Lavernock to Penarth, near Cardiff, South Glamorgan

[ST 175 673]–[ST 190 702]

Introduction

The coastline between Lavernock Point and Penarth exposes one of the best sections of Rhaetian sediments in South Wales. The cliffs at Penarth, Lavernock Point and St Mary's Well Bay form the composite type section for the Penarth Group, and its constituents, the Westbury and the Lilstock formations, and hence this is one of the most stratigraphically important localities in the country. This area has also yielded many fossils from its famous bone bed.

The Upper Triassic sediments of South Wales have been studied for many years, the first brief description being by De La Beche (1846), and the first fuller account by Etheridge (1872). Since then, many accounts of the geology and palaeontology of this region of South Wales have been produced, for example Howard (1894), Strahan and Cantrill (1902), Richardson (1905), Ivimey-Cook (1974), Tucker (1977, 1978), Waters and Lawrence (1987), Hodges (1994), and Warrington and Ivimey-Cook (1995). Detailed studies of the isotopic composition of many of the lithologies have provided insights into the palaeoenvironments and geochemistry of the sediments (Leslie *et al.,* 1992). The fossils have been recorded by Etheridge (1872), Woodward (1888), Storrie (1883, 1895), Orbell (1973), Storrs (1993, 1994), and Dineley and Metcalf (1999), list fishes from this site.

Description

Sedimentology

The sea cliffs between Lavernock and Penarth expose some 16 m of sediments at the top of the Mercia Mudstone Group (Tucker, 1978; Warrington *et al.,* 1980; Waters and Lawrence, 1987), together with the Westbury and Lilstock formations of the Penarth Group and the Jurassic Lower Lias (Figure 4.6). The beds are folded in low amplitude folds with some faulting (Figure 4.6) and (Figure 4.7)a. The lowest Mercia Mudstone Group beds seen consist largely of reddish or brownish, hard, silty mudstones with sporadic greenish patches and beds, some of which are laterally continuous, although it has not been possible to use them for local or regional correlation. The mudstones are often calcareous and dolomitic and there is little evidence of sedimentary structures. Units range in thickness from 0.5 to 3.0 m, with blocky mudstones at the base, becoming more fissile towards the top (Ivimey-Cook, 1974; Waters and Lawrence, 1987).

The Mercia Mudstone Group sediments in this area characteristically have more calcite and dolomite than comparable localities in southwestern England. This has been attributed to the close proximity of an abundant source rock, the Carboniferous Limestone (Allcattan, 1976). Sulphate minerals are also common, for example gypsum and alabaster (Tucker, 1978). Several layers of gypsum nodules, each with an average thickness of 0.5 m, have been recorded within the red-brown Mercia Mudstone Group near Penarth (Tucker, 1978; Waters and Lawrence, 1987). Near Penarth, the gypsum nodules were once quarried for 'Penarth alabaster' (Ivimey-Cook, 1974).

The overlying Blue Anchor Formation follows the red mudstones above a disconformity that is characterized by a change in colour of the sediments from red to green and by the appearance of well-developed bedding. At Lavernock Point the junction is further highlighted by a green mudstone that contains abundant gypsum nodules (Waters and Lawrence, 1987).

The Blue Anchor Formation is best exposed to the north of Lavernock Point [ST 187 682]; (Figure 4.7)a and (Figure 4.8)), and this section is characteristic of localities in the area. The sediments comprise fine-grained mudstones with some beds of limestone and dolomite, especially near the top of the formation, and thin beds of intraformational breccia (Waters and Lawrence, 1987). The mudstones are often bedded; some silt-laminated mudstones display well-developed desiccation cracks, and may be blocky, fissile or massive. The massive mudstones often have a conchoidal fracture caused by a high proportion of calcite and/or dolomite cement. The colour of the lithologies changes through the section, from dark green and greenish-yellow at the base, though a series of pinkish-red and green beds (the 'pink band' of Strahan and Cantrill, 1902), approximately 7 m from the base of the formation, to greyish-green and dark grey units at the top (Waters and Lawrence, 1987).

