Tenby–Saundersfoot coast

Highlights

Tenby–Saundersfoot coast is the only extensive exposure of Millstone Grit and lower Coal Measures on the western extremity (Pembrokeshire) of the south crop of the South Wales Coalfield. It provides a unique insight into the palaeogeography and evolution of the coalfield. It also yields some of the best plant and bivalve fossil assemblages for the basal Coal Measures in Britain, with important consequences for understanding their biostratigraphy.

Introduction

The coast between the harbours at Tenby and Saundersfoot, Dyfed [SN 136 016]–[SN 136 046], . exposes Namurian and lower Westphalian strata, representing a westerly extension of the south crop of the South Wales Coalfield (Figure 4.4). The strata have been seriously disturbed by Variscan tectonics, but the excellent exposure has allowed a more or less continuous succession to be established. There are a number of accounts of the field geology, the most important being by Strahan *et al.* (1914), Dixon (1921), Jenkins (1962), Owen *et al.* (1966), Williams (1968) and Kelling and George (1971). There are also two unpublished theses that describe the geology and sedimentology in great detail (Williams, 1966; G. T. George, 1970).

Description

Lithostratigraphy

Some 375 m of mudstones, shales, siltstones and sandstones here belong to the Millstone Grit and basal Coal Measures groups. They are separated from the underlying Carboniferous Limestone by the Ritec Fault. A summary lithostratigraphical log is shown in (Figure 4.5).

The lower 230 m consist of shales and siltstones, with subsidiary sandstones. They appear to be equivalent to the Bishopston Formation of the Gower (see Barland Common, below), which represents mid-basinal deposits. However, some of the sandstones in the Tenby sequence have been interpreted as beach deposits associated with a coastal barrier bar, whilst others may be fluvial in origin (G.T. George, 1970; Kelling and G.T. George, 1971). It is thus likely that the Tenby sequence was formed nearer the basin margin than the Gower succession (Kelling, 1974).

Overlying the Bishopston Formation is an interval dominated by sandstones, with only a few marine mudstones. Early authors took these sandstones to be a diachronous equivalent of the Farewell Rock Formation in the main part of the South Wales Coalfield. However, it is now evident that they represent a quite distinct body of sandstone, known as the Upper Sandstone Formation. This interval is taken to represent fluvial deposits associated with a delta lobe advancing from the north-west (Kelling, 1974).

Above the Upper Sandstone Formation is a sequence of five regressive cycles, which mark the base of the Coal Measures Group here. Each has a marine band at the base, overlain by beach and channel deposits, and terminated by a seat earth and coal representing emergent conditions (Williams, 1966, 1968). The lowest of these marine bands can be correlated with the Subcrenatum Marine Band, but the remainder have only limited, brackish water fossil assemblages (see below). Nevertheless, they probably equate to the four marine bands recorded as M_1–M_4 in the main part of the South Wales Coalfield by Leitch *et al.,* (1958) (the M_5 Marine Band recognized by Leitch *et al.* does not occur at Tenby, but has been found in the Broadhaven section on the west coast of Pembrokeshire (Jenkins, 1962)).

This basal Coal Measures interval has a number of distinctive features. The Subcrenatum Marine Band is thicker here (15 m) than in any other parts of the South Wales Coalfield, and consists of a number of discrete layers. This would appear to agree with the model proposed by Bloxham and Thomas (1969), whereby this marine band was generated by a marine transgression originating from the west or south-west.

Between the Subcrenatum and M_1 marine bands is an interval of arenaceous deposits with spectacular slump structures (Kuenen, 1948; Williams, 1969). Williams argued that they were caused by the movement of partially consolidated sediment down a south-sloping palaeoslope, confirming palaeogeographical conclusions drawn elsewhere in the South Wales Coalfield (Bluck, 1961).

Above the M_3 Marine Band is a conglomerate with re-worked, silicified, coral fragments (Leach, 1933; Dix, 1942), known as the Monkstone Grit. Owen (*in* Nevin, 1961) compared it with the Clay-Gall Sandstone of the Leinster, Slieveardagh and Crataloe coalfields in Ireland, which contains similar coral fragments. Owen argued that both deposits were probably derived from a landmass to the south.

The top 200 m of the section consist predominantly of fluvial channel and floodbasin lake sediments. At the base is a thick, presumably channel sandstone unit with an erosive base, that forms the prominent Monkstone Point. Jenkins (1962) suggested that it is equivalent to the Farewell Rock further east, but this is unlikely in view of its stratigraphical position. Within this top part of the sequence are a number of thin coals and/or seat earths, including the Stammers Seams which was worked at one time at Saundersfoot.

Biostratigraphy

Marine bands

The lowest marine fossils are present in nodular limestones found near Barrel-post Rock (De la Beche 1846; Bisat, 1933). There has been disagreement concerning their biostratigraphical position, but it is now thought that they are of the *Homoceras beyrichianum* Zone, indicating the upper Chokierian.

Towards the top of the Bishopston Formation is a marine band which appears to correlate with the Anthracoceratites Marine Band on the north crop of the South Wales Coalfield. This level may thus be provisionally regarded as the Marsdenian–Yeadonian boundary in this sequence.

Within the Upper Sandstone Formation are three marine bands. From the lowest, Jones (1969) reported *Cancelloceras cancellatum* (Bisat) and *Agastrioceras carinatum* (Frech), clearly indicating the lower Yeadonian, whilst the upper one yielded *Cancelloceras cumbriense* (Bisat), indicating the upper Yeadonian. The middle band has so far only yielded the bivalves *Sanguinolites* and *Edmondia.*

Above the Upper Sandstone Formation is a sequence of five marine bands, but only the lowest has yielded a biostratigraphically diagnostic assemblage, indicating the Subcrenatum Marine Band. This thus marks the Yeadonian–Langsettian (Namurian–Westphalian) boundary. The remaining four have only yielded *Lingula, Orbiculoidea,* fish fragments and annelid tracks (Jenkins, 1962; Williams, 1966, 1968) and thus represent brackish, rather than fully marine, conditions. Nevertheless, it is generally agreed that they equate to the M_1–M_4 marine bands recognized by Leitch *et al.* (1958) in the main part of the South Wales Coalfield.

Non-marine bivalves

Eagar *in* Jones (1969) described a suite of bivalves from an interval within the Bishopston Formation known as the Gasker Rock Shell Bed. They appear to belong to the *Carbonicola ornata* Trueman–*Carbonicola deansi* Eagar group of species. Eagar noted that if correctly identified, this is the oldest known occurrence of this type of assemblage, which usually occurs in the topmost Marsdenian.

Nine horizons within the Coal Measures here have yielded non-marine bivalves. They are designated horizons 14–22 by Jenkins (1962) and although it is a little awkward (numerical order does not reflect stratigraphical order) this scheme is still used today. The lowest three beds occur in that part of the sequence also containing the marine bands. The lowest (Bed 20) yielded *Curvirimula* sp., which is more characteristic of brackish than fully non-marine conditions (Trueman and Weir, 1960). Beds 21 and 22 have yielded more typical non-marine assemblages, the former yielding *Carbonicola* cf. *extenuata* Eagar and C aff. *fallax* Wright, and the latter rare examples of *C. lenisulcata* (Trueman). These appear to belong to the *C. fallax*–*C. protea* Subzone (lower *C. lenisulcata* Zone), and are the only evidence of this subzone reported so far from the South Wales Coalfield.

The bivalves from the next highest three beds (17–19) have been described by Jenkins (1960). The identifications made by Jenkins suggest that they belong to the *C. fallax–C. protea* Subzone. However, Eagar (1964) points out that the Bed 19 assemblage is typical of the *Carbonicola pontifex* Eagar group, which suggests a rather higher stratigraphical position, in the *Carbonicola proxima* Subzone. Furthermore, the drawings of shells from Bed 18 (Jenkins, 1960, text figs 3F–L) invite a comparison with *Carbonicola extima* Eagar (1964, textfigs 3A–K), which are small shells found frequently in the C. *proxima* Subzone. The Bed 17 assemblage (Jenkins, 1960, text fig. 2) is also similar to the *C. proxima* Subzone, such as described by Eagar (1962, text fig. 9). The evidence from Tenby–Saundersfoot is therefore in general agreement with observations made in the Pennines (Calver, 1969a), that non-marine bivalves from just above the Listeri Marine Band usually belong to the *C. proxima* Subzone.

There are no published descriptions or illustrations of the fossils from the upper three beds (14–16). However, identifications given by Jenkins (1962) suggest that they include *Carbonicola extenuata* Eagar, which is consistent with them belonging to the *C. proxima* Subzone.

In similar stratigraphical intervals in the main part of the South Wales Coalfield, Leitch *et al.* (1958) recognized only two horizons yielding non-marine bivalves, which they designated C_1 and C_2. They are presumably equivalent to two of the horizons designated beds 14–19, but at present it is impossible to give a detailed correlation.

Plant macrofossils

Plant macrofossils are known from four horizons here, all in the Coal Measures (Goode, 1913; Kidston, 1923–1925; Dix, 1933, 1934). The best known are the two Monkstone Point Plant Beds, one of which underlies the M_1 Marine Band and the other overlies a thin coal between the M_3 and M_4 marine bands. They both yield essentially similar assemblages, including *Neuralethopteris jongmansii* Laveine, *Alethopteris uropbylla* (Brongniart) Goppert, *Karinopteris acuta* (Brongniart) Boersma and *Sphenophyllum cuneifolium* Sternberg. The presence of *N jongmansii is* of particular biostratigraphical significance, since it is normally restricted to the lower *Lyginopteris hoeninghausii* Zone (Laveine, 1967). Both in stratigraphical position and species composition, the lower of these two plant beds bears a striking similarity to the Plant Bed C at Nant Llech (see below).

A third bed yielding plants fossils occurs between Monkstone Point and Swallowtrees. Kidston (1923a, 1923b, 1925) recorded a number of species from here, but only one (*Adiantites* sp.) was described and illustrated.

The fourth and stratigraphically highest of the plant beds in this section outcrops 200 m south of Saundersfoot Harbour. Kidston (1923d) and Dix (1934) recorded from here *Lyginopteris hoeninghausii* (Brongniart) Gothan, *Karinopteris acuta* (Brongniart) Boersma, *Palmatopteris furcata* (Brongniart) Potonié and *Sphenophyllum cuneifolium* Sternberg. The assemblage is fully consistent with the *L. hoeninghausii* Zone, but as yet no species have been found which indicate the lower or upper parts of the zone.

Interpretation

This is the best available exposure of the Millstone Grit and lower Coal Measures at the western end of the south crop of the South Wales Coalfield. There are outcrops of a similar succession along the Cleddau (Jenkins, 1962), but exposure is on the whole very poor.

The Millstone Grit here is most similar to the south crop succession in the Gower, such as at Barland Common (see below). In neither section, is there a clearly defined Basal Grit Formation, as seen on the north crop, and most of the Millstone Grit is assigned to a single unit, the Bishopston Formation. The marine faunas are also very similar in both areas, belonging to the 'Goniatite–Pectinoid Biofacies' of Ramsbottom (1969b). There are nevertheless important differences between the Pembrokeshire and Gower successions. In particular, there is a higher proportion of sandstones in Pembrokeshire, resulting from coastal barrier bars and fluvial deltas, which indicates a position nearer the basin margin (Kelling, 1974).

The Coal Measures here can also be compared closely with the south crop near Swansea. The best documented succession in the latter area is in the Margam No. 1 Borehole (Woodland, Archer and Evans, 1957), which only differs from the Pembrokeshire succession by the greater development of marine strata. Compared with the north crop successions, such as seen at the Nant Llech and Cwm Gwrelych–Nant Llyn Fach (see below), the Saundersfoot sequence is significantly thicker and has more non-marine bivalve beds. Even compared with the north crop exposures only a few kilometres to the north, such as the Amroth Coast (see below), the Saundersfoot succession is significantly thicker. Both the thickness of the succession and the more numerous non-marine bivalve horizons suggest that the south crop occupies a more central position in the depositional basin (also see the isopachyte maps by Leitch *et al.,* 1957, figs 6–7).

There are certain similarities between the Coal Measures of Saundersfoot and that of the small coalfields in south-east Ireland (e.g. Leinster, Slieveardagh). For instance, the Clay Gall Sandstone, immediately below the Listeri Marine Band at Leinster, can be compared with the Monkstone Grit near Tenby (Owen *in* Nevill, 1961). However, the sequences between the Subcrenatum and Listeri marine bands in the Irish coalfields are much reduced compared with the Tenby–Saundersfoot succession, and there is no evidence of the M_1, M_2 and M_4 marine bands.

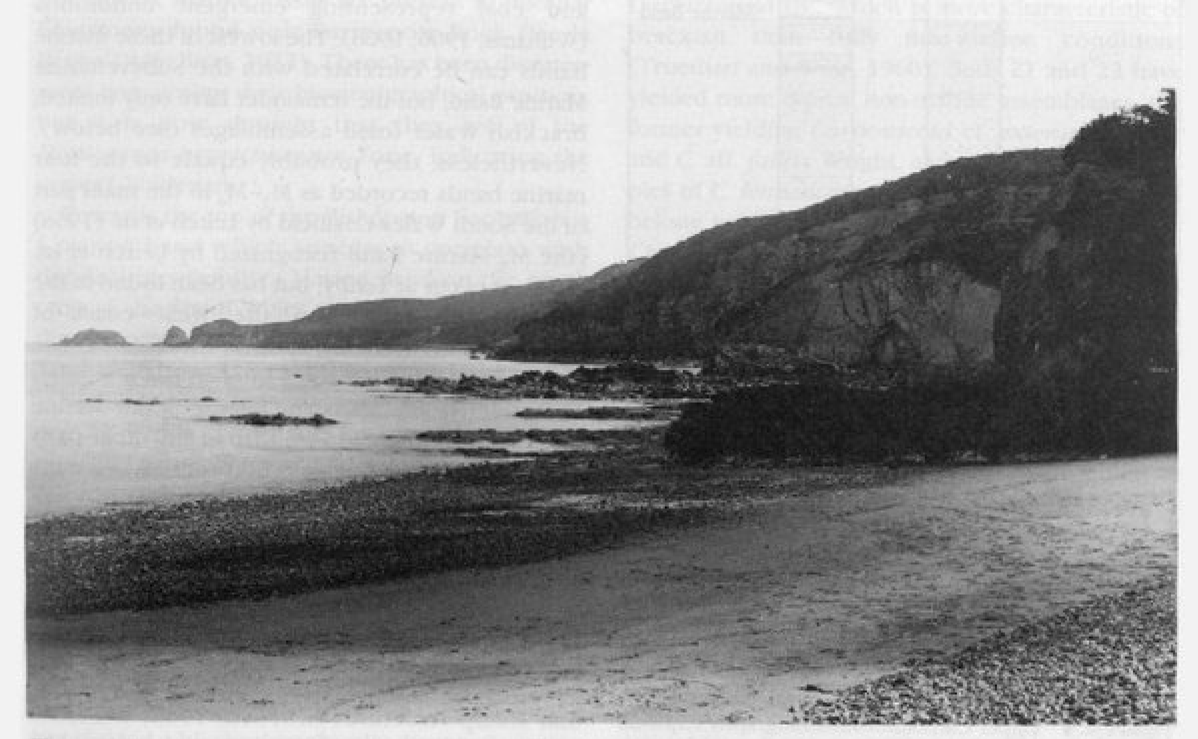
The presence of slumped beds above the Subcrenatum Marine Band may have a tectonic significance. On the north crop, the Farewell Rock occurs at the same position in the sequence, and this extensive sandstone body presumably resulted from uplift of the hinterland allowing increased erosion. It is likely that earth movements associated with this uplift were responsible for the slumping of sediment near Saundersfoot.

The sequence offers one of the most complete records of lower Langsettian non-marine bivalve fossils outside of the Pennines coalfields. Based mainly on Eagar's (1956) work on the latter areas, Ramsbottom *et al.* (1978, pl. 1) subdivide the *C. lenisulcata* Zone into three subzones (or 'faunal belts'): in ascending order, *C. fallax–C. protea, C. extenuata* and *C. proxima.* The evidence from Saundersfoot does not support this view, however, as there is a complete overlap in the stratigraphical ranges of the *Carbonicola extenuata* and *C. proxima* assemblages. This is in general agreement with observations made in Belgium (Pastiels, 1960), and appears to support the original view of Calver (1956), that the *C. lenisulcata* Zone is divisible into just two subzones (or telts'): *C. protea–C. fallax* and *C. proxima.*

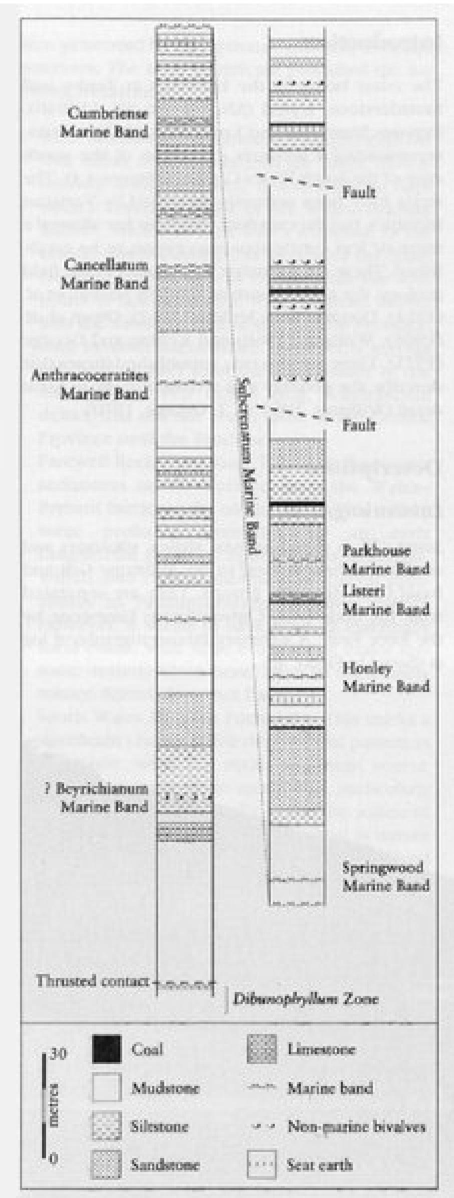
Conclusions

This is one of the best exposures of rocks known as Millstone Grit and basal Coal Measures in the western part of the South Wales Coalfield (Figure 4.6). There are abundant fossils, including the remains of marine animals such as ammonoids, non-marine bivalves, and plants, which allow detailed correlations to be made with other sequences of this age in Europe. The Coal Measures non-marine bivalve faunas are particularly rich here, and are only better developed in Europe in the Pennines Coalfield. The rocks here represent deposits laid down about 312–320 million years ago, in and adjacent to a river delta. Compared with many of the sequences of this age in South Wales, the Millstone Grit here has significantly less sandstone, suggesting that it was deposited further away from the main delta, which supplied the sands. The best comparison is with successions in the Gower, which also are relatively poor in sandstones, but which are mostly very poorly exposed. Also of interest here is the presence of well devel oped slump-structures in some of the rocks, suggesting that some seismic movement distrurbed the sediment shortly after it was laid down. The combination of features visible in the rocks exposed along the Tenby–Saundersfoot coast makes them of considerable significance for understanding the evolution of this part of Britain during the Late Carboniferous.

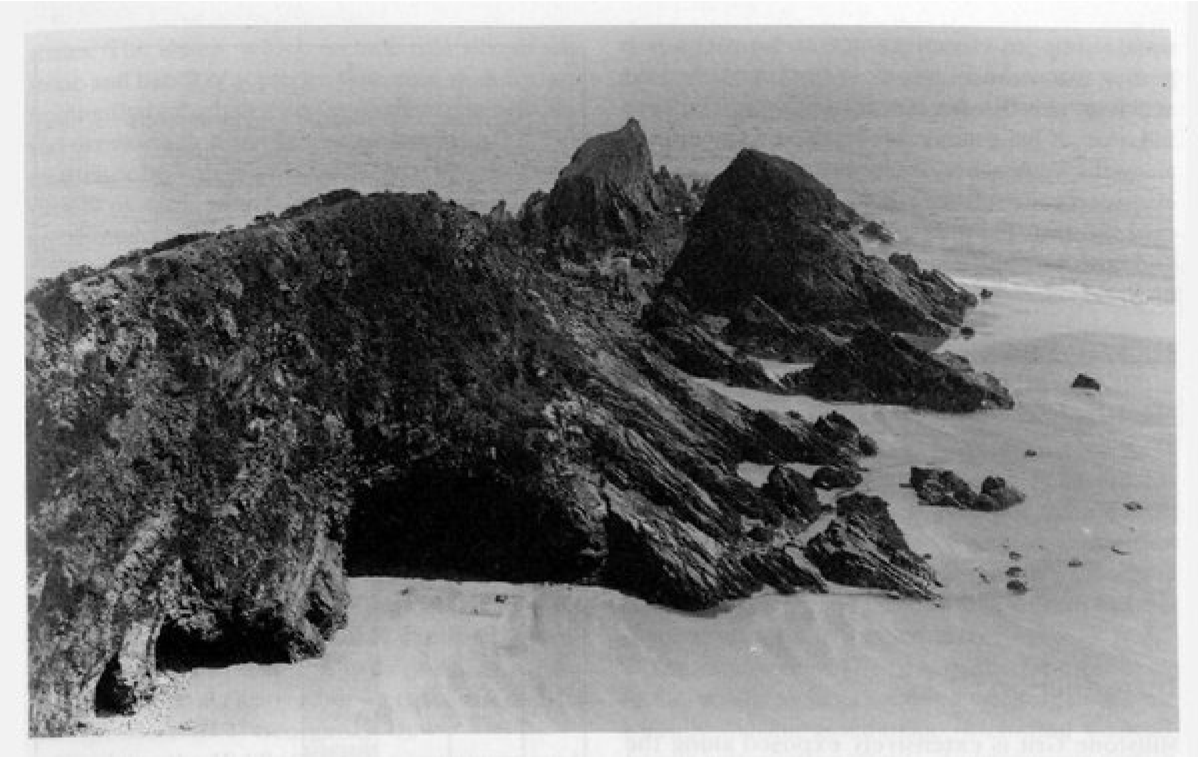
References



(Figure 4.4) Coast between Saundersfoot and Monkstone Point, Tenby–Saundersfoot Coast GCR site. Reproduced by permission of the Director, British Geological Survey: NERC copyright reserved (A333).



(Figure 4.5) Upper Carboniferous stratigraphy exposed along the Tenby–Saundersfoot coast. Based on Jones (1974, fig. 25) and Jenkins (1962, p1. 5).



(Figure 4.6) Monkstone Point, Tenby–Saundersfoot Coast GCR site. Reproduced by permission of the Director, British Geological Survey: NERC copyright reserved (A339).