.

Above this, the Chadian Caswell Bay (Gully) Oolite (Ramsay, 1987; Searl, 1989a) is a cross-bedded oolitic grainstone unit (*c.* 45 m). A minor palaeokarst associated with rhizocretions occurs approximately 10 m from its top. The unit is capped by a more prominent, undulating palaeokarstic surface with a thin calcrete crust (Wright, 1982a). This second surface exhibits smooth pits and intervening highs, with relief of up to a metre. The calcrete crust is more of a discontinuous veneer, and contains abundant rhizocretions with an alveolar-septal structure composed of well-preserved micron-sized needle fibre calcite, a form of calcite regarded as the product of soil fungal activity (Wright, 1986b). Overlying this is 7 m of the Caswell Bay Mudstone, which consists of argillaceous and peloidal limestones and dolostones, described in detail by Ramsay (1987). This unit has a restricted biota mainly of ostracodes and calcispheres.

The top of this unit is erosional and is overlain by the Arundian High Tor Limestone (*c.* 100 m), with richly fossiliferous bioclastic grainstones passing up into a more matrix-rich lithofacies. Detailed descriptions of the facies have been provided by Ramsay (1987), and aspects of the biota have been documented by Beus (1984) for nearby localities. Simpson (1985b) provides a simple interpretive log for the unit. There is a finer-grained unit capping the lower third of the section, and also a palaeosol (Ramsay, 1987).

The overlying Holkerian Hunts Bay Oolite, which reaches a thickness of 275 m thick in the area (Figure 9.21), is dominated by cross-stratified and structureless oolitic grainstones, laminated fine bioclastic packstones and grainstones, and extensive developments of peloidal, grapestone grainstones (Ramsay, 1987).

Interpretation

This site has been used in a number of detailed sedimentological and palaeontological studies, making it one of the best documented limestone sections in Britain. The overall setting for the succession has been interpreted as a southward-dipping carbonate ramp (Wright, 1986a), and sea-level changes during Courceyan to Holkerian times created a set of distinctive facies, ranging from outer ramp to terrestrial (Figure 9.20).

The Shipway Limestone was mainly deposited in a storm-dominated mid- to inner-ramp setting (Wu, 1982; Faulkner, 1988). Anderson and Goodwin (1990) offered an unusual interpretation for this unit, suggesting it represents a cyclic peritidal deposit, but this view has not found support (for example, Wright and Faulkner, 1991). The Brofiscin Oolite has been interpreted as a progradational shoreline-detached sand-body with a strong longshore transport component (Burchette *et al.,* 1990). The sharp base to this unit might suggest that it represents a forced regressive sand, which became subaerially exposed to generate vadose cements. The overlying Tears Point Limestone represents a return to deeper, mid- or even outer-ramp conditions (Ramsay, 1987; Faulkner, 1989a). The exact environmental significance of the Langland Dolomite is unclear but there is evidence, at least locally, of subaerial exposure at the top of the Friars Point Limestone, beneath the Caswell Bay (Gully) Oolite to the east in the Bridgend and Cardiff areas (Waters and Lawrence, 1987; Wilson *et al.,* 1990), and a prominent exposure surface occurs at this level south of Bristol, developed on offshore limestones (Faulkner *et al.,* 1990). This implies that a rapid (forced) regression may have taken place at the end of Penmaen Burrows Limestone Group times, and within early Viséan times.

