Sidmouth

[SY 092 838]–[SY 131 873]

(Potential GCR site)

Highlights

The Otter Sandstone Formation at Sidmouth in Devon is the richest active Middle Triassic verte brate-bearing site in the British Isles. Six or more species of fish and amphibian have been found here, most of them recently, and the site represents one of the most promising localities of its age anywhere in the world.

Introduction

The fossiliferous beds occur in the series of high cliffs to the west of Sidmouth between Chiselbury Bay [SY 092 838] and Chit Rocks [SY 121 869], and at Port Royal, just east of Sidmouth [SY 1297 8730]. The whole locality (Figure 11.5) is important as one of the most productive sources of vertebrates of mid-Triassic age in Britain, and fresh finds are made every year after cliff falls. However, it is difficult and dangerous to collect from the cliff face and most of the fossils have come from fallen blocks on the foreshore, or *in situ* from ledges at beach level.

Whitaker (1869) distinguished 'red sandstone' overlain by 'red marl' in the New Red Sandstone at High Peak [SY 144 858], which is in turn overlain by Cretaceous Upper Greensand, and he reported the first finds of vertebrates from the Otter Sandstone Formation. Lavis (1876) reviewed the Sidmouth coast in more detail, and Seeley (1876) described a fine lower jaw and other bones of the tetrapod *Mastodonsaurus lavisi.* Hutchinson (1879) further reported fossil plant remains that he identified as stems of an equisete or calamite. Ussher (1876), Metcalfe (1884), Carter (1888), Irving (1888, 1892, 1893), Hull (1892) and Woodward and Ussher (1911) discussed the stratigraphy and dating of the coastal section near Sidmouth, with particular attention to occurrences of fossil vertebrate material. Metcalfe (1884) figured remains of the reptile *Rhynchosaurus,* together with *Mastodonsaurus* jaws and other bones collected from fallen blocks near High Peak, while Carter (1888) described further remains, including fish scales and coprolites.

A second phase of work on the Otter Sandstone Formation coast section began in the 1960s. Laming (1966, 1968) and Henson (1970) provided further information on the sedimentology and stratigraphy of the formation. Warrington *et al.* (1980), Laming (1982) and Warrington and Scrivener (1990) discussed the problems of correlating the Otter Sandstone with other Triassic sequences. Leonard *et al.* (1982), Selwood *et al.* (1984), Mader and Laming (1985), Lorsong *et al.* (1990), Smith (1990), Purvis and Wright (1991), Smith and Edwards (1991) and Wright *et al.* (1991) carried out studies on the sedimentology of the Otter Sandstone Formation, focusing on the paleosols and other climatic indicators. Spencer and Isaac (1983), Milner *et al.* (1990), Benton (1990) and Benton *et al.* (1994) described collections of fishes and tetrapods made between 1982 and 1994 by P. Spencer that greatly enlarged the faunal list.

The Otter Sandstone Formation has been regarded as 'sparsely fossiliferous' (Spencer and Isaac, 1983). This impression may be the result of the steepness and height of the cliffs, and the fact that most fossils so far collected have come from fallen blocks on the shore. The Sidmouth to Budleigh Salterton section has yielded the largest number of remains of fossil vertebrates from the New Red Sandstone of Devon, and one of the widest ranges of fossil tetrapods from the British Middle Triassic, and it has continued to produce new fossils.

Description

The Otter Sandstone Formation (Sherwood Sandstone Group) is exposed in a series of high sea cliffs along the coast from west of Ladram Bay to just east of Sidmouth (Figure 11.6). The nature of the cliffs was described by all the Victorian authors mentioned above. Whitaker (1869) noted that most of the cliff at High Peak was formed by the 'red marl' which was heavily weathered above the harder 'red sandstone'. Irving (1888, pp.152–3) stated that the latter was underlain by

'massive, strongly current-bedded (Bunter) sandstones' which continue to the mouth of the Otter River. The succession is summarized below, with measurements estimated from Lavis (1876, fig. 1), on the assumption that High Peak is 155 m high (contour on 1:50 000 OS topographical map).

