St Audries Bay, near Watchet, Somerset

[ST 907 433]–[ST 112 432]

Introduction

St Audries Bay includes a candidate Global Stratotype Section and Point (GSSP) for the base of the Jurassic System. This coast section also includes the type locality for the ammonite *Psiloceras planorbis,* the index fossil of the *planorbis* Zone, the basal unit of the Hettangian Stage, and hence of the Jurassic System (Warrington *et al.,* 1994; Warrington and Ivimey-Cook, 1995).

The St Audries Bay section has been described by many authors, including Richardson (1911), Warrington (1974b), Hamilton and Whittaker (1977), Sykes (1977), Mayall (1979, 1981, 1983), Whittaker and Green (1983), MacQuaker (1984, 1994), Warrington and Whittaker (1984), Leslie *et al.* (1993), Talbot *et al.* (1994), Warrington *et al.* (1994), and Swift (1995). The proposal that a site in this area should be the global standard for the base of the Jurassic System was discussed by George *et al.* (1969), Morton (1971), Warrington *et al.* (1994), and Warrington and Ivimey-Cook (1990, 1995). Briden and Daniels (1999) presented a magnetostratigraphical record of the Mercia Mudstone Group part of the section.

Description

The cliffs at St Audries Bay (Figure 4.21), 5 km east of Watchet, expose the upper Mercia Mudstone Group, the Penarth Group and Lower Lias deposits including the *Pre planorbis* Beds, and overlying Lower Jurassic rocks of Hettangian and Sinemurian age. The beds dip to the southwest, so progressively younger units are exposed from east to west. The Penarth Group occurs in the cliffs in the western side of the bay and crops out on the foreshore. The unstable nature of the cliffs means that the 'fresh' exposures of the section are continually produced by natural erosive processes. St Audries Bay forms part of the extensive Blue Anchor to Lilstock Coast Site of Special Scientific Interest (SSSI).

Sedimentology

The Mercia Mudstone Group exposed here comprises red and green mudstones (*c.* 67 m seen) succeeded by the overlying Blue Anchor Formation (*c.* 37 m thick); the beds dip to the south-west and are affected by small faults (Leslie *et al.,* 1993).

The Blue Anchor Formation is divided into the Rydon and Williton members (Mayan, 1981). The 34 m-thick Rydon Member (approximately equivalent to the 'Tea Green Marls' and 'Grey Marls' of the former terminology) is characterized by grey, black, green and occasional red-brown, dolomitic mudstones and dolomites. The more resistant dolomites often form prominent bands, especially in the upper sections of the member. The beds also contain gypsum crystals; these comonly dissolve out, forming cavities or collapse breccias (Mayan., 1981). The thin Williton Member (formerly named the 'Sully Beds'), rests disconformably on the Rydon Member, above an erosion surface penetrated by *Diplocraterion* burrows. The Williton Member consists predominantly of grey shales with flaser and lenticular beds of fine sandstone and silt.

The Westbury Formation comprises alternations of thinly laminated black shales with occasional thin limestones. The Lilstock Formation is composed of mudstones, limestones and marls with rare sandstones that comprise the Cotham Member. Some Cotham Member sediments bear deep cracks on upper surfaces. The upper parts of the formation are the Langport Member.

The following detailed composite description is taken from Whittaker and Green (1983, pp. 47–58), measured west of St. Audries Slip [ST 1032 4327]:

	Thickness (m)
Penarth Group	
Lilstock Formation: Langport Member:	
Mudstone, grey, with a green tint and with impersistent limestones	0.34
Limestones, brownish-grey, fine-grained, hard and splintery and divisible into four beds. The top is somewhat irregular. The lowest bed is composed of rubbly limestone and has an irregular base	0.3–0.33
Mudstone, greenish-grey, marly, silty and blocky. More fissile in the lowest 0.10 m	0.30–0.33
Limestone, pale grey, silty, with calcite stringers; fairly regular and uniform laterally	0.09–0.10
Mudstone, grey, marly, rather blocky	0.05–0.06
Limestone, grey, hard, splintery, with scattered pyrite. Locally in two (0.05 m thick) beds separated by a mudstone parting	0.10
Mudstone, dark grey, manly and rather shaly	0.06
Limestone, grey, hard, very fine-grained, almost porcellanous; laminated and with vertical calcite stringers	0.10–0.15
Marl, grey	0.03
Limestone, pale grey, fine-grained, porcellanous, splintery, with a conchoidal fracture. Not everywhere present	0–0.05
Lilstock Formation: Cotham Member:	
Shale, greenish-grey, laminated, fairly blocky in the top 0.08 m	0.38–0.46
Sandstone, greenish-grey. Small cavities are present in a band 0.05 m below the top; the bed is laminated in the lowest 0.06 m	0.15–0.18
Marl, greenish-grey or green, fairly fissile	0.03
Sandstone, dark greenish-grey	0.03–0.04
Siltstone, greenish-grey, hard, marly. Contortions and slump structures are present in the top half; the bed is laminated below	0.20–0.28
Mudstone, green or olive-green; marly but fairly fissile in the top 0.15 m and the bottom 0.10 m	0.43
Siltstone or silty marl, hard, calcareous; somewhat laminated, with a lensoid parting character	0.15–0.19
Marl, pale green, rather fissile, with contorted harder beds in places	0.63
Westbury Formation:	
Shale, black	0.05
Shale, black: a lensoid band of intercalated green marl	0.03–0.05
Shale, black, with green marl wisps and partings	0.05–0.08
Marl, dark grey, silty, hard, calcareous	0.05–0.08
'Beef'	0.03–0.05
Shale, black	0.53–0.61
'Beef'	0.03–0.05
Limestone, very dark grey, earthy	0.03–0.05
'Beef'	0.03–0.08
Shale, black	0.91–0.97
'Beef'	0.05–0.08

Limestone, dark grey, earthy	0.08–0.10
Shale, black	0.03
Limestone, dark grey, earthy	0.13–0.20
'Beef'	0.03
Shale, black	seen 0.15
Mercia Mudstone Group	
Blue Anchor Formation: Williton Member:	
Predominantly of greyish and dark marls with occasional shales.	
Hard siltstones at the top	3.0
Blue Anchor Formation: Rydon Member ('Tea Green Marl'):	
Green marls	34.0
Undifferentiated mudstones:	
Red and green mudstones, with a few green siltstone beds seen	67.25

Palaeontology

The Blue Anchor Formation at St Audries Bay has yielded diverse fossils (Warrington and Whittaker, 1984; Warrington and Ivimey-Cook, 1992, 1995; Warrington *et al.,* 1994). Trace fossils, invertebrate body fossils, including fragmentary gastropods and remains of vertebrates such as the fishes *Gyrolepis, Hybodus* cf. *cloacinus,* '*Sphaerodus*', and '*Sargodon*'have been recorded from the upper beds in the formation (Warrington and Whittaker, 1984).

Dinoflagellate cysts occur sporadically in the uppermost metre of the Blue Anchor Formation (Warrington, 1974b). The palynomorph assemblage from the beds at the top of the Williton Member is one of the most diverse in the country from beds of this age, and includes miospores and organic-walled microplankton (Warrington, 1974b, 1981; Warrington and Whittaker, 1984; Warrington and Ivimey-Cook, 1995).

The Westbury Formation contains a diverse invertebrate and vertebrate faunal assemblage, including bivalves (*Chlamys, Protocardia, Rhaetavicula*), ophiuriods, scales and teeth of marine fishes (*Acrodus, Birgeria, Dalatias, Gyrolepis, Hybodus*)and marine reptiles (Warrington *et al.,* 1994; Warrington and Ivimey-Cook, 1995). The Penarth Group sediments have also yielded microfossils including dinoflagellate cysts, miospores, foraminifera and scolecodonts (Warrington, 1974b, 1981).

Interpretation

The sediments at St Audries Bay document changing palaeoenvironments, from terrestrial hypersaline lakes to marine conditions. The oldest beds, the fine-grained, red, calcareous and dolomitic sediments of the Mercia Mudstone Group, are thought to have been deposited in water on a low-lying plain that was probably close to sea level (Hamilton and Whittaker, 1977; Talbot *et al.,* 1994). Palaeomagnetic measurements on the Mercia Mudstone Group red beds (Briden and Daniels, 1999) supported a general assumption that these units are Norian in age.