Gypsum is common in six units through the Mercia Mudstone Group, and takes the form of large nodules (0.2 m in diameter) and thin veins of satin spar. However, the nodules are rarely seen in outcrop: after dissolution, cavities remain that have occasionally been infilled with calcite.

The succeeding Penarth Group comprises the dark grey argillaceous facies of the Westbury Formation, followed by the dominantly argillaceous Cotham Member, which is overlain by porcellanous limestone and mudstones of the Langport Member (Waters and Lawrence, 1987). The junction between the Blue Anchor Formation and the Westbury Formation is an erosion surface. The top bed of the Blue Anchor Formation is seen on the foreshore slightly to the north of Lavernock Point [ST 188 681]; here the eroded upper surface displays well-developed U-shaped burrows and cracks that are often infilled with mudstone, quartz grains and sporadic fish remains (Mayall, 1981; Waters and Lawrence, 1987).

At Lavernock Point the Westbury Formation (Figure 4.7)b has a thickness of *c.* 6.6 m (Warrington and Ivimey-Cook, 1995). A regionally important but laterally impersistent bone-bearing facies is seen within the basal metre of the formation. The basal beds at Lavernock consist of limestones and shales (Sykes, 1977) with abundant *Liostrea bristovi,* the presence of which has earned these beds the informal name, the '*bristovi* limestones' (Ivimey-Cook, 1974; Waters and Lawrence, 1987). These are overlain by a bone bed, the 'fish bed' of Storrie (1883), although Sykes (1977) also records the presence of vertebrate fossils in the sediments immediately overlying the Blue Anchor Formation contact (see below). The bone bed is composed of a coarse-grained, sandy conglomerate that often infills scours or channels in the top of the '*bristovi* limestone' (Storrie, 1883).

The Westbury Formation includes six sedimentary cycles (Ivimey-Cook, 1974; Waters and Lawrence, 1987). The cycles commence with fine-grained sandstone or silty limestone and fine upwards into shales with horizons with abundant bivalve fossils. In the lower part of the cycles the bivalve assemblage is rich and varied, while in the upper sections it is more restricted. The tops of the cycles are marked either by an erosion surface or by a transition from shale through silty shale to the sandstone or silty limestone of the overlying cycle.

The following section of the Westbury Formation was measured at Lavernock Point [ST 188 682] by Sykes (1977):

	Thickness (m)
Penarth Group: *Westbury Formation:*	
Shale, grey near the top	1.7
Limestone with fibrous calcite layers	0.05
Black shale	0.5
Limestone with fibrous calcite layer	0.012
Black shale	*c.* 1.2
Limestone	0.1
Black shale	1.3
Bone bed with shaly partings:	0.165
(e) black shale with impure limestone at the top	0.025
(d) black shale with light scattered bone bed and trace bone bed in patches	0.02
(c) sandy limestone, upper part contains coarse and fine quartz, vertebrate fossils and coprolites. Lower part is compact, with a shelly fauna and rare vertebrate fossils	0.065
(b) dark grey, impure limestone	0.015
(a) cemented and pyritic mudstone, with scattered coarse grains and vertebrate fossils	0.04
Black shale	0.075

Limestone, arenaceous, with isolated quartz grains, vertebrate fossils and bivalves	up to 0.025
Black shale, with scattered patches of trace bone bed	1.0

The Lilstock Formation (Penarth Group) is best seen in the cliffs at Lavernock Point and at nearby St. Mary's Well Bay; this formation is also exposed at Penarth, but is not easily accessible there. At Lavernock, the Cotham Member is dominated by pale grey, calcareous and silty mudstones; the lower beds of the member often contain well-developed wavy and lenticular beds, many of which exhibit ripples (Ivimey-Cook, 1974). The member is divided into two by a desiccation horizon. The cracks are often seen to extend down into the Westbury Formation and are up to 0.08 m wide. When viewed from above the cracks form polygons up to 0.90 m across. At Lavernock Point this feature occurs at the top of a greyish-green mudstone with synsedimentary deformation structures (Waters and Lawrence, 1987).