	Thickness (m)
CRETACEOUS	
Chalk gravel	5
Greensand	30
———unconformity———	
TRIASSIC	
Upper (Keuper) Marls (unnamed formation of Mercia Mudstone Group)	60
The Otter Sandstone Formation	*c.* 60

The Otter Sandstone Formation (the 'red sandstone') comprises *c.* 118 m of medium- to fine-grained red sandstones that dip gently eastwards in the coast section. The formation continues northwards to Somerset and eastwards as far as Hampshire and the Isle of Wight beneath younger Triassic sediments (Holloway *et al.,* 1989). It rests unconformably on the Budleigh Salterton Pebble Beds (Scythian), a 20–30 m thick unit of fluvial conglomerates (Henson, 1970; Smith, 1990; Smith and Edwards, 1991). The contact is marked by an extensive ventifact horizon (Leonard *et al.,* 1982) that represents a non-sequence of unknown duration, and is interpreted by Wright *et al.* (1991) as a desert pavement associated with a shift from a semiarid to an arid climate.

Calcretes occur abundantly at Otterton Point, Budleigh Salterton, but farther east they are rarer, and the formation is dominated by sandstones in large and small channels, with occasional siltstone lenses. The sandstones occur in cycles, commonly with conglomeratic bases, and fine upwards through cross-bedded sandstones to ripple-marked sandstones. The Otter Sandstone Formation is capped by water-laid siltstones and mudstones of the Mercia Mudstone Group.

Henson (1970), Laming (1982, pp. 165, 167, 169), and Mader and Laming (1985) interpreted the Otter Sandstone Formation as comprising fluvial and aeolian deposits. Sandstones near the base are aeolian, and middle and upper parts of the formation are of fluvial origin and were deposited by ephemeral braided streams flowing from the south and south-west (Selwood *et al.,* 1984). The comparatively thin mudstones are interpreted as the deposits of temporary lakes on the flood plain. The calcretes indicate subaerial soil and subsurface calcrete formation in semi-arid conditions (Mader and Laming, 1985; Lorsong *et al.,* 1990; Mader, 1990; Purvis and Wright, 1991). The climate was semi-arid, with long dry periods when river beds dried out, and seasonal or occasional rains leading to violent river action and flash floods.

Recent collections of fish material and amphibian bones have come from the top 40 m or so of the Otter Sandstone Formation and occur in all lithologies, but most commonly in intraformational conglomerates and breccias (Spencer and Isaac, 1983). Lower in the sequence, in breccias exposed west of Chiselbury Bay, the abundance of tetrapod finds declines significantly. The bones are generally in a fine- to medium-grained reddish sandstone that commonly contains clasts of pinkish, greenish or ochreous calcrete and mud flakes up to 20 mm in diameter. The more complete fish specimens are, however, preserved in dark red siltstone, sometimes in association with plants and conchostracan crustaceans. Plant remains are preserved in iron oxide in all the lower-energy deposits, and their occurrence appears to be controlled by the sedimentology.

The only specimens found *in situ* by Spencer and Isaac (1983, p. 268) came from 'the lowest of three intraformational conglomerates', but these were 'indeterminate bone fragments'. It is likely that fossils occur at numerous levels throughout the Otter Sandstone Formation, but most have been found in fallen blocks on the shore, and locating the original horizons in the cliffs is difficult.

The Victorian authors believed that one or more discrete bone beds occurred at the eastern end of the outcrop. Lavis (1876) and Metcalfe (1884) put the bone bed 'about 10 feet from the top of the sandstone'; Woodward and Ussher (1911) placed it 'about 50 feet below the base of the Keuper Marls', some 40 ft (13 m) lower in the section.

Metcalfe (1884) gave further details of this locality at High Peak, stating that bones were found in fallen blocks of sandstone from a light-coloured band in the cliff close below the base of the 'Upper Marls' (Mercia Mudstone Group). Carter (1888) recovered bone material and coprolites from this locality.

