Aust Cliff, Avon

[ST 565 895]–[ST 572 901]

Highlights

Aust Cliff is world-famous for its superb exposure of Rhaetian marine bone beds. Abundant reptile fossils have been collected, and continue to be collected, representing a mix of mainly marine ichthyosaurs and plesiosaurs, but also rare dinosaur bones.

Introduction

Aust Cliff, at the eastern end of the Severn Road Bridge (Figure 4.19), is Britain's most prolific site for Rhaetian fossil reptiles. The cliff exposes the boundary between the Upper Triassic and Lower Jurassic, and was first described by Buckland and Conybeare (1824), and subsequent accounts have been given by many authors, including Strickland (1841), Etheridge (1868), Short (1904), Reynolds (1946), Hamilton (1977) and Storrs (1994). The Aust section has yielded important collections of ichthyosaurs, plesiosaurs and dinosaurs, as well as fishes. The rare dinosaur remains are generally heavily abraded and it is likely that they have been transported for some distance. The site is subject to constant erosion and occasionally produces good new specimens.

Description

Aust Cliff exposes a section through the Upper Triassic and the lower part of the Lower Jurassic (Figure 4.19). It represents the truncated face of a ridge of Triassic and Lower Jurassic rocks surrounded by alluvium. A very gentle anticlinal structure is shown, cut by five small faults with throws to the south ranging from *c.* 1 m to 4.5 m.

Both flexing and faulting have been explained by compaction of the Mercia Mudstone Group sediments. The Mesozoic succession exposed in the cliff is readily subdivided lithologically and biostratigraphically. The lower part of the cliff consists of the Mercia Mudstone Group, including the Blue Anchor Formation ('Tea Green Marls'). Macrofossils are generally absent from these beds, but occur abundantly in the overlying dark and lighter grey sediments of the Penarth Group (including the 'Rhaetic'). Limestones and shales at the top of the cliff form the lowest part of the Lias. This Mesozoic succession rests unconformably on the upturned edges of a Carboniferous Limestone ridge, exposing the Lower Dolomites which dip about 15° southwest. The section (based on Reynolds, 1946, Hamilton, 1977, and Warrington *et al.,* 1980) is:

JURASSIC	Blue Lias (Hettangian)	Thickness (m)
	planorbis Beds	(variable)
TRIASSIC	*Pre-planorbis* Beds	(variable)
Penarth Group	Lilstock Formation	*c.* 3.4
	Westbury Formation (bone beds at base)	*c.* 4.3
Mercia Mudstone Group	Blue Anchor Formation	*c.* 7.0
	Red mudstones	*c.* 30.0
CARBONIFEROUS	Carboniferous Limestone	(variable)

The reptile remains are found predominantly in the 'Rhaetic Bone Bed' (Figure 4.20) which occurs in places at the base of the Westbury Formation, the subdivisions of which are (Reynolds, 1946):

	Thickness (m)
8. Greenish-black shales	0.3
7. Hard grey limestone ('upper *Pecten* Bed')	0.13

6. Black Shales	2.4
5. Hard pyritous limestone (lower *Pecten* Bed')	0.18
4. Black shales, hard fissile paper shale above	1.2
3. Bone Bed	0.02–0.15
'Tea-Green Marls'	

The 'Bone Bed' occurs as lenses of grit or intraformational conglomerate (or breccia) of sedimentary rocks with a calcite-cemented sandy matrix on top of the Blue Anchor Formation, the surface of which may be ripple-marked. The conglomeratic component is made up mainly from clasts of the Blue Anchor Formation sediments, together with quartz pebbles and bone fragments. Many of the fragments of Blue Anchor Formation sediment are squeezed and plastically deformed, which suggests that they were still soft when incorporated into the bone bed. The quartz pebbles are mainly of vein quartz, are mostly well rounded, and are probably derived from older beds (although Wickes, 1904, suggested that they might represent stomach stones, or gastroliths, swallowed by plesiosaurs to aid in the digestion of food).