The unit overlying the desiccation horizon comprises blue-grey sandy oolitic sediments that weather to a pale brown or buff; it contains well-developed cross-laminations and planar laminations, and the upper surface preserves straight-crested ripples. This bed has a maximum thickness of 0.26 m, but is generally only a few centimetres thick. It is overlain by fine-grained sandstones, siltstones and mudstones, many showing lenticular and wavy bedding. These sediments grade upwards into micritic limestones (Waters and Lawrence, 1987).

The boundary with the overlying Langport Member is regionally variable, and includes examples of gradational and sharp contacts. The basal part of the Langport Member consists of thin, pale greenish-grey, porcellaneous limestones interbedded with shaly mudstones, and some coarser-grained, shell-rich limestones (Swift, 1995). This unit is no more than 0.35 m thick, and is best seen as a ridge on the foreshore. These beds were formerly called the 'Langport Beds' or the 'White Lias' by, for example, Richardson (1905, 1911).

The remainder of the Langport Member comprises about 2.2 m of calcareous mudstones with laterally impersistent developments of fine sandstone, siltstone and shelly limestone (Swift, 1995), which had been correlated with similar beds in the Watchet area that are now included in the Lias Group (Whittaker, 1978). These beds display a range of sedimentary structures and lithological textures, including planar bedding, cross-laminations, lenticular beds, massive blocky sediments, nodules, and *Chondrites* burrows (Waters and Lawrence, 1987).

Palaeontology

The Blue Anchor Formation has yielded several taxa, including trace fossils thought to represent the remains of burrows. Sporadic vertebrate fossils, including fishes (for example, *Acrodus, Birgeria, Ceratodus* (rare), *Dalatias, Hybodus, Lissodus, Saurichthys,* and *Nemacanthus monilifer*), reptiles and possibly amphibians have been recovered from some of the intraformational breccia units, especially towards the top of the formation (Storrie, 1895; Ivimey-Cook, 1974; Waters and Lawrence, 1987; Storrs, 1994). Plesiosaur remains were also discovered at the Penarth cement works (Howard, 1894), and a mammalian tooth crown identified by Etheridge (1872) as *Microlestes antiquus* was recovered from the Westbury Formation near Penarth (Storrs, 1993). Microfossils, including miospores such as *Gliscopollis meyeriana, Ricciisporites tuberculatus* and *Vesicaspora fuscus,* and organic-walled microplankton such as acritarchs and dinoflagellate cysts, are also known from the Blue Anchor Formation (Orbell, 1973; Warrington in Waters and Lawrence, 1987).

The overlying Westbury Formation has yielded many macrofossils characteristic of marine environments. Invertebrate taxa from the Westbury Formation include bivalves, foraminifera, ostracods, the inarticulate brachiopod *Orbiculoidea,* echinoid fragments, ophiuroids and cirripedes, all indicative of shallow marine conditions (Waters and Lawrence, 1987). At the base of the Westbury Formation, the presence of the marine bivalve *Liostrea bristovi* may indicate a correlation with the Williton Member of the Blue Anchor Formation in Somerset (Mayall, 1981; Waters and Lawrence, 1987). Palynomorphs are also present (Orbell, 1973; Warrington in Waters and Lawrence, 1987), and include terrestrial miospores and marine organic-walled plankton dominated by *Rhaetogonyaulax rhaetica.*

The Lilstock Formation contains several faunal assemblages, each associated with distinct palaeoenvironmental conditions. Bivalves, such as *Dimyopsis, Liostrea* and *Modiolus* and, rarely, *Plicatula* and *Tutcheria,* are known from these lithologies. The Langport Member has yielded a few miospores, as well as foraminifera and ostra-cods. Many of the taxa seen in the upper parts of this member are species more commonly associated with the Lias Group (Waters and Lawrence, 1987; Swift, 1995).

