Ladram Bay to Sidmouth, Devon

[SY 097 848]–[SY 131 873]

Potential GCR site

Introduction

The coastal cliffs around Ladram Bay and towards Sidmouth preserve an excellent section through the upper part of the Mid Triassic (Anisian) Otter Sandstone Formation.

The formation comprises approximately 210 m of cross-bedded sandstones associated with gravels, conglomerates, and mudstones. These are overlain by red marls of the Mercia Mudstone Group. The Otter Sandstone Formation has yielded an extensive Mid Triassic fauna, including branchiopod crustaceans, insects, fishes, temnospondyl amphibians, pro-colophonid reptiles, and archosaurs. In the GCR, the site has also been selected for its important fossil amphibians and reptiles (Benton and Spencer, 1995), fossil fishes (Dineley and Metcalfe, 1999) and coastal geomorphology (May and Hansom, in prep.). It is also being considered for addition to the GCR in its own right for its contribution to the study of the sedimentology and palaeoenvironments of Mid Triassic strata that are concealed beneath younger deposits farther east in the Wessex Basin, and form an important hydrocarbon reservoir in the Wytch Farm oilfield near Poole, Dorset. The site forms part of the Dorset and East Devon Coast World Heritage site.

The sediments from this section were described briefly by Whitaker (1869), Ussher (1875, 1876), Irving (1888, 1892, 1893), Hull (1892), Hutchinson (1906), and Woodward and Ussher (1911). More modern sedimentological studies have been produced by Henson (1970), Leonard *et al.* (1982), Mader (1985), Mader and Laming (1985), Purvis and Wright (1991), Smith and Edwards (1991), Wright *et al.* (1991), and Newell (1992). Descriptions of the vertebrate fossils and their occurrences have been given by Metcalfe (1884), Carter (1888), Spencer and Isaac (1983), Milner *et al.* (1990), Benton (1990), Benton and Gower (1997) and Benton *et al.* (1994).

Description

Triassic sediments are exposed in cliffs of varying height, and on the foreshore, between Ladram Bay and Sidmouth (Figure 3.75). The succession is almost continuously exposed through the greater part of its thickness in the coast from Otterton Point northwards, past Ladram Bay, to High Peak. The thickest succession is seen in High Peak, the 150-m-high cliff immediately to the west of Sidmouth, where Triassic rocks are capped by Cretaceous strata.

Sedimentology

The sandstones of the Otter Sandstone Formation are typically red and were deposited in a series of fining-upwards cycles up to 2 m thick. These cycles rest on erosion surfaces that are commonly overlain by thin beds of conglomerate; finer-grained siltstone or mudstone units occur at the tops of some cycles. Cross-bedding and calcrete horizons are common, and mud cracks are occasionally preserved in the finer-grained sediments.

The lowest, aeolian, part of the Otter Sandstone Formation is best seen at Budleigh Salterton (see above). The boundary between these and the overlying fluvial sandstones is not seen in the coastal outcrops around Budleigh Salterton. South of Ladram Bay and between Ladram Bay and Sidmouth, the formation contains calcite in the form of vertically orientated, elongate cylindrical concretions (rhizocretions) or as laterally extensive sheets.

Fluvial sandstones of the upper part of the Otter Sandstone Formation (Figure 3.76) are well exposed in and around Ladram Bay [SY 097 852]. Here, the sandstones (some 80% of the section) typically consist of fine- to medium-grained, moderately well-sorted litharenites (quartz with feldspar, lithic fragments and kaolinite), and contain erosion surfaces and structures such as channels, trough cross-bedding, tabular cross-bedding (as cosets or solitary sets), ripple

cross-laminations, and scours (Newell, 1992). Intraclast conglomerates, which take the form of horizontally bedded to massive conglomerates and associated tabular cross-bedded conglomerates, as well as mudclast-lined erosion surfaces, mudrocks, and carbonate concretions are also present (Mader, 1985; Newell, 1992).

The top of the Otter Sandstone Formation marks the boundary of the Sherwood Sandsone Group with the overlying Mercia Mudstone Group. The contact is seen in the vicinity of High Peak Hill [SY 104 858] and is traceable down-dip eastwards to the western end of Sidmouth Beach [SY 110 866], where it reaches beach level. Mudstone becomes more abundant towards the top of the Otter Sandstone Formation, and the top of the highest prominent sandstone bed is taken as the Otter Sandstone–Mercia Mudstone boundary. This boundary is also seen immediately east of Sidmouth, in the western part of Salcombe Hill Cliff.

Palaeontology

The fauna from the Otter Sandstone is diverse, and includes invertebrate and vertebrate taxa. Invertebrates are represented by the branchiopod crustaceans *Lioestheria* and *Euestheria,* and insects. Vertebrates include the fishes *Dipteronotus cyphus, Gyrolepis,* and *Lepidosteus* (Dineley and Metcalfe, 1999). The tetrapods are especially important and include the temnospondyl amphibians *Mastodonsaurus lavisi, Eocyclotosaurus,* and an indeterminate capitosaurid, reptiles such as the procolophonid *Kapes,* the rhynchosaur *Rhynchosaurus spenceri,* and rauisuchian archosaurs (Benton and Spencer, 1995; Benton and Gower, 1997).