The vertebrate remains are mainly phosphatized bones, teeth and scales. They are disarticulated and often rolled and worn, indicating some post-mortem transport. Coprolites (faecal droppings), some possibly of aquatic reptiles, are also abundant: these contain crustacean fragments and abundant fish scales and they are heavily phosphatized, containing 25–50% calcium phosphate. A reconstruction of the Rhaetian sea floor based on fossils from Aust Cliff and neighbouring localities is shown in (Figure 4.21).

According to the classification of Sykes (1977), the Bone Bed had a part-primary and part-secondary origin. The indications of primary deposition include the condition and orientation of the fossils, and the poorly sorted nature of the deposit. However, most of the fossils and other clasts show signs of abrasion, which indicates that the deposit is largely reworked. This is borne out by finds of teeth of the Carboniferous fishes *Psephodus magnus, Psammodus porosus* and *Helodus* in the bone bed, presumably reworked from the local Carboniferous Limestone or the Coal Measures. Macquaker (1994) and Storrs (1994) conclude that the bed represents a tempestite.

Vertebrate remains are most abundant in the impersistent Bone Bed. A similar fish fauna occurs in the succeeding basal sands of the Westbury Formation and also at the base of the limestone bands and in the shales. Bone-rich debris is also sometimes present in the topmost layers of the green marls at the base of the Rhaetian sequence where the marl is intensely bioturbated. These occurrences of reptile and fish bones in Rhaetian horizons at Aust, other than in the basal bone bed itself, are classified as trace bone beds (Sykes, 1977, p. 220).

Fauna

Dozens of slabs of sediment with fish and reptile bones and teeth are preserved in BRSMG, BRSUG, BMNH, BGS(GSM), CAMSM and in most other British collections. Many of the specimens collected during the last century were identified to species level, and made the types of new species and new genera, but there is no point in listing those since there is rarely enough evidence for such precise determination (see Storrs, 1994, for discussion).

Chondrichthyes: Elasmobranchii

Polyacrodus, Hybodus, Nemacanthus, Palaeospinax, Pseudodalatias, Lissodus

Osteichthyes: Actinopterygii: 'Palaeonisciformes'

Birgeria, Gyrolepis

Osteichthyes: Actinopterygii: 'Semionotiformes'

Sargodon, Colobodus

Osteichthyes: Sarcopterygii: Dipnoi

Ceratodus

Ichthyopterygia: Ichthyosauridae

'Ichthyosaurus'

Sauropterygia: Plesiosauria: ?Plesiosauridae '*Plesiosaurus'*

Archosauromorpha: Choristodera: Pachystropheidae

Pachystropheus rhaeticus (=Rysosteus)

Archosauria: Dinosauria

? Camelotia, megalosaur

Interpretation

The Bone Bed is assumed to have been deposited under marine coastal conditions. The conglomerate shows signs of rapid deposition and winnowing by wave action and shore-line currents. It has been suggested (Macquaker, 1994; Storrs, 1994) that the Aust bone bed represents a storm deposit: a mass of rocks and fossils picked off the shore-line and carried back down into deeper water by the ebb current of a storm sturge, or exhumed and redeposited from penecontemporaneous shallow-water sediments. Other authors suggest that reworking of strand-line deposits produced by the Rhaetian transgression might equally have produced the bone bed. This occurred with overstep across the former playa-type sediments of the Mercia Mudstone Group, a palaeoenvironment of intrinsically low relief. Although the palaeontological evidence does not give precise dating, it is probable that the marine flooding phase occurred very rapidly and would have had a strong erosive force. Kent (1970), for example, suggested that the whole of the Midlands was submerged by the transgression almost simultaneously.

Fish remains are common in the Bone Bed at Aust. These include the teeth and fm spines of sharks, teeth and scales of primitive, heavily-scaled, bony fish (*'Birgeria', Sargodon, Gyrolepis*). The most characteristic remains, however, are palatal tooth-plates of the lung fish *Ceratodus,* a form close to the extant *Neoceratodus* from Australia.

Temnospondyl amphibians have been reported from Aust, based on mandibles referred to *Metopias diagnosticus* (e.g. Reynolds, 1946), but these have turned out to be the teeth and jaws of a palaeonisciform fish (identified as*'Birgeria*' *acuminata* Agassiz by Savage and Large, 1966, but probably representing a new genus; Storrs, 1994).