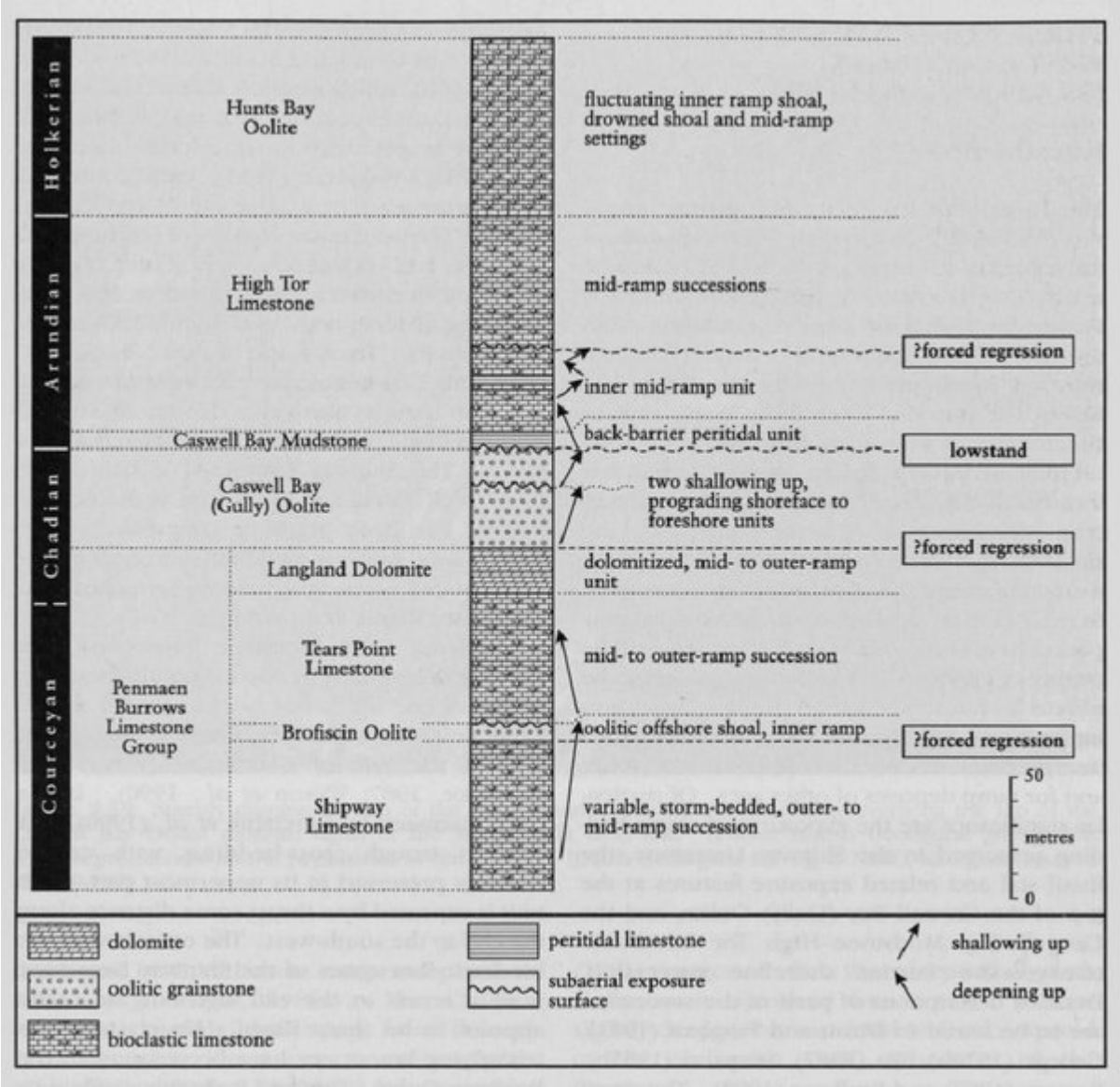
The overlying Caswell Bay (Gully) Oolite represents two prograding shoreface–foreshore packages, each capped by a palaeokarst and palaeosol (Searl, 1989a; Burchette *et al.,* 1990). The Caswell Bay Mudstone and lower part of the High Tor Limestone are transgressive deposits formed in back-barrier and shoreface settings (Riding and Wright, 1981; Burchette *et al.,* 1990). The contact between the two units represents a shoreface erosion surface or ravinement. The bulk of the High Tor Limestone is a storm-dominated inner- to mid-ramp succession with shoaling events, evidenced by a peritidal unit, and also a thin palaeosol (Simpson, 1985b; Ramsay, 1987).

The Hunts Bay Oolite was deposited as a complex of oolite shoals covered in small sand waves, together with protected settings intermittently agitated where grapestones were produced. Deepening phases resulted in the deposition of finer-grained bioclastic packstones and grainstones (Ramsay, 1987).