Interpretation

The Otter Sandstone Formation is interpreted as a sequence of continental sediments. The vertical cylindrical calcitic concretions formed around the vertical tap roots of plants and were precipitated under conditions of high evapotranspiration, in an arid environments subject to a monsoonal climate. The calcrete sheets are characteristic of precipitation within the sediment profile from groundwaters, at or slightly above the ancient water table, and formed under arid climatic conditions (Purvis and Wright, 1991).

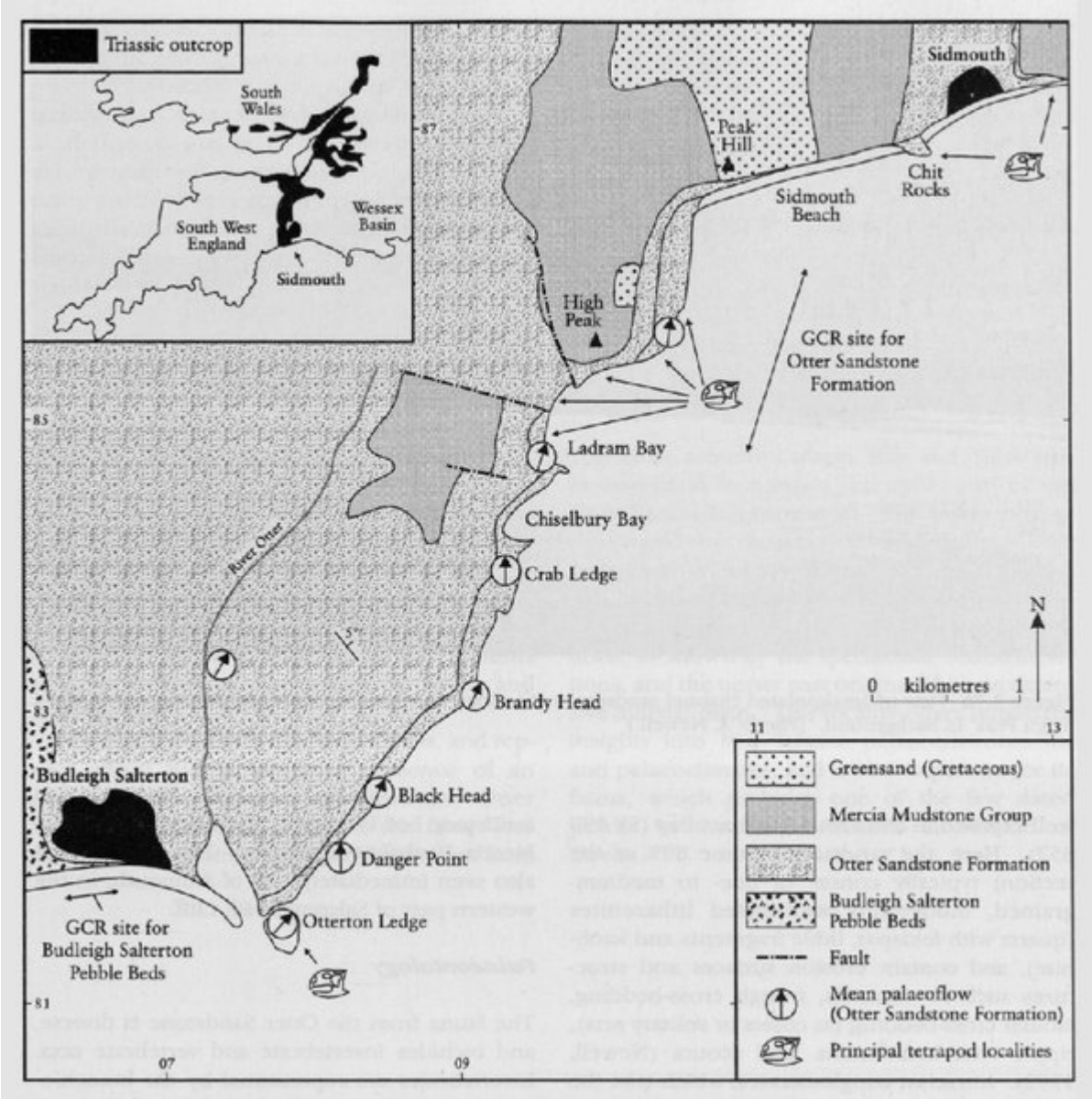
The Otter Sandstone Formation, above the basal aeolian beds seen at Budleigh Salterton (see GCR site report, this volume) was deposited under predominantly fluvial conditions. These sediments are typically coarse-grained towards the base, and consist of intraformational conglomerates with cross-bedded sandstones. Many of the conglomerates rest on erosion surfaces that may have well-developed scour structures (Newell, 1992). It is thought that the fluvial sandstones were deposited on a broad plain that supported many braided rivers that were responsible for reworking substantial amounts of the underlying aeolian sediments (Mader and Laming, 1985).