The Blue Anchor Formation sediments represent terrestrial evaporitic lakes (Rydon Member of Mayall, 1981) and shallow marine environments (Williton Member of Mayall, 1981). Evidence for marine environments occurs at the top of the Blue Anchor Formation, where fossils such as dinoflagellate cysts, bivalves, trace fossils, and foraminifera indicate shallow marine conditions (Warrington *et al.,* 1994) of the Williton Member sea (Mayall, 1981).

Analysis of the clays (Mayan, 1979) has provided a more complete understanding of the depositional environments of the Triassic sediments at several localities, including St Audries Bay. The presence of corrensite in the Williton Member suggests that North Somerset was located at the edge of an evaporitic drainage basin. Sedimentary structures such as ripples and mudcracks, as well as evaporite minerals, appear to support this view. Changes in the clay mineralogy (the appearance of vermiculite and an increase in the relative abundance of illite-smectite) across the boundary between the Williton Member and the overlying Westbury Formation suggest that the boundary represents a minor hiatus (Mayan, 1979).

The Westbury Formation is characterized by alternating beds of shales and limestones, which might indicate fluctuations in the energy regime associated with changing sea level and storm activity, or fluctuations in seawater chemistry. MacQuaker's (1984) petrographical analysis of the sediments led him to conclude that the cyclicity was primary, with the fine-grained shales representing deposition under low-energy conditions. The limestones, with their high proportion of bioclastic material, were deposited under higher-energy conditions. From this, it is thought that the two sediment types were deposited on a shallow marine shelf that was prone to storm activity. During storms, sediment and shells from the sea floor were reworked, producing the coarser-grained sediment fraction (MacQuaker, 1984). The sediments also display the results of early-stage diagenetic activity, for example micrite, the production of cone-in-cone structures and the decalcification of some of the shell material.

The basal 0.36 m of the Westbury Formation at St Audries Bay was described by Sykes (1977) as a black shale, with minor bone beds distributed through the sediment. It is thought that the bone beds represent a phase of reworking associated with storm events and transgression (MacQuaker, 1994).