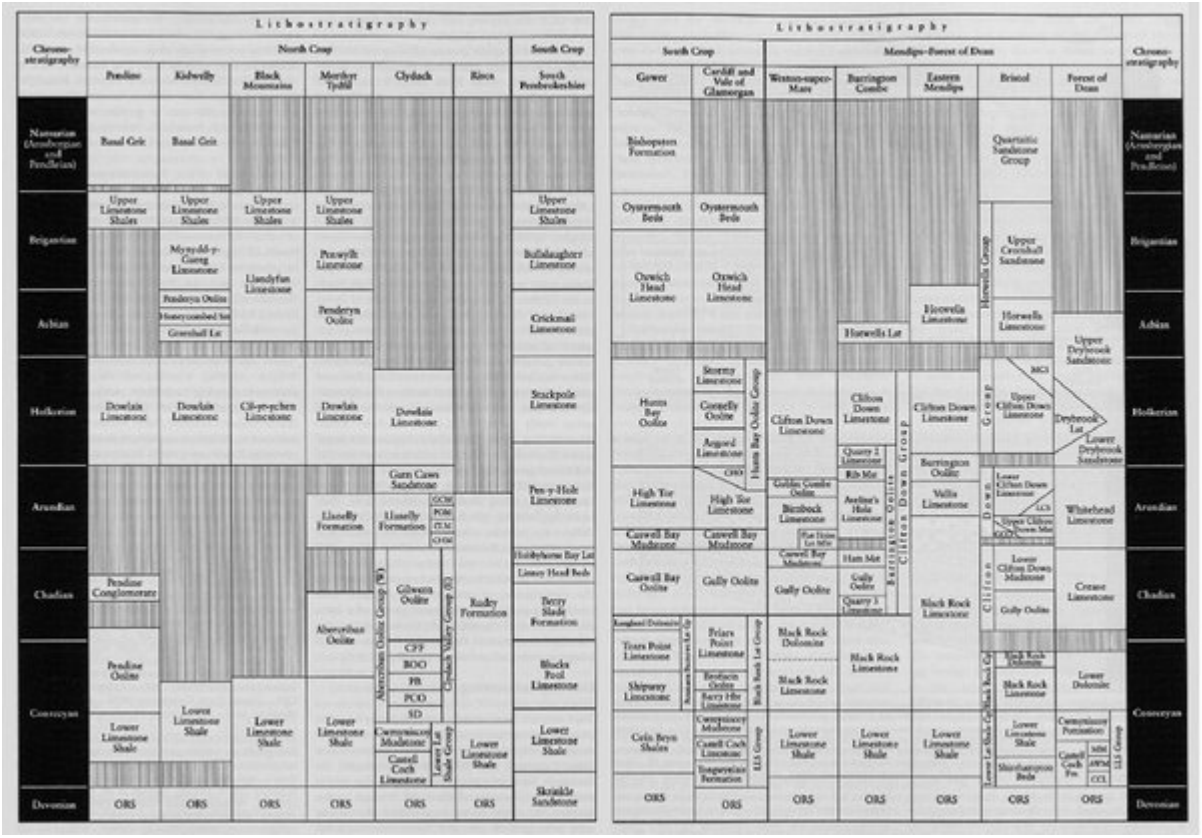
Conclusions

The variety of related carbonate facies in the full succession makes this site one of national importance not only for studying early Carboniferous carbonates, but also for illustrating ancient limestone deposystems. A ramp model provides the best explanation for the succession, over which sea-level changes and progradational events created fluctuating water depths. The Shipway Limestone provides an especially good outcrop for examining a range of storm deposits. The top Caswell Bay (Gully) Oolite to basal High Tor Limestone is a very well-exposed succession of shallowing-upwards oolitic shoreface deposits, capped by a prominent subaerial exposure surface, and overlain by transgressive back-barrier and lower shoreface facies.