Interpretation

The red Mercia Mudstone Group sediments are characteristic of deposition in and around a large hypersaline water body in open connection with the sea (see Chapter 3). The overlying Blue Anchor Formation here indicates deposition in marginal environments close to a saline water body. The desiccation cracks and evaporitic minerals indicate that the lake level fluctuated, often exposing large areas of the lake floor to subaerial processes (Waters and Lawrence, 1987). Palaeontological and geochemical evidence from the Blue Anchor Formation suggests a change in climatic conditions from arid to more humid, which allowed the colonization of large areas of the land by an increasingly diverse flora (Mayall, 1981; Waters and Lawrence, 1987). At Lavernock Point, the sporadic organic-walled plankton in the uppermost beds of the Blue Anchor Formation indicate the beginnings of the marine influence seen in the overlying Penarth Group (Orbell, 1973; Waters and Lawrence, 1987).

The cyclical sedimentation of the Westbury Formation has been interpreted as an alternation of occasional periods of higher-energy conditions (for example turbulence in the water column) producing the coarser-grained beds, followed by a return to the low-energy regime typical of the Westbury Formation (Ivimey-Cook, 1974), characteristic of open water marine or marginal marine conditions (Hamilton and Whittaker, 1977; Whittaker and Green, 1983; MacQuaker *et al,* 1985; MacQuaker, 1994). The '*bristovi* limestones' at the base of the Westbury Formation were deposited under relatively short-lived, but widespread semi-marine conditions (Waters and Lawrence, 1987). The bone bed was deposited as a transgressive lag, probably on a migrating shoreline (MacQuaker, 1994).

The Cotham Member includes restricted marine beds near the base, followed by sediments indicative of freshwater lagoonal conditions (Mayall, 1983). The lenticular beds, ripples, and desiccation cracks show that the lagoon waters were generally shallow, and that the lagoons periodically dried up.

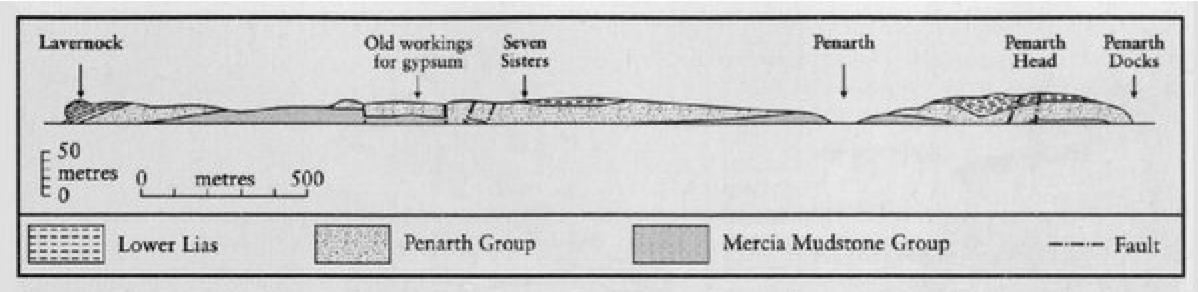
The overlying porcellanous limestones, shelly limestones, thin sandstones and siltstones of the Langport Member were deposited under lagoonal and marine conditions. The sediments and fossils of the lower part of the Langport Member indicate marine flooding of the Cotham Member lagoons: the fauna is characteristic of shallow sub-tidal environments and the thin shelly limestones were deposited under storm conditions (Whittaker and Green, 1983; Waters and Lawrence, 1987; Swift, 1995). The overlying pale grey calcareous siltstones have been interpreted as offshore marine deposits, probably deposited in a shallow sea, with coarser sandstones and limestones representing episodic storm events.