Hutchinson (1879, p. 384) gave the most detailed account of the fossiliferous horizons. He found equisetalean stems in a bed at the top of the sandstone and 'about eight or ten feet above' two or three 'White bands' that appear as clear horizons in the cliff face. Then, 'one or two steps below' the White bands 'is what I venture to call the Saurian or Batrachian band, in which Mr Lavis found his Labyrinthodon; but I cannot exactly say how many feet this band is below the white bands, because the fall down of the under cliff has concealed the stratification at this place; but it may be fifty feet below, and amongst the beds of red rock. Be that as it may, the Saurian band rises out of the beach somewhere under Windgate, as the hollow between the two hills is called, and ascends westwards into High Peak Hill, and having proceeded for about half-a-mile, and having attained a height of sixty or seventy feet above the sea, a fall of the cliff enabled Mr Lavis to find his specimens on the beach, and I was so fortunate as to see them soon afterwards.'

Woodward and Ussher (1911, pp. 12–13) summarized an unpublished section drawn up by Hutchinson in 1878 in which he located the bone bed '100 feet above the talus on the beach, and about 50 feet below the base of the Keuper Marls'. No trace of any tetrapod-bearing horizon in the form of a bone bed can be seen today, and there is no evidence that one existed. The Victorian geologists evidently expected to find bones at discrete levels, and had no concept of restricted lenticular deposits, such as channel lags.

The tetrapod fossils are generally preserved in a fine- to medium-grained, orange to reddish sandstone that often contains sedimentary clasts, including reworked rhizolith concretions, up to 20 mm in diameter, and claystone intraclasts that may have a pinkish, greenish or ochreous colour. The bones generally occur as isolated elements: jaws, teeth, partial skulls or single postcranial bones, but some occur in articulation. The bones generally show little obvious sign of abrasion, and some tiny reptile and fish jaws are exquisitely preserved. More details of taphonomy were given by Benton *et al.* (*1994*)and Benton and Spencer (1995).

About half of the identifiable tetrapod bones are rhynchosaur remains. The amphibians are represented mainly by skull and pectoral girdle elements, all relatively dense and with characteristic sculpture. Specimens of the fish *Dipteronotus typhus* obtained from a claystone lens east of Windgate are extremely well articulated and occur in association with a 'still-water' fauna of branchiopod crustaceans.

Fauna

The list of fishes and temnospondyl amphibians is compiled from Milner *et al.* (1990) and Benton *et al.* (1994)

Osteichthyes: Actinopterygii: Neopterygii: Cleithrolepididae

Dipteronotus cyphus Egerton, 1854 Complete specimens, pieces of flank, individual scales and spines (EXEMS = The Royal Albert Memorial Museum, Exeter)

Osteichthyes: Actinopterygii

Gyrolepis(*?*) and others

Scales

Actinopterygii: Neopterygii: Ginglymodi

Lepisosteus sp.

Scales in coprolites

Osteichthyes: Actinopterygii: Semionotidae

Lepidotes

TETRAPODA

'Temnospondyli': Mastodonsauridae

'*Mastodonsaurus lavisi*' (Seeley, 1876) *nomen dubium*

Holotype. The posterior part of right mandible (NHM R.4215). Skull fragments and part of a lower jaw (NHM, EXEMS)

'Temnospondyli': Benthosuchidae

Eocyclotosaurus sp.

Remains of a skull, and other fragments (EXEMS)

Temnospondyli': Capitosauridae Capitosauridae *incertae sedis*

Posterior part of mandible (EXEMS) 'Temnospondyli'

indeterminate temnospondyl fragments (EXEMS)

Interpretation

Attempts to recover palynomorphs from the Otter Sandstone Formation have so far not been successful (Warrington, 1971). Its age is poorly constrained by occurrences of Late Permian miospores in the lower part of the Permo-Triassic succession near Exeter (Warrington and Scrivener, 1988, 1990) and Carnian taxa in the Mercia Mudstone Group, 135 m above the Otter Sandstone Formation. The only other biostratigraphical indicator is the vertebrate fauna. Walker (1969, 1970), Paton (1974) and Benton (1990) favoured a Ladinian age for the fauna, but Milner *et al.* (1990) argued that an Anisian age was most likely. The association of the perleidid fish *Dipteronotus cyphus* (Anisian–basal Ladinian) with some of the reptile remains identifies the Anisian as the only shared date.