Some of the fossil fishes, amphibians, and reptiles afford biostratigraphical evidence of an Anisian (Mid Triassic) age for the Otter Sandstone Formation. Overall, the fauna and flora from this formation is similar to that from the Bromsgrove Sandstone Formation in the English Midlands, the Upper Bundsandstein of Germany and the *Voltzia* Sandstone of France (Milner *et al.,* 1990; Benton *et al.,* 1994). The procolophonid *Kapes* provides a correlation with the Russian Triassic succession; this genus is known from the Gam Svita of the Yarenskian Gorizont, and from the Donguz Gorizont, which are dated, respectively, as upper Olenekian and upper Anisian to lower Ladinian respectively (Spencer and Benton, 2000).

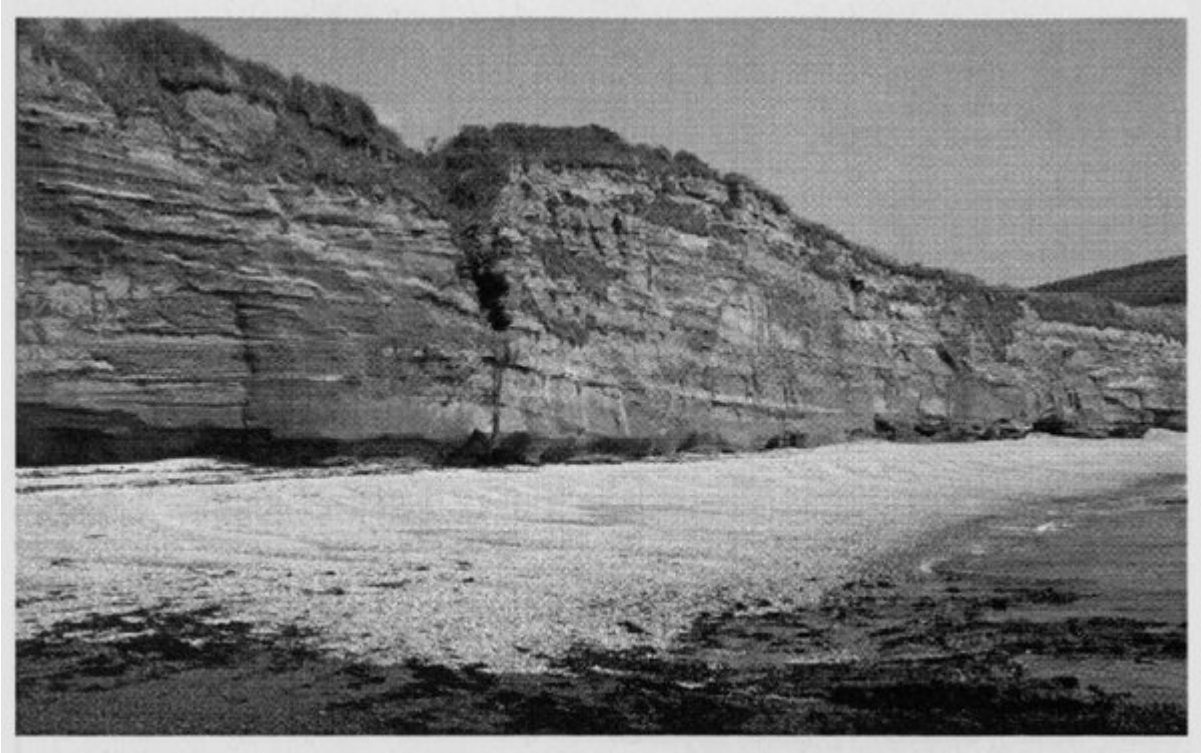
Conclusions

The cliffs around Ladram Bay and Sidmouth expose good sections in the upper part of the Otter Sandstone Formation. The sediments are dominated by cross-bedded sandstones, with occasional gravel and pebble beds, mudstones, and calcretes. The lower part of the formation here was deposited under monsoonal conditions, as shown by the spectacular rhizoconcretions, and the upper part originated on an extensive alluvial plain. This locality offers important insights into Mid Triassic palaeoenvironments and palaeoclimates, and is also important for its fauna, which provides one of the few dated points in the Permo-Triassic succession of Devon.

References



(Figure 3.75) Map of the coastal outcrop of the Otter Sandstone Formation between Sidmouth and Budleigh Salterton, together with mean fluvial palaeoflow directions, and showing principal localities for fossil tetrapods. (From Benton et al., 1994.)



(Figure 3.76) View of amalgamated channel sandstones at Ladram Bay, looking north-east towards the wooded 'High Peak' in background. (Photo: A. Newell.)