The changing palynological diversity within the Penarth Group reflects changing palaeoenvironmental conditions. Generally, species diversity increases upwards through the Westbury Formation and the Cotham Member, but declines in the younger beds. This pattern reflects the colonization by plants of large areas of land during the deposition of the Westbury Formation beds, and the subsequent development of a more restricted, low-diversity assemblage associated with inundation of land during the Late Triassic marine transgression (Waters and Lawrence, 1987).

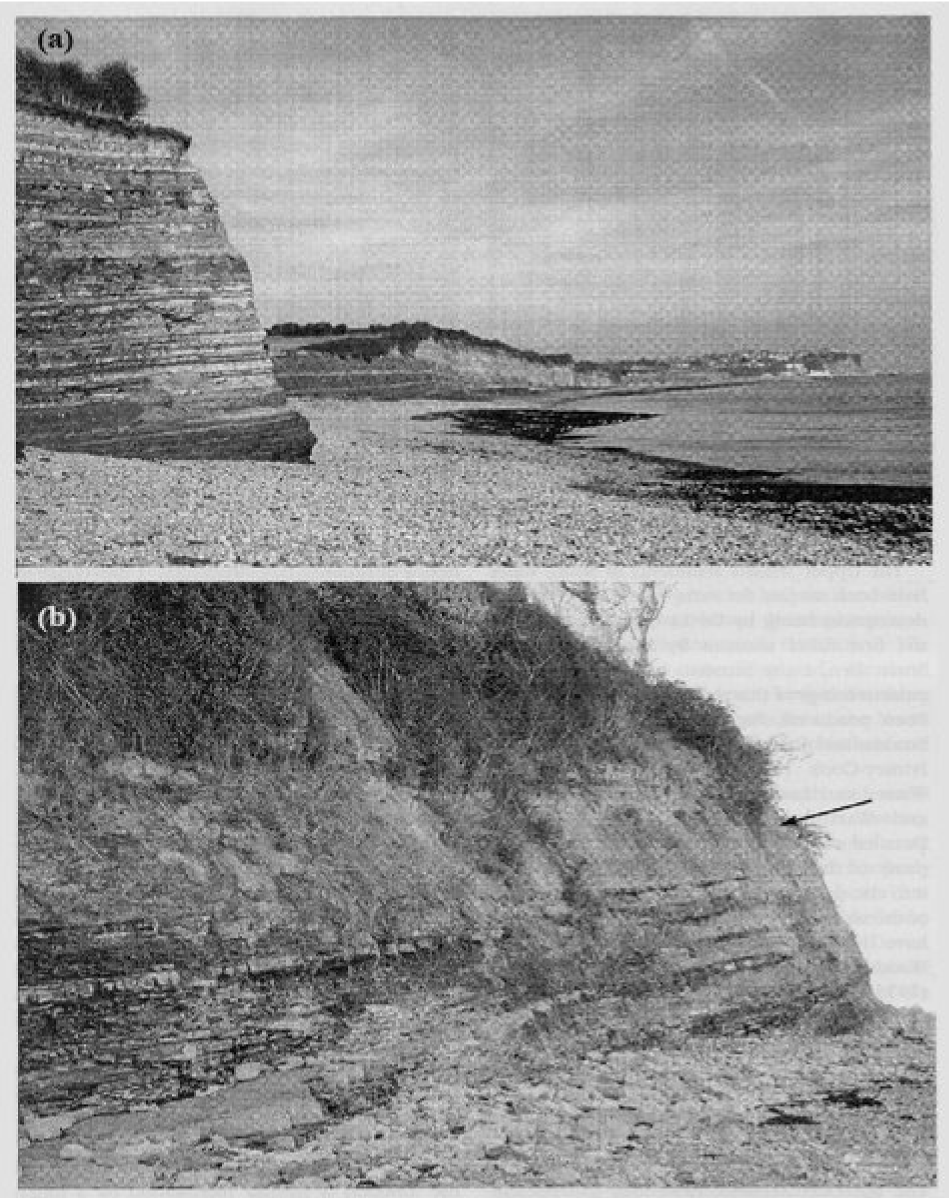
Conclusions

The sea cliffs between Lavernock Point and Penarth expose an excellent section of Upper Triassic rocks comprising the Mercia Mudstone Group (including the Blue Anchor Formation) and the Penarth Group (the Westbury Formation and the Cotham and Langport Members of the Lilstock Formation). This sequence reflects the transition from a terrestrial, arid, playa environment to fully marine conditions following the Late Triassic transgression. Along with St Mary's Well Bay, Penarth and Lavernock Point form the composite type locality for the Rhaetian Penarth Group (Warrington *et al.,* 1980), making this one of the most important stratigraphical sites in the country.