The remains of three temnospondyl amphibians ('*M. lavisi*', *Eocyclotosaurus* sp., capitosaur *incertae sedis*)are abundant in the Otter Sandstone Formation. These were all aquatic superficially crocodile-like forms, and they were probably carnivores or piscivores which fed at the waterside. The new eocyclotosaur material represents the first find of a benthosuchid from the Middle Triassic in Britain. It is a fairly well-preserved partial skull, but specifically indeterminable and identified only as *Eocyclotosaurus* sp. (Milner *et al.,* 1990). It is similar to *Eocyclotosaurus* species from France and Germany.

The fossils of '*Mastodonsaurus lavisi*' show some resemblance to material from Coton End and Bromsgrove (Paton 1974, pp. 265–82) and these show closest resemblance to *M. cappelensis* from the Upper Buntsandstein (Anisian) of Baden-Württemburg, Germany (Milner *et al.,* 1990). The material consists of jaw and some skull bones that are not specifically diagnostic, as Paton's (1974) description of the species was based upon *Mastodonsaurus* generic characters only. However, Milner *et al.* (1990) suggested that the species should retain its name for practical purposes, but as a *nomen dubium. M. lavisi* is the largest temnospondyl in the Otter Sandstone herpetofauna with an estimated skull length of 500–600 mm. It may have grown to at least 2 m.

The other temnospondyl material consists of a partial right mandible, identified by Spencer and Isaac (1983) as that of *Cyclotosaurus* sp., but considered by Milner *et al.* (1990) to be undiagnostic capitosaurid and several indeterminate temnospondyl specimens (Milner *et al.,* 1990).

Dipteronotus cyphus, a deep-bodied perlei-did fish (7–10 cm long) which possesses a dorsal hump, is represented at Sidmouth by many well-preserved partial and complete remains (Figure 11.7). Specimens of *D. cyphus,* including the holotype, have been obtained elsewhere only at Bromsgrove, from the upper member of the Bromsgrove Sandstone

Formation. The Otter Sandstone specimens are better preserved than those from Bromsgrove and the species was redescribed from two partial Sidmouth specimens (Gardiner, *in* Milner *et al.* 1990). *Dipteronotus* is known also from the Scythian of Europe and the Carnian–Norian of Morocco.

The only other fishes recovered from the Otter Sandstone are some poorly preserved actinopterygian specimens, probably *Gyrolepis* from the same laminated mudstones as *D. cyphus* and *Lepidotes* (=*Lepidotus*) scales that occur within coprolites, probably attributable to the fish-eating amphibians. *Gyrolepis* is a genus known from several localities in the English Midlands including the Bromsgrove Sandstone Formation of Bromsgrove (Sherwood Sandstone Group) and the Colwick Formation of Colwick Wood, Nottinghamshire, the Arden Sandstone Member of Leamington, Warwickshire, and the Dane Hills Sandstone Member of Aylestone Road in Leicester and Spinney Hills, Leicestershire (all Mercia Mudstone Group; Gardiner, *in* Milner *et al.,* 1990). The presence of the three tern-nospondyl amphibians, which were aquatic carnivores, suggests a rich fish fauna of which only three genera have been recovered. However, much unidentified fish material has been collected in recent years (P. Spencer, pers. comm., 1994) which may prove the existence of a much more diverse assemblage.

The only plants so far found in the Otter Sandstone Formation are stems and leaves of large horsetails (Hutchinson, 1879), and recently found *Schizoneura,* a form also known from the Bromsgrove Sandstone Formation (Benton and Spencer, 1995).