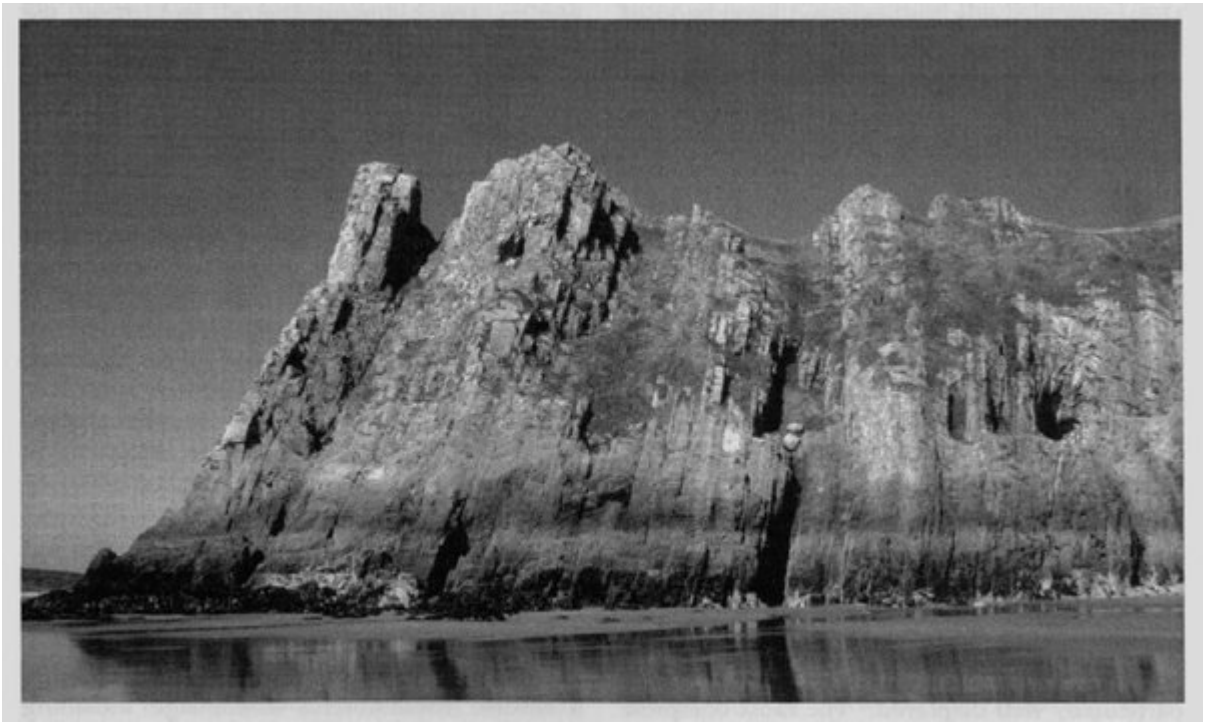
References



(Figure 9.20) The interpretation of depositional environments represented by the Lower Carboniferous succession at the Three Cliffs Bay GCR site, Gower.



(Figure 9.2) Simplified stratigraphical chart illustrating the most widely used lithostratigraphical terms for the Lower Carboniferous sequences in South Wales, the Forest of Dean, Bristol and the Mendips. (SD — Sychnant Dolomite; PCO — Pwil y Cwm Oolite; PB — Pantydarren Beds; BOO — Blaen Onnen Oolite; CFF — Coed Ffyddlwn Formation; CHM — Clydach Halt Member; CLM —Cheltenham Limestone Member; POM — Penllwyn Oolite Member; GCM — Gilwern Clay Member; LIS —Lower Limestone Shale; CHO — Cefnyrhendy Oolite; CCL — Castell Coch Limestone; AWM — Astridge Wood Member; MM — Mitcheldean Member; GCO — Goblin Combe Oolite; LCS — Lower Cromhall Sandstone; MCS — Middle Cromhall Sandstone.) Areas of vertical ruling indicate non-sequences. Not to scale. Based on information from and after Welch and Trotter (1961), Green and Welch (1965), Institute of Geological Sciences (1973, 1977c), George et al. (1976), Wright (1982b), Whittaker and Green (1983), Burchette (1987), Waters and Lawrence (1987), Barclay et al. (1988), Scott (1988), Barclay (1989), Wilson et al. (1990) and Kellaway and Welch (1993).



(Figure 9.21) General view of the cliff section in the Hunts Bay Oolite (Holkerian) at Three Cliffs Bay. (Photo: P.J. Cossey.)