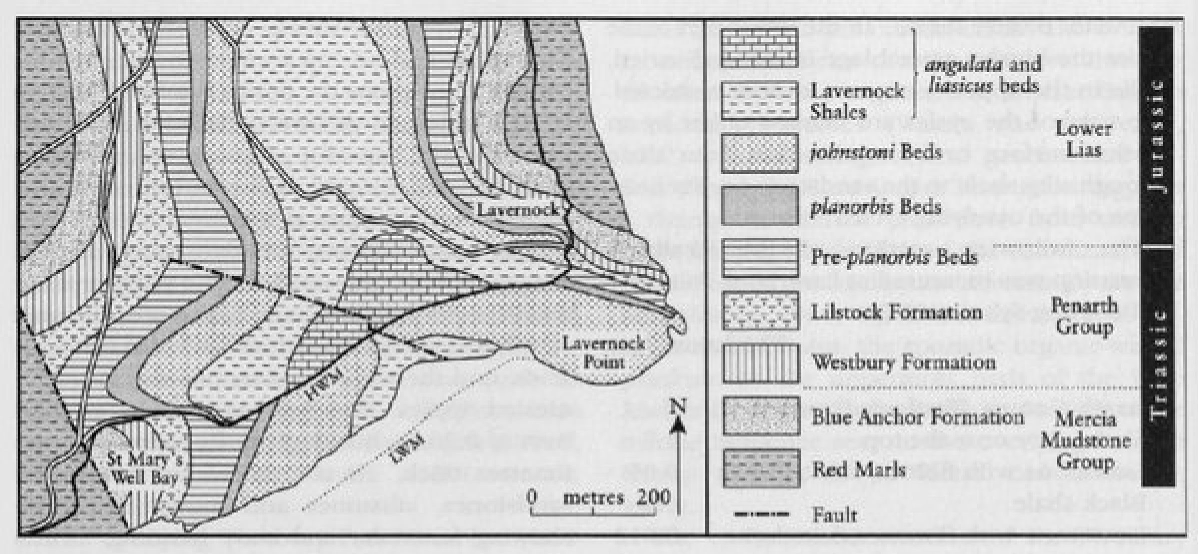
[References](#)



(Figure 4.6) Section of the cliffs from Lavernock to Penarth, showing the occurrence of the Mercia Mudstone, Penarth, and Lias groups. (After Woodward, 1888.)



(Figure 4.7) The Penarth Group, and underlying Mercia Mudstone Group, at Lavernock Point. (a) Overview of the cliffs and foreshore. The nearest face shows the Blue Anchor Formation of the Mercia Mudstone Group underlain by typical 'red beds' of the same group exposed in the core of a low anticline in the middle distance. To the north of this structure, the Penarth Group and lower beds of the overlying Lias Group occur in a shallow syncline. The town of Penarth is in the background to the right. (B) Cyclic units of sandstones, silty grey limestones and dark grey shales of the Westbury Formation, overlain by paler beds of the Lilstock Formation (arrowed). (Photos: Andrew Swift.)



(Figure 4.8) Geological map of the Lavernock–St Mary's Well Bay district, showing the Mercia Mudstone Group, Penarth Group, and Lower Lias sediments. (After Trueman, 1920.)