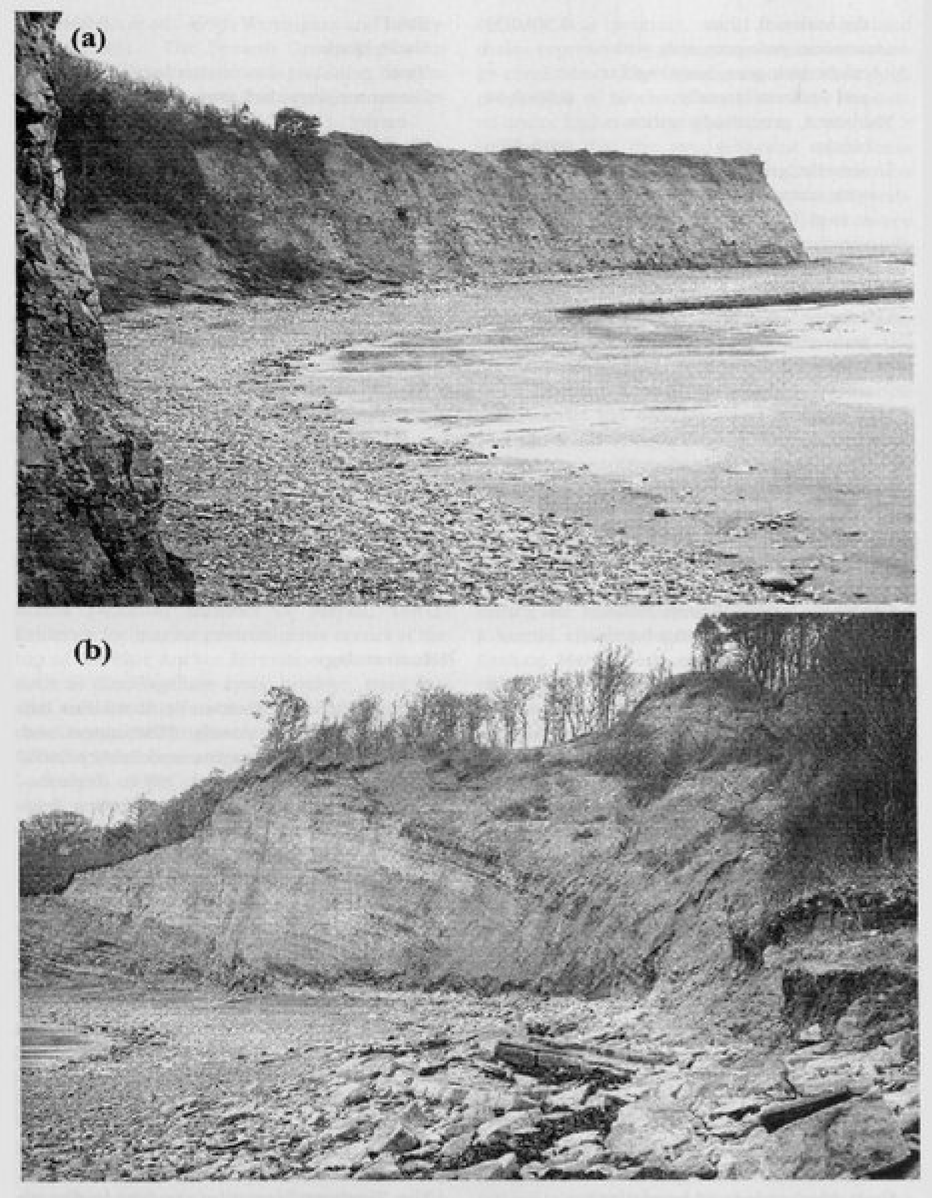
The clay mineral kaolinite in the Lilstock Formation of Somerset and Devon suggests that during late Triassic times the region experienced a humid climatic regime (Mayall, 1979). The Cotham Member calcareous grey and greenish mudstones, siltstones and sandstones were deposited in a shallow lagoon, which may have experienced periods of emergence, as indicated by deep cracks in the surfaces of some beds (Mayan, 1981). A distinctive deformed bed in the lower part of the Cotham Member may have been deposited in an extensive shallow-water body, and deformed by dewatering or slumping of unconsolidated sediments (Whittaker and Green, 1983), possibly initiated by local vertical uplift or tectonic activity (Mayall, 1983). The Langport Member was deposited in warm, very shallow shelf lagoons. The porcellanous limestones are thought to have formed under emergent conditions where calcium carbonate crystallized very quickly. The greyish muds may have been deposited in slightly deeper waters (Whittaker and. Green, 1983).

The ammonite *Psiloceras planorbis* has long been known from the Lias sediments of St. Audries Bay (Warrington *et al.,* 1994), and indeed, the Watchet area is the type area for this ammonite.

Conclusions

The Triassic and Jurassic sediments exposed in the sea cliffs and on the foreshore of St. Audries Bay form a classic example of the succession from the Mercia Mudstone Group, through the Penarth Group, into Lias Group, and span the Triassic-Jurassic boundary These sediments record a transition from continental conditions, from supra- and inter-tidal sabkhas and lagoons in the Mercia Mudstone Group, to more established marine conditions in the Westbury Formation; a return to lagoonal environments characterized the Lilstock Formation. This excellent section is of international significance, as candidate GSSP for the base of the Jurassic System (Warrington *et al.,* 1994).

References



(Figure 4.21) The Penarth Group at St Audries Bay. (a) The west side of the bay. The Blue Anchor Formation is in the left foreground. The Penarth Group is in the left middle distance and below the Lias Group in the cliff in the background. The base of the Jurassic succession is at the foot of the headland. (b) View looking east from the Penarth Group exposure at beach level. The cliff consists largely of the Rydon Member (Blue Anchor Formation) overlain by the Williton Member. The Westbury Formation dips towards the right from the highest point in the cliff (Photos: Andrew Swift.)