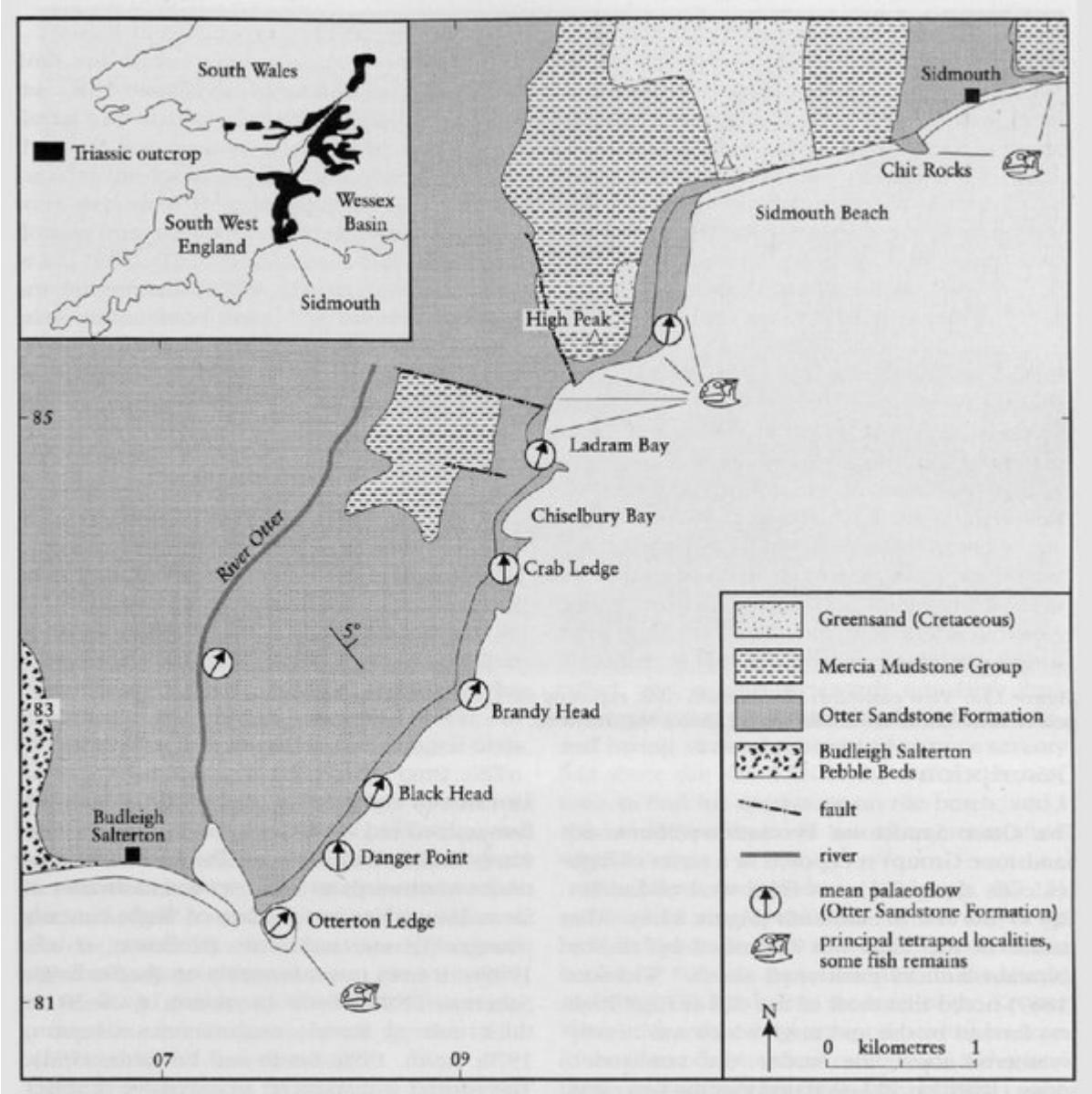
Comparison with other localities

The Otter Sandstone fauna and flora is comparable to that of the Bromsgrove Sandstone Formation at Bromsgrove, Guy's Cliffe and Coton End, Warwickshire. Outside the British Isles, the fauna compares with Early to Mid-Triassic faunas from France (Gres a *Voltzia*)and Germany (Buntsandstein) and Mid- to Late Triassic faunas from Germany (Lettenkeuper; Milner, *et al.,* 1990).

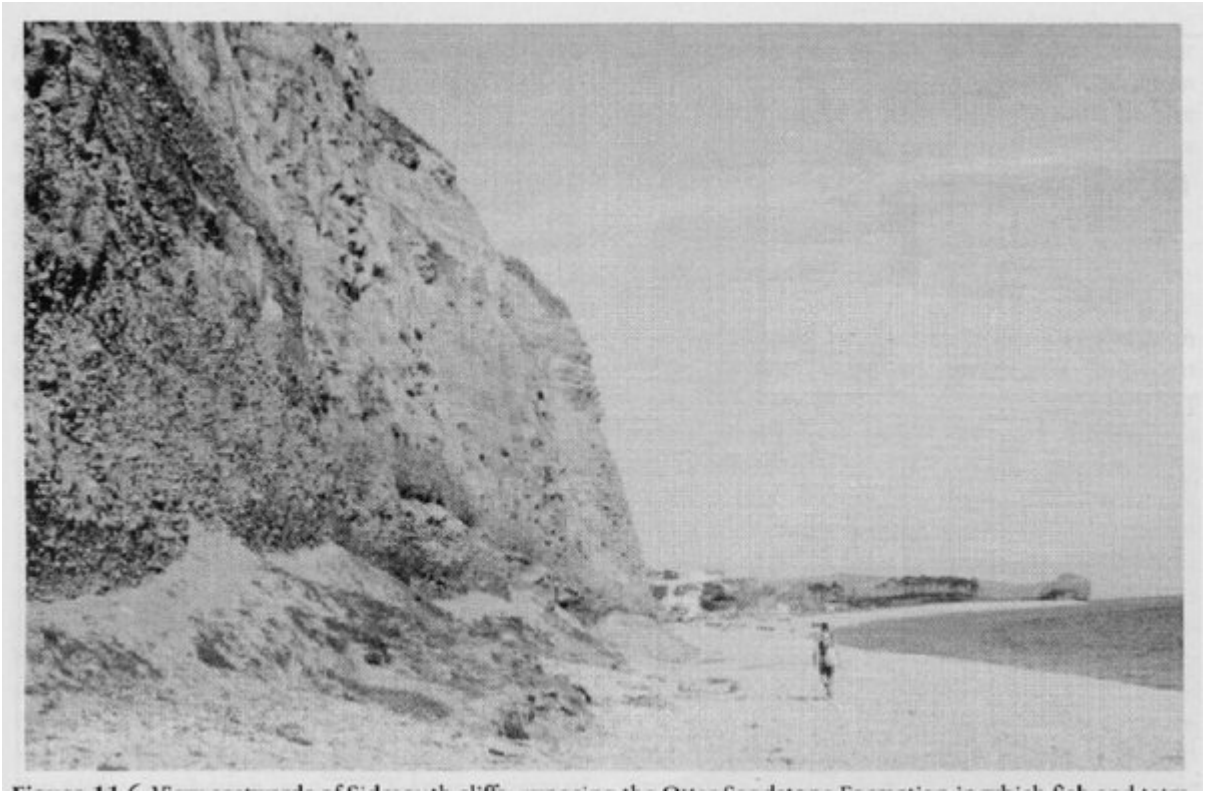
Conclusion

The Otter Sandstone Formation exposed along the coast at Sidmouth offers vast potential for study of mid-Triassic amphibian and fish faunas. There are no mainland European freshwater faunas of the same age, since the Muschelkalk marine transgression occupies that interval of time. The assemblage comprises the richest mid Triassic continental amphibian fauna in Britain and probably in western Europe. New finds, including as yet undescribed fish remains, continue to be made *in situ* and in fallen blocks, with erosion constantly supplying new specimens. This potential and the importance of past finds give the site its conservation value.

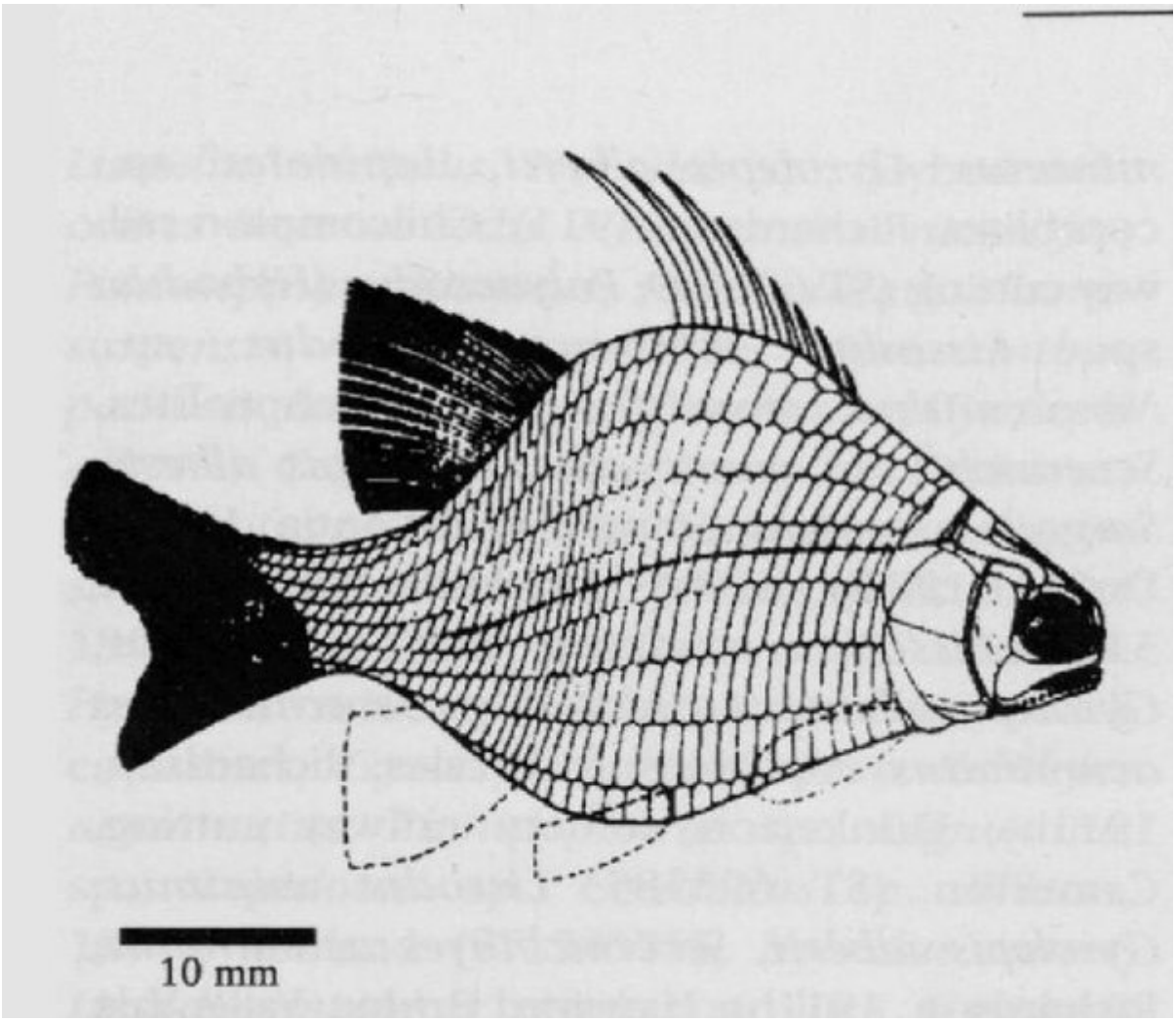
References



(Figure 11.5) Map of coastal outcrop of the Otter Sandstone Formation between Sidmouth and Budleigh Salterton, South Devon (from Benton and Spencer, 1995).



(Figure 11.6) View eastwards of Sidmouth cliffs, exposing the Otter Sandstone Formation in which fish and tetra-pod remains occur at various levels (photo: M.J. Benton).



(Figure 11.7) Otter Sandstone Formation fish: Dipteronotus cyphus Egerton.