J.N.C.C.

Fossil Reptiles of Great Britain

M.J. Benton and P.S. Spencer

Department of Geology,
University of Bristol,
Bristol, UK.

GCR Editors: W.A. Wimbledon and D. Palmer

JOINT NATURE CONSERVATION COMMITTEE

CHAPMAN & HALL

London · Glasgow · Weinheim · New York · Tokyo · Melbourne · Madras

Chapter 7

British Late Jurassic fossil reptile sites

INTRODUCTION: BRITISH LATE JURASSIC REPTILE SITES

Late Jurassic reptiles have come from many localities along the length of the English outcrop, between the Dorset coast and Yorkshire, and are represented in rocks ranging in age from Late Oxfordian to the Portlandian. The recorded British Late Jurassic reptile sites are detailed below stage by stage. The listings are based on sources as noted, together with examinations of major museum collections.

OXFORDIAN

Reptile remains are rare in the Upper Oxford Clay and Corallian Beds. A few sites have yielded plesiosaurs and marine crocodilians, but the most important remains are isolated finds of dinosaurs from Dorset, Cambridgeshire and Yorkshire. References include Newton (1878), Fox-Strangways (1892), H.B. Woodward (1895), Strahan (1898), Galton (1980a, 1980b), Martill (1986, 1988) and Martill and Hudson (1991).

DORSET: Sandsfoot Castle, Weymouth (SY 676774; *Pliosaurus, Teleosaurus* jaw from Sandsfoot Grit (*regulare* Zone; Upper Oxfordian)); Hill Crest Road, Weymouth (?SY 673775; *Muraenosaurus*); Nothe, Weymouth (SY 688788; *Teleosaurus* from Lower Calcareous Grit); Osmington (?SY 7252; *Ophthalmosaurus* from the Corallian); Preston (?SY 6983; *Muraenosaurus, Macropterygius*).

WILTSHIRE: Steeple Ashton (ST 9157; *Plesiosaurus* from the 'Coral Rag'); Rood Ashton (ST 887560; '*Plesiosaurus*' from the 'Coral Rag'); Heddington (SU 0067; *Pliosaurus* teeth).

BERKSHIRE: Hatford, Faringdon (SU 3394; '*Plesiosaurus*', dinosaur from the Corallian).

OXFORDSHIRE: Stanford-in-the-Vale (SU 3493; *Megalosaurus* from the 'Coral Rag'); Marcham (SU 4596; *Teleosaurus* from the Corallian); Cothill (SU 4699; crocodile from the 'Lower Calcareous Grit'); Bladon Fields (SP 4414; *Teleosaurus* from the Corallian); Littlemore, Oxford (SP 5302; *Megalosaurus*); Wheatley (SP 5907; *Pliosaurus* teeth); Headington 'Quarry Field' (?SP 555071; *Cetiosaurus*, *Metriorhynchus* from the 'Coral Rag' and 'Lower Calcareous Grit'); Garsington (SP 5802; '*Plesiosaurus*').

BEDFORDSHIRE: Ampthill (TL 0438; *Steneosaurus, Ophthalmosaurus* in the Ampthill Clay).

CAMBRIDGESHIRE: Great Gransden (TL 260561 or TL 252564; type of dinosaur *Cryptodraco eumerus*, *Pliosaurus* from Ampthill Clay [?*serratum* Zone)]; Warboys Brick Pit (TL 308818; *Ophthalmosaurus* from Upper Oxford Clay [*mariae* Zone]; Martill, 1986); Gamlingay (TL 2352; *Ophthalmosaurus*); Mepal (TL 4480; '*Plesiosaurus*' in the Ampthill Clay).

YORKSHIRE: Slingsby (SE 708744; *Pliosaurus, Steneosaurus* teeth; type of *Dacentrurus*? *phillipsi* from Malton Oolite Member [*vertebrale* Subzone; *densiplicatum* Zone]); Malton (SE 7871; *Pliosaurus, Steneosaurus, Metriorhynchus*); Appleton-le-Street (?SE 734737; *Pliosaurus* from 'Birdsall Calcareous Grit'); Scarborough (TA 0488; *Pliosaurus*); North Grimstone (SE 8467; *Pliosaurus, Teleosaurus*); locality unknown (type of *Priodontognathus phillipsii* ?from the Calcareous Grit).

KIMMERIDGIAN

Overall the Kimmeridge Clay has yielded abundant turtles, crocodiles, pterosaurs, plesiosaurs, pliosaurs, ichthyosaurs and dinosaurs, and includes some of the best Late Jurassic marine reptile faunas in the world. There are many localities, although most sites have yielded only remains of one or two marine reptiles. However, abundant remains have been found in Dorset, Wiltshire, Oxfordshire, Cambridgeshire and Yorkshire. References include Seeley (1869a), Phillips (1871), H.B. Woodward (1895), Strahan (1898), Arkell (1933, 1947a, 1947c), Tarlo (1958, 1959b, 1959c, 1960), Delair (1959, 1960, 1966), Brookfield (1978b), Cope (1967, 1978) and Taylor and Benton (1986).

DORSET: Ringstead Bay (SY 751813; *Steneosaurus, Pliosaurus, Ophthalmosaurus*); Osmington Mills (SY 7382; *Pliosaurus*; *Ophthalmosaurus*, some at least from the *mutabilis* Zone, one plesiosaur limb bone from the *eudoxus* Zone; Clarke and Etches, 1992); Isle of Portland coast (SY 6872–SY 7072; *Ophthalmosaurus, Cimoliasaurus, Pliosaurus, Thaumatosaurus,* *Colymbosaurus*; recent *Colymbosaurus* specimen from Grove Cliff (SY 706722) in the *pavlovi* Zone, Brown, 1984; Palmer, 1988); Upwey (SY 6684; '*Plesiosaurus*'); Hazelbury Bryan (*Pliosaurus*); Motcombe (ST 8425; *Liopleurodon*); Gillingham Brick Pit (ST 809258; *Liopleurodon, Dacentrurus, Ophthalmosaurus*, type of *Ophthalmosaurus pleydelli* from the *mutabilis* and *cymodoce* Zones (Lower Kimmeridgian)); Fiddleford, near Sturminster Newton (ST 8013; *Ophthalmosaurus, Liopleurodon*).

SOMERSET: ?Ilminster (ST 3614; *Ophthalmosaurus, Liopleurodon*).

WILTSHIRE: Stour cutting (ST 779305; *Ophthalmosaurus*; Bristow *et al.*, 1992, p. 141); Broughton-Gifford (ST 8763; *Peloneustes*); Westbury Clay Pit (ST 880527; '*Plesiosaurus*'; recent finds of thalassemyid turtle and *Metriorhynchus* skull from *mutabilis* Zone, and *Pliosaurus* skull from *eudoxus* Zone; plesiosaur limb bone from the *eudoxus* Zone, Clarke and Etches, 1992); Chippenham (ST 9173; *Pliosaurus*); Foxhangers (ST 937615; *Ophthalmosaurus, Cimoliasaurus, Pliosaurus, Liopleurodon, Metriorhynchus, Megalosaurus*; Delair, 1973); Rodborne, near Swindon (ST 9383; ?nodosaurid ankylosaur; Galton, 1980b (?Lower Kimmeridgian)); Westbrook(e), Bromham (ST 9666; type of *Ophthalmosaurus trigonus*); Potterne (ST 9958; *Cimoliasaurus, Ophthalmosaurus*); Devizes (SU 0161; *Thalassemys, Ophthalmosaurus, Cimoliasaurus, Pliosaurus, Liopleurodon, Metriorhynchus*); Wootton Bassett (SU 0682; *Ophthalmosaurus, Cimoliasaurus, Pliosaurus, Liopleurodon, Metriorhynchus*; type of *Dacentrurus hastiger* from the Early Kimmeridgian); Swindon Brick and Tile Pits (SU 156834; *Ophthalmosaurus, Megalosaurus, Ornithocheirus, Cimoliasaurus, Pliosaurus, Liopleurodon, Thaumatosaurus*; types of *Plesiochelys passmorei* (turtle), *Bothriospondylus suffossus* and *Omosaurus armatus* (dinosaurs), *Pliosaurus brachydeirus* and *P. macromerus* from *baylei* and *cymodoce* Zones (Lower Kimmeridgian); Delair, 1982a); Stanton-Fitzwarren (SU 1790; *Ophthalmosaurus, Liopleurodon*).

BERKSHIRE: Stanford-in-the-Vale (SU 3493; *Ophthalmosaurus, 'Plesiosaurus'*); Oday Common, south of Abingdon (SU 492949; pliosaur; Delair, 1982a; ichthyosaur in Abingdon Museum; turtle).

OXFORDSHIRE: Hardwick (SP 3706; *Machimosaurus*); Marcham (SU 4596; *Pliosaurus, 'Plesiosaurus'*); Drayton (SU 4794; *Ophthalmosaurus, 'Plesiosaurus'* from Lower Kimmeridge Clay); Foxcombe Hill (SP 4901; *Cimoliasaurus, Pliosaurus, Ophthalmosaurus*); Culham (SU 5095; *Dakosaurus*); Radley Sand-pits (SU 5199; *Pliosaurus*); Oxford (SP 5106 – ?exact locality; *Cimoliasaurus, Pliosaurus*); Sandford-on-Thames (SP 5301; *Pliosaurus*); Headington Pits, Oxford (SP 555072; *Cimoliasaurus, Ophthalmosaurus*, type of *Pliosaurus brachyspondylus*); Nuneham Courtenay (SU 5599; *Ophthalmosaurus, Plesiosaurus*); Baldon (SP 5600; *Cimoliasaurus, Macropterygius*); Horspath (SP 5704; *Pliosaurus*); Shotover Hill (SP 588065; *Ophthalmosaurus, Cimoliasaurus, Pliosaurus, Dakosaurus, Metriorhynchus*, type of *Liopleurodon macromerus, Pliosaurus grandis, P. nitidus, Cimoliasaurus trochantencus, Metriorhynchus palpebrosum*); Garsington (SP 5802; *Metriorhynchus, 'Plesiosaurus', Pliosaurus, Ophthalmosaurus*); Wheatley (SP 5905; *Cimoliasaurus, Ophthalmosaurus, Macropterygius*).

BUCKINGHAMSHIRE: Hartwell (SP 7916; *Liopleurodon*); Hardwick (SP 8019; *Pliosaurus*); Winslow (SP 7627; *Ophthalmosaurus*); Denbigh Hill, Fenny Stratford (SP 8834; *Pliosaurus*); Newport Pagnell (SP 8743; *Cimoliasaurus*); Aylesbury (SP 821134; 'marine reptiles', including a pliosaur recently, from Lower and Upper Kimmeridge Clay, mainly from the Homan's Bridge Shale Member; Upper Kimmeridge Clay, *wheatleyensis* Zone).

NORTHAMPTONSHIRE: Higham Ferrers (SP 9668; *Pliosaurus*).

CAMBRIDGESHIRE: Cottenham (TL 452684; *Dakosaurus, 'Plesiosaurus', Pliosaurus, Ophthalmosaurus*); Haddenham (TL 4674; *Cimoliasaurus, Pliosaurus*); Wood Walton (TL 2180; *Pliosaurus*); Witcham (TL 4680; plesiosaur); Downham (TL 5283; *Pliosaurus*); Great Ouse River Board Pit, Stretham (TL 516743; *Liopleurodon, Ornithopsis*); Chettisham, Ely (TL 5583; *Ophthalmosaurus, Cimoliasaurus, Teleosaurus*); Peterborough (TL 1998; *Pliosaurus*); Oakley Cutting (TL 0254; *Steneosaurus*); Bourn (TL 3256; *Dakosaurus*).

NORFOLK: Stow Pumping Station (TL 589057; ?pliosaur); Downham Bridge (TF 601033;

?pliosaur); Downham Market Brickyard (TR 608039, TR 610031; *Ophthalmosaurus, 'Plesiosaurus', Teleosaurus, Dakosaurus*); Southery Pumping Station (TL 612932; ?pliosaur); Ten Mile Bottom (TL 612966; ?pliosaur); Denver Sluice (TF 591013; *Pliosaurus, ?Ornithopsis*); Setchey (TF 6313; *Pliosaurus*); Stowbridge (TF 604069; type of ichthyosaur *Grendelius mordax* from *wheatleyensis* Zone).

LINCOLNSHIRE: Market Rasen (TF 1089; *Ophthalmosaurus*, type of *Pliosaurus brachydeirus*?); Sweaton (*Ophthalmosaurus*).

YORKSHIRE: Speeton, Filey Bay (TA 1576; *Ophthalmosaurus*).

PORTLANDIAN: PORTLAND BEDS

The term 'Portlandian' is used here to refer to the last stratigraphic stage of the Jurassic, in preference to 'Tithonian', the primary international reference standard. This is because a basal boundary stratotype for the Tithonian has not been selected, and because the Kimmeridgian stage as used by British workers is much longer than that used elsewhere. Stratigraphic equivalents are:

UK, northern France	Tethys	Russia, Poland
Portlandian Upper Kimmeridgian	Tithonian	Volgian
Lower Kimmeridgian	Kimmeridgian	Kimmeridgian

Cope (1993) has attempted to resolve this problem by reintroduction of the Bolonian Stage for the Upper Kimmeridgian *sensu anglico*, thus allowing the standard use of the Portlandian and Volgian stage names. For the present work, we use the traditional British 'long' Kimmeridgian stage name.

Reptiles have only been found on the Isle of Portland (turtles, plesiosaurs, ichthyosaurs). Isolated specimens of marine reptiles have also been collected in Wiltshire, Oxfordshire and Buckinghamshire, with a few dinosaur teeth from near Aylesbury. References include Phillips (1871), H.B. Woodward (1895), Strahan (1898) and Arkell (1933, 1947a, 1947c). Sites not included in the reptiles GCR coverage are listed here.

DORSET: Winspit Quarry, Seacombe (SY 985767; type of *'Plesiosaurus winspitensis'*); Haysoms' Quarry, St Aldhelm's Head (SY 964761; turtle); Preston, Weymouth (SZ 7038; turtle).

WILTSHIRE: Tisbury (ST 9429; *Cimoliasaurus*); Chicksgrove (sauropod, ?stegosaur, and megalosaur teeth, lizards, pterosaurs, *Goniopholis*); Town Gardens Quarry, Swindon (SU 152834; *Ichthyosaurus*).

OXFORDSHIRE: Oxford (SP 5106 – ?exact locality; type of *Metriorhynchus gracile*); Shotover Hill (SP 5906; *Cimoliasaurus*); Garsington (SP 5802; *Cetiosaurus*).

BUCKINGHAMSHIRE: Brill Brick Yard (SP 655144; *Plesiosaurus, Teleosaurus*); Quainton Hill (SP 7420; *Cimoliasaurus*).

LATE PORTLANDIAN TO EARLY BERRIASIAN: PURBECK BEDS

The Purbeck Limestone Formation is split between the Jurassic and Cretaceous. Late Jurassic forms include the lizards, 'dwarf' crocodilians and some turtles. Early Cretaceous forms are most of the turtles, pterosaurs, crocodilians and footprints. Extremely abundant remains have been obtained from Durlston Bay and quarries west of Swanage, and the smaller freshwater and terrestrial animals are of particular importance (lizards, turtles, small crocodilians, dinosaurs and pterosaurs). References include H.B. Woodward (1895), Delair (1958, 1966, 1982b), Charig and Newman (1962) and Anderson and Bazley (1971).

DORSET: Swanage Quarries (SZ 021781, etc.; many of forms found at Durlston Bay – exact information not available; type of *Pholidosaurus laevis* (crocodilian) from Keat's Quarry); Townsend Road, Swanage (SZ 02657835; dinosaur footprints; Ensom, 1982a); Herston Quarries (SZ 020784, etc.; *Goniopholis, Pleurosternum*, dinosaur footprints in the Pink Bed (Bristow's Bed 50) of the Upper Building Stones; Charig and Newman, 1962); Acton Quarries, Langton Matravers (SY 990783; *Pleurosternum*, type of pterosaur *Ornithocheirus validus*, dinosaur footprints); opposite lane leading to Old Court Pound (former underground workings with access at SY 99197872; footprints *Purbeckopus pentadactylus*; Delair, 1963; Ensom, 1984a, 1986a); Reynold's Quarry, Dancing Ledge (SY 997773 or SY 998769; *Goniopholis*, dinosaur footprints); Seacombe (SY 984767; *Goniopholis*); Sunnydown Farm Quarry, Langton Matravers (SY 98227880; sauropod and other dinosaur tracks and microvertebrate remains; Ensom, 1987a, 1987b, 1988, 1989c, 1990; West, 1988; Ensom *et al.*, 1991); Encombe (?SY 944793; '*Plesiosaurus*'); Nelson Burt Quarry, Worth Matravers (?SY 9777; '*Iguanodon*' in the 'Pinkstone Bed'); Woodyhyde Farm (SY 97507978; footprint; Ensom, 1986b); Corfe (?SY 9782; *Pleurosternum, Goniopholis*); Preston (SZ 7083; *Pleurosternum*); Portland (SZ 6771; *Cimoliasaurus* in the 'Cinder Bed'); Weymouth (exact locality?; ankylosaur); Lulworth Cove (SZ 8380; nodosaurid, *Goniopholis* from Dirt Bed); Worbarrow Tout (SY 869796; dinosaur footprints from several horizons; West *et al.*, 1969; Delair, 1982b; Ensom, 1982b, 1984b, 1985a, 1985b, 1987c; West and El-Shahat, 1985).

WILTSHIRE: Chicksgrove Quarry; Town Gardens Quarry, Swindon (SU 152835; 'reptiles', including megalosaur tooth, in Purbeck; Delair, 1973).

EAST SUSSEX: Darwell Beech Farm (?TQ 7119; *Goniopholis* and 'other reptiles' from a temporary exposure); Poundsford Farm (TQ 637226; *Megalosaurus*); Archer Wood (TQ 741819; 'reptile bones'). All from Cretaceous part of Purbeck.

Most of the listed sites could not serve as candidates for inclusion in the GCR since they have been lost to landfill and building. For the most part, only coastal sites could be considered, and the richness and accessibility of the Dorset coast is reflected in the choice of nine proposed GCR sites:

1. Furzy Cliff, Overcombe, Dorset (SY 698818). Late Jurassic (Early Oxfordian), Upper Oxford Clay.
2. Smallmouth Sands, Weymouth, Dorset (SY 669764–SY 672771). Late Jurassic (Early Kimmeridgian), Lower Kimmeridge Clay.
3. Roswell Pits, Ely, Cambridgeshire (TL 555808–TL 551805). Late Jurassic (Early Kimmeridgian), Lower Kimmeridge Clay.
4. Chawley Brick Pits, Cumnor Hurst, Oxfordshire (SP 475043). Late Jurassic (Early Kimmeridgian), Lower Kimmeridge Clay.
5. Kimmeridge Bay (Gaulter Gap–Broad Bench), Dorset (SY 9179). Late Jurassic (Early Kimmeridgian), Kimmeridge Clay.
6. Encombe Bay, Swyre Head–Chapman's Pool, Dorset (SY 937773–SY 955771). Late Jurassic (Late Kimmeridgian), Upper Kimmeridge Clay.
7. Isle of Portland, Dorset (SY 6478). Late Jurassic (Portlandian), Portland Sand–Purbeck Beds.
8. Bugle Pit, Hartwell, Buckinghamshire (SP 793121). Late Jurassic (Portlandian), Portland Stone and lowest Purbeck Beds.
9. Durlston Bay, Dorset (SZ 034780). Late Jurassic–Early Cretaceous (Portlandian–Berriasian), Portland Stone–Upper Purbeck Beds.

LATE JURASSIC (OXFORDIAN)

Oxfordian reptiles are rare, especially those of Early Oxfordian age, the only recorded sites being at Cothill and Headington in Oxfordshire and Furzy Cliff, Overcombe Dorset. This may be because of a lack of suitable exposure in the Upper Oxford Clay, but is more probably related to a genuine scarcity of reptilian remains. The rarity of reptiles from British Early Oxfordian rocks is also matched abroad, and the few British sites are of great importance in bridging the faunal gap between the underlying Callovian Middle Oxford Clay and the overlying beds of the Mid Oxfordian (*densiplicatum* Zone), both of which preserve better reptile remains. The best-known Early Oxfordian site is at Furzy Cliff and this is selected as a GCR site.

British Mid and Late Oxfordian localities have produced more reptile remains. The Coral Rag (Mid Oxfordian) of various sites in Wiltshire, Berkshire, Oxfordshire and Yorkshire have yielded teeth of plesiosaurs, pliosaurs, crocodiles, vertebrae of plesiosaurs and dinosaurs, and isolated dinosaur limb bones. The Mid Oxfordian of Yorkshire is important as the source of rare dinosaurs; a nodosaur ankylosaur (*Priodontognathus*) from the Calcareous Grit, and a stegosaur femur, the type of *Dacentrurus*? *phillipsii*, from the Malton Oolite Member of the Coralline Oolite Formation of Slingsby, are the only evidence for the Stegosauridae so far from the Oxfordian anywhere in the world (Galton, 1985b). Late Oxfordian reptiles are known from the Sandsfoot Grits of Weymouth and the Ampthill Clay of Cambridgeshire and Bedfordshire.

Comparable Mid and Late Oxfordian sites abroad include Vaches Noires, near Dives, Normandy (*Eustreptospondylus, Steneosaurus*), Calvados, Bourgogne and La Vendée

(*Steneosaurus*), Boulogne-sur-Mer (*Steneosaurus*), the La Turbie-Cap d'Aggio region, Monaco ('Megalosaurus', ?crocodile) and Baden-Württemberg, Germany (*Teleosaurus*).

FURZY CLIFF, OVERCOMBE, DORSET (SY 697817–SY 703819)

Highlights

Furzy Cliff is Britain's best Oxfordian age reptile locality. It is the source of the unique specimen of the meat-eating dinosaur *Metriacanthosaurus*, as well as an ichthyosaur and a plesiosaur.

Introduction

The Upper Oxford Clay exposed at Furzy Cliff, or Jordan (Jordon) Cliff, Overcombe, has yielded sparse fossil reptile remains, but these are of considerable importance because of their age. A recent cliff fall has re-exposed large portions of the site, and the prospects for future finds are good (Figure 7.1). The fossil reptiles have been described by Huene (1923,1926), Walker (1964) and Cope (1974).

Description

Buckman (1925) was the first to examine the stratigraphy of Furzy Cliff in detail, and he used it to distinguish one component of his three-fold division of the Upper Oxford Clay (Early Oxfordian) in south Dorset. This included: (1) clays with *Quenstedtoceras*; (2) clays with large *Gryphaea dilatata*, named the Jordan Cliff Beds; and (3) clays with reddish-brown nodules and large perisphinctids, named the Red Beds. Arkell (1947c) revised and amended the nomenclature, naming unit (1) Furzedown Clays, (2) Jordan Cliff Clays and (3) Red Nodule Beds. Buckman did not give thicknesses for the units and those of Arkell (1947c) and of Torrens (1969a) have since proved

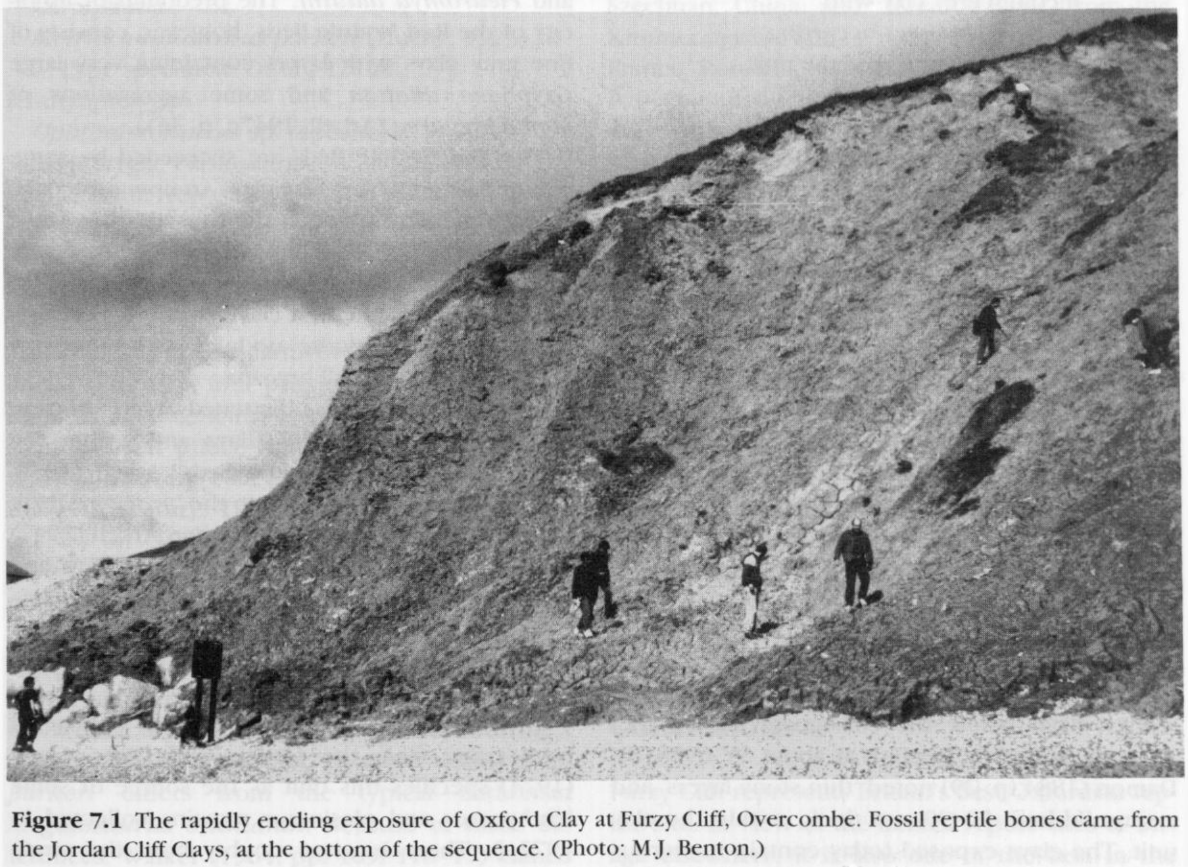


Figure 7.1 The rapidly eroding exposure of Oxford Clay at Furzy Cliff, Overcombe. Fossil reptile bones came from the Jordan Cliff Clays, at the bottom of the sequence. (Photo: M.J. Benton.)

to be overestimates, particularly in the case of the Red Nodule Beds (Wright, 1986). In the summer of 1983 a major landslip at Furzy Cliff permitted the first accurate measured sections to be made (Wright, 1986). The Red Nodule Bed was found to be a thin unit in the middle of a distinctive clay sequence named by Wright (1986) the Bowleaze Clay Member (formerly the Red Beds). The revised section at Furzy Cliff (Wright, 1986) is:

	Thickness (m)
Nothe Grit	
11. Argillaceous sandstone	seen 1.5
Bowleaze Clays	
10. Pale and medium grey clay	*c.* 6
9. Red Nodule Bed	0.35
8. Pale and medium grey clay	0.40
7. Dark, carbonaceous clay with intraformational bored surfaces	1.40
6. Pale and medium grey clay with bored surfaces, *Gryphaea* and perisphinctids	*c.* 1
5. Interbedded dark, carbonaceous and pale and medium grey clay with scattered nodules occurring toward the middle of the unit. *Gryphaea* and perisphinctids	*c.* 2
4. Pale and medium grey clay	*c.*3
3. Pale and medium grey clay containing perisphinctids	*c.* 0.15
2. Pale and medium grey clay with nodule-bearing horizon at the base	1.10
Jordan Cliff Clays	
1. Pale and medium grey clays with *Gryphaea*	seen 10.5

The Jordan Cliff Clays (*c.* 10 m) are unbioturbated, extremely fine-grained, fissile, dark slaty-blue clays that weather to a lighter, greenish-grey or reddish-brown colour. Although the lowest clays are now obscured by new sea defences, they were described briefly by H.B. Woodward (1895) and Damon (1884). H.B. Woodward (1895, p. 16) noted the unit as 'beds of bluish-grey clay, with small hard cementstones' from below the coastguard station (i.e. western end of the section at about SY 698818). Damon (1884, p. 29) noted 'thin stony layers' and a serpulid bed, 50–90 mm thick, within the clay unit. The clays exposed today contain numerous *Isognomon promytiloides*. They are succeeded by 8 m of a tough, blocky, silty clay with numerous *Gryphaea dilatata* encrusted with *Serpula* sp. In this unit, encrusted *Modiolus bipartitus* and cardioceratids are common.

The Bowleaze Clays (*c.* 14.5 m) are predominantly very fine-grained, but with frequent incursions of sandy clay. The base is marked by a persistent band of white, elliptical limestone nodules which are associated with coarse silt and fine sand. There are about 4 m of these very fine, pale-grey clays which contain 'nests' of *Lopha gregaria* and *Liostrea* sp. Above these, the lithology changes with the first of several inputs of dark, sandy clay. The Red Nodule Beds consist of two bands of nodules which occur in the cliff about 8 m above the base of the Bowleaze Clays. Their colour is an artefact of weathering in a zone 0.5 m below the soil surface. The nodules are typically found coated with a layer of iron oxide and were formerly known as 'kidney stones' (H.B. Woodward, 1895, p. 16), but when fresh they are pale buff-coloured, dense and sideritic, frequently with septarian cracks infilled with calcite and zinc blende. The nodules commonly enclose the remains of *Modiolus bipartitus*, *Modiola, Astarte* and *Pleuromya alduini*. The predominant lithology of the Red Nodule Beds, however, consists of fine grey clays with layers containing very large *Gryphaea dilatata* and some aggregations of *Lopha gregarea* (Arkell, 1947c, p. 34).

The Red Nodule Beds are succeeded by some 6 m of pale grey, very fine clay. An upwards coarsening trend is reversed at the top with the sands of the Nothe Grit resting on the clay with a very sharp junction. This is exposed only at Ham Cliff (SY 712817). The highest clay is markedly calcareous, containing micrite nodules and numerous Foraminifera and small bryozoa.

Ammonites occur as flattened white impressions in the Jordan Cliff Clays and within the nodules of the Red Nodule Beds. Arkell (1933, p. 343) assigned all of these to the '*praecordatum* Zone' (?*mariae* Zone in part). Later, Arkell (1941) revised the zonation of the Early Oxfordian and placed the Jordan Cliff Clays in the *mariae-cordatum* Zones (*scarburgense-bukowskii* Subzones) and the Red Nodule Beds (Bowleaze Clays) in the *costicardia* Subzone.

The reptile remains at Furzy Cliff appear to have come from the Jordan Cliff Clays. Cope (1974) specifies this unit as the source of some ichthyosaur and plesiosaur remains collected in 1972–3. There is some doubt about the stratigraphic position of *Megalosaurus parkeri* (i.e. *Metriacanthosaurus parkeri*), but it may also have come from the Jordan Cliff Clay. It is certainly from the Oxford Clay, as an oyster, *Gryphaea dilatata,* found adhering to one of the vertebrae, has been taken to indicate an Upper Oxford Clay (Early Oxfordian) age for the specimen (Walker, 1964, p. 117).

The ichthyosaur was preserved in a semi-articulated state. A series of 39 vertebrae, with associated neural spines and ribs, was excavated. However, the limbs, neck region and skull seem to have been lost. Several other ichthyosaur and plesiosaur vertebrae and teeth were found associated. The evidence suggests limited transport and winnowing, but the skeleton was clearly not excessively disturbed or the neural spines and ribs would have been lost. Huene (1926) gave no taphonomic information on the *Megalosaurus* specimen. The remains consist of elements of the pelvis and hind-limb region, and they are rather distorted and cracked.

Fauna

Archosauria: Dinosauria: Saurischia: Theropoda:
  Carnosauria
  Metriacanthosaurus parkeri (Huene, 1923)
    Type specimen: OUM J.12144
Ichthyopterygia
  Ophthalmosaurus sp. repository?
Sauropterygia: Plesiosauria
  'plesiosaur' repository?

Interpretation

The remains of the carnivorous dinosaur (three dorsal vertebrae, four proximal caudal vertebrae, right ilium, fragments of right and left ischium, right and left pubis, right femur, upper part of right tibia) were collected together, probably in the 19th century. They were described as a new species of *Megalosaurus, M. parkeri* Huene (1923), characterized by the high, elongate neural spines on the dorsal vertebrae, the shape of the ilium and ischium, and the expansion of the pubic 'foot' (Huene, 1923, 1926). The femur was a slender bone with the lesser trochanter toward the top and the cnemial process bearing a strong upward projection. In these respects, *M. parkeri* differs from the typical Bathonian *Megalosaurus bucklandi*. Because of these differences, Walker (1964, pp. 109, 116–17) named *M. parkeri* as the type species of the new genus, *Metriacanthosaurus*. The relationship of *Metriacanthosaurus* with other theropods has been problematic. Most workers (e.g. Walker, 1964; Steel, 1970) assign it to the *Megalosauridae*, but no other megalosaur bears the same enlarged neural spines. On the basis of the height of the neural spines, Huene (1926) suggested that *Metriacanthosaurus* could represent an early member of the Spinosauridae, and this assignment was discussed further in Walker (1964). It has since been realized that the development of expanded neural spines occurs in a range of unrelated tetrapod groups and can no longer be regarded as a viable phyletic character. Molnar (1990) was unable to find any characters that would allow *Metriacanthosaurus* to be classified further than Theropoda *inc. sed.*

Other Late Jurassic carnosaurs include *Allosaurus, Antrodemus, Ceratosaurus* and *Dryptosaurus* from the Morrison Formation of North America (Kimmeridgian–Portlandian?), *Allosaurus, Ceratosaurus* and *Elaphrosaurus* from the Tendaguru beds of Tanzania (Late Kimmeridgian), *Yuangchuanosaurus* and *Szechuanosaurus* from the Late Jurassic of North Szechuan, China, and '*Megalosaurus*' from the Kimmeridgian and Portlandian of northern France, Portugal, Wiltshire and Dorset (Encombe Bay–Chapman's Pool site, see below). The only other Oxfordian carnosaur known is *Eustreptospondylus divesensis* Walker (1964) from the Vaches Noires, near Dives, Normandy (a cranium). *Megalosaurus nicaeensis* (Ambayrac, 1913) from the Oxfordian of Monaco turns out to be a pliosaur (Buffetaut, 1982). *Metriacanthosaurus parkeri* fills a gap in the phylogeny of the carnosaurs.

The ichthyosaur and plesiosaur remains from Furzy Cliff have only been recorded briefly (Cope, 1974), and they have not been described. The ichthyosaur consisted of 34 dorsal centra and 5 caudals, with neural spines and ribs. Plesiosaur remains were isolated vertebrae and possibly teeth. The ichthyosaur has tentatively been identified as *Ophthalmosaurus* sp., a genus common in the Late Jurassic.

Conclusions

Furzy Cliff represents Britain's best Oxfordian reptile site. In view of the limited reptile sites of this age elsewhere, it is also one of the best in the world. The dinosaur *Metriacanthosaurus* is represented by good postcranial remains and occupies a unique position in carnosaur evolution. The ichthyosaur *Ophthalmosaurus* is the only British Oxfordian ichthyosaur known, and one of the few known from that stage worldwide. Thus, the small number of finds to date from Furzy Cliff are of great importance, and the site has potential for further discoveries, hence its conservation value.

LATE JURASSIC (KIMMERIDGIAN) OF ENGLAND

Reptiles have been recorded from 60 sites in the Kimmeridge Clay between Dorset and Yorkshire (listed above). The faunas are dominated by marine forms (plesiosaurs, ichthyosaurs, and marine crocodiles; see Figures 7.5 and 7.8), but some localities (e.g. Weymouth) have also yielded significant remains of terrestrial reptiles, including important dinosaurs and turtles. Kimmeridge Bay, the type locality for the Kimmeridgian Stage, has produced the largest fauna, which includes the type specimens of six species. The five GCR localities (Figure 5.1), at Smallmouth Sands, Weymouth (SY 669764–SY 672771), Roswell Pits, Ely (TL 555808–TL 551805), Chawley (SP 475043), Gaulter Gap–Broad Bench, Kimmeridge Bay (SY 9179) and Encombe Bay (SY 937773–SY 955771), provide good coverage of rocks of Early to Late Kimmeridgian age, and cover the best known fossil reptile localities.

SMALLMOUTH SANDS, WEYMOUTH, DORSET (SY 669764–SY 672772)

Highlights

Smallmouth Sands has produced one of the most diverse assemblages of Kimmeridge Clay reptiles anywhere in the world. Its fauna of four species of turtles and three of pterosaurs is unique and, of its total fauna, six species are known only from this site.

Introduction

The Kimmeridge Clay south-west of Weymouth has yielded a large selection of marine and terrestrial reptiles, including many type specimens. Most of the finds appear to have been made on Smallmouth Sands and possibly also in the railway cutting behind. Little in the way of large finds has been collected recently because the enclosure of Portland Harbour has reduced erosion, but the relevant beds could be re-excavated. In addition, specimens are occasionally found offshore from this site and in degraded Kimmeridge Clay beds west of the classic site.

The Kimmeridge Clay outcrop in the Weymouth district forms a tract along the northern shore of the Isle of Portland which is continued across the floor of Portland Harbour. It is best exposed between Sandsfoot Castle and Portland Ferry bridge at Small Mouth, where it forms a series of low sea cliffs. The earliest good account of these cliff exposures was provided by Waagen (1865). The Kimmeridge Clay south of Sandsfoot Castle includes the lowest beds in the *mutabilis* Zone, and shows good sections of the *cymodoce* and *baylei* Zones (Arkell, 1933, p. 454), the three lowest Kimmeridgian zones. The section between Sandsfoot Castle and Smallmouth bridge has been described by several authors (Damon, 1884, p. 77; Blake and Hudleston, 1877, pp. 269–70; Salfeld, 1914, pp. 201–3; Arkell, 1933, pp. 385, 454; 1935, pp. 80–1; 1947c, pp. 56, 88; Birkelund *et al.*, 1978, p. 35; Cox and Gallois, 1981, pp. 4, 9), but most interest has focused on the Corallian.

Description

The section, based on Arkell (1933), Cox and Gallois (1981) and Cope (*in* Cope *et al.*, 1980b, p. 80) is:

	Thickness (m)
Lower Kimmeridgian	
mutabilis Zone	
Clays with nodules (?bed 13 (in part)–17 of Damon, 1884)	?20+
cymodoce Zone	
Black Head Siltstone	0.5
Shales with *D. delta* (bed 13 (in part) of Damon, 1884; bed 24 (in part) of Salfeld, 1914)	2.0+
Wyke Siltstone (bed 12 of Damon, 1884; bed	

	Thickness (m)
23 of Salfeld, 1914)	1.0
baylei Zone	
pale grey mudstones with thin, tabular clay ironstones at base (beds 8–11 of Damon, 1884; beds 21–22 of Salfeld, 1914)	?6+
dark grey mudstone with *D. delta* (? bed 7 of Damon, 1884; bed 20 of Salfeld, 1914; bed 13 of Arkell, 1933, 1947c)	3.0
Nanogyra nana Bed (bed 7 (in part) of Damon, 1884; bed 19 of Salfeld, 1914; bed 12 of Arkell, 1933, 1947c)	0.25
Rhactorhynchia inconstans Bed (bed 6 of Damon, 1884; bed 18 of Salfeld 1914; bed 11 of Arkell, 1933, 1947c)	0.7
Upper Oxfordian (Corallian)	
Westbury Iron Ore Beds (beds 1–5(?) of Damon, 1884; beds 13–17 of Salfeld, 1914; beds 8–10 of Arkell, 1933, 1947c)	

The beds dip south-west, and the clays with nodules of the *mutabilis* and higher ammonite zones are indicated largely by nodules washed ashore from the floor of Portland Harbour (Cope, *in* Cope *et al.*, 1980b, p. 80). Higher units of the Kimmeridge Clay occur in the harbour and on the north shore of the Isle of Portland.

The reptiles appear to have come from lower units of the Kimmeridge Clay and probably also from the top of the Corallian and from material washed out of Portland Harbour. Damon (1884, p. 77) noted that 'gigantic saurian remains have been found. Among others, *Gigantosaurus megalonyx*, Hulke in his bed 12. This was described as 'gritty clay. . . 3ft', and it is almost certainly equivalent to the Wyke Siltstone, thus *cymodoce* Zone. Damon (1884, p. 77 further noted 'saurian remains' below a 'layer of large flattened septaria', his bed 14, possibly equivalent to the main *Xenostephanus*-rich beds (Cox and Gallois, 1981, p. 5) at the base of the *mutabilis* Zone. Damon (1884, p. 77) also stated that his bed 16 (another horizon higher in the *mutabilis* Zone) also 'contains saurian bones'. BMNH R1798, a partial skull and mandible of *Kimmerosaurus langhami* (no detailed collection data available), most probably came from the cliff exposure between Sandsfoot Castle and the old Portland Ferry Bridge (Damon, 1884; Brown *et al.*, 1986, p. 226).

In his description of *Cetiosaurus humerocristatus*, 'a very large saurian limb-bone', Hulke (1874a, p. 16) noted that 'it was enveloped in large septarian masses, which stuck so closely to it that thin laminae of the surface of the bone were unavoidably detached in stripping the matrix from it'. The nodules probably indicate that the bone came from one of Damon's septarian beds of the *mutabilis* Zone, or from the harbour. Hulke (1874a, p. 16) noted further that 'the bone has been much fissured, and cemented together by spar; and some parts have been distorted by squeezing; but the general figure is well preserved'. The other fossil bones collected here have also been broken and disarticulated.

Other remains, including fragments of juvenile and mature turtles, including the type of *Pelobatochelys blakei*, were noted by the early authors as coming from the junction between the lowest Kimmeridge Clay and the highest Corallian (Oxfordian) horizons. These beds, the Westbury Iron Ore Beds, have formed the subject of many studies, and Blake (1875), for example, concluded that they were 'passage beds'. Other fossils (now lost) seem to have been collected from the uppermost Corallian beds at Sandsfoot itself (Blake and Hudleston, 1877). The ichthyosaur *Brachypterygius extremus* appears to have come from the lowest Kimmeridgian zone or, more probably, from the same 'Passage Beds' (Delair, 1986, p. 133). The fossils from the uppermost Corallian Beds at Sandsfoot show close affinities with those from the immediately overlying Kimmeridgian zones (Arkell, 1935; Brookfield, 1978b; Delair, 1986).

Finds of bones have also been made in Portland Harbour. A jaw fragment of a megalosaurid dinosaur was dredged up in the 1980s (Powell, 1988), and associated ammonites indicated the *autissiodorensis* Zone (top of the Early Kimmeridgian).

The reptile remains from Smallmouth Sands most frequently consist of isolated limb bones, vertebrae or teeth, although partially articulated specimens have been found (e.g. the ichthyosaur paddle described by Boulenger (1904b) and Delair (1987), and several connected series of ichthyosaur vertebrae).

Fauna

Mansel-Pleydell (1888) and Delair (1958, 1959, 1960, 1986) have summarized the reptiles from

'Weymouth'. Some synonymizing can be done as a result of later work, but most of the material has not been studied recently. Most of the Kimmeridge Clay specimens labelled 'Weymouth' may come from the Smallmouth Sands section, on the basis of Damon (1884, pp. 69, 77), outcrop distribution and labels on certain specimens. Repository numbers are given for type specimens, and an estimate of total numbers of each specimen of each species preserved in major collections is appended.

	Numbers
Testudines: Cryptodira: Thalassemyidae	
Acichelys (Eurysternum) sp.	4
Pelobatochelys blakei Seeley, 1875	
Type specimens: BMNH 41235, 44177–8, R2	7
Pelobatochelys sp.	2
Tropidemys langi Rütimeyer, 1873	4
Testudines: Cryptodira: Plesiochelyidae	
Plesiochelys sp.	4
Archosauria: Crocodylia: Thalattosuchia	
Dakosaurus maximus (Plieninger, 1846)	4
Metriorhynchus sp.	3
Steneosaurus sp.	8
Archosauria: Pterosauria	
Rhamphorhynchus manselii (Owen, 1874)	
Type specimen: BMNH 41970	11
Rhamphorhynchus pleydelli (Owen, 1874)	
Type specimen: BMNH 42378	7
Rhamphorhynchus sp.	10
'*Ornithocheirus* sp.'	1
Pterodactylus suprajurensis Sauvage, 1873	1
Archosauria: Dinosauria: Saurischia: Theropoda: Megalosauridae	
megalosaurid	1
Archosauria: Dinosauria: Saurischia: Sauropoda	
Pelorosaurus humerocristatus (Hulke, 1874)	
Type specimen: BMNH 44635	2
Archosauria: Dinosauria: Ornithischia: Ornithopoda	
'hypsilophodontid'	1