The most common reptile remains are ichthyosaurs and plesiosaurs, with a few possible dinosaurs. Ichthyosaurs are represented at Aust by their vertebrae, which are flat circular biconcave elements. One in the BRSUG measures 180 mm across. Other ichthyosaur remains include a humerus (BRSMG), a large lower jaw (Huene, 1912c) and numerous isolated teeth.

The vertebrae and teeth of *Plesiosaurus* are the commonest reptile remains from Aust. The vertebrae are distinguished from those of ichthyosaurs by, among other features, being thicker and having two planar surfaces on the centra. Three species have been named: *P. rugosus, P. costatus* and *P. rostratus. P. rugosus* was erected by Owen (1840a) for some vertebrae (BRSMG) which were regarded as sufficiently distinct by Seeley (1874b) to be named as a new genus, *Eretmosaurus,* together with some limbs, limb girdles and apparently similar vertebrae from Granby. Swinton (1930) doubted the validity of the genus, but Persson (1963) retained it, and classified it as a rhomaleosaurid. *P. costatus* was also erected by Owen (1840a) for certain cervical vertebrae, which Swinton (1930) regarded as a possible new genus. Other plesiosaurs reported from Aust include *P. hawkinsi* and *P. rostratus* (Reynolds, 1946). Most plesiosaur specimens from Aust are non-diagnostic teeth, vertebrae, ribs and paddle bones, which Storrs (1994) regarded as Plesiosauria *incertae sedis.* Unfortunately, most of the specimens were destroyed in the BRSMG during the Second World War.

Owen (1842b) named a small reptile vertebra, with a partial humerus and femur from Aust as *Rysosteus.* This was interpreted as a dinosaur by Reynolds (1946), but recent studies by Storrs and Gower (1993), based on material from Aust and from other British Westbury Formation localities, suggests that most *Rysosteus* specimens are the same as *Pachystropheus rhaeticus* Huene, 1935. Storrs and Gower (1993) reinterpret *Pachystropheus (Rysosteus*) as a choristodere, a superficially crocodile-like diapsid of uncertain affinities, and a group that is best known from the Late Cretaceous and Palaeogene, but does have British Mid Jurassic representatives (*Cteniogenys;* see Bathonian site reports below).

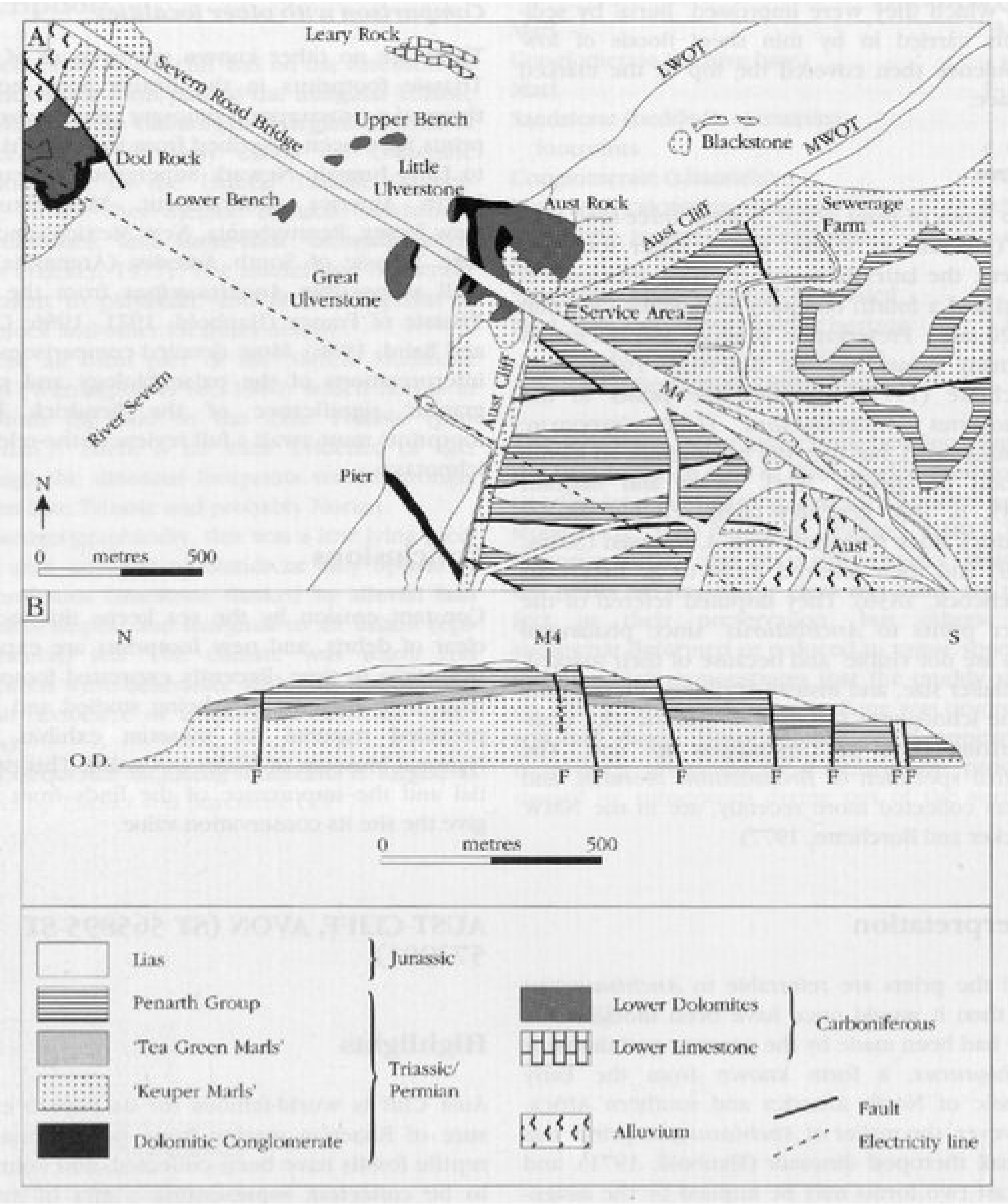
Some very large bones, possibly dinosaurian (Reynolds, 1946), lack their articular ends, so that identification is difficult. Three large specimens, found in 1844 (370 mm long, 420 mm in circumference), 1846 (600 mm long, 125 mm in diameter at one end), and between 1846 and 1875 (200 mm long, 370 mm in circumference), were described by Stutchbury (1850) and Sanders (1876).

Some smaller bones (a vertebra, four ends of phalanges, a small rib) in the BMNH and LEICS (Reynolds, 1946) have been identified as *Zanclodon* (Lydekker, 1888a). That attribution is incorrect (*Zanclodon* is an indeterminate archosaur), but they may be termed 'megalosaur *incertae sedis'* for the present. Occasional megalosaur teeth have also been found at Aust (Reynolds, 1946), and three phalanges (BRSUG and in private collections) may also be attributed to a megalosaur. The present whereabouts of these so-called dinosaurs from Aust are uncertain.

Conclusions

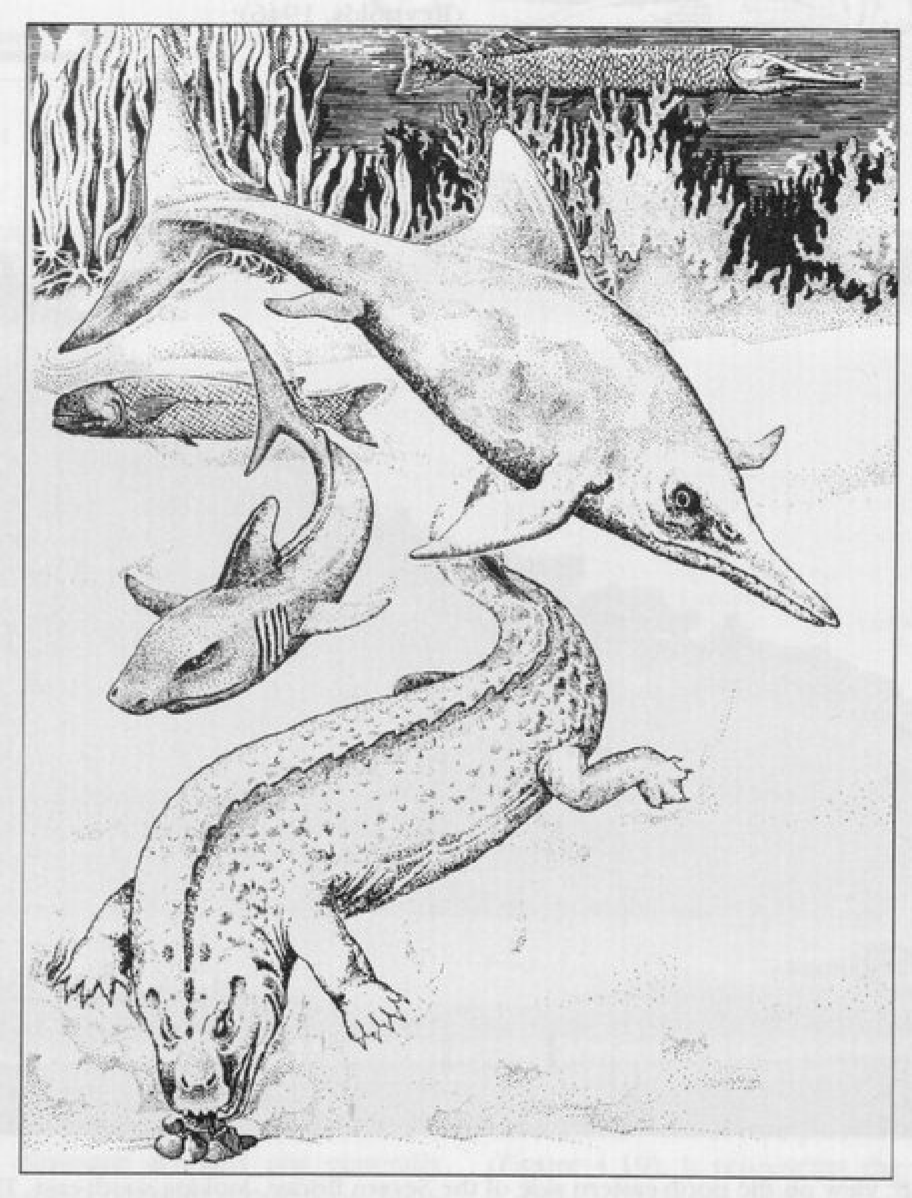
Aust Cliff exposes the best section of the Rhaetian beds with the 'Rhaetic Bone Bed' in Britain thus giving the site considerable conservation value. This bone bed occurs in many other localities in England and South Wales, but it is probably best developed at Aust and here contains the most diverse fauna of reptiles. The bone beds of the Westbury Formation have been of considerable importance in Triassic vertebrate palaeontology (Storrs, in press), and have played an important role in the discussion of bone bed formation and diagenesis (e.g. Antia, 1979).

References



(Figure 4.19) The Rhaetian at Aust Cliff. (A) Geological map of the Aust Cliff area; (B) the broad anticlinal structure of Aust Cliff, showing the Lias (1); the Rhaetian (Penarth Group) (2); the 'Tea Green Marls' (3); and the 'Keuper Marls' (4). Both after Hamilton (1977).

(Figure 4.20) Aust Cliff: view on the north-eastern side of the Severn Bridge, looking south-east. The red sediments of the Mercia Mudstone Group extend about four-fifths of the way up the cliff, capped by the Penarth Group (latest Triassic). The Blue Lias of the Jurassic lies at the very top, in the vegetation line. Vertebrate remains are found in lenses of 'Rhaetic' Bone Bed, at the base of the Penarth Group. (Photo: G.W. Storrs.)



(Figure 4.21) Reconstruction of the Rhaetian sea floor, based on fossils from Aust Cliff and neighbouring localities. The fishes are Saurichthys, at top right, Birgeria at top left, and a hybodont shark in front of it. The marine reptiles include ichthyosaurs (mid-top) and placodonts (lower left). After Duff, McKirdy and Harley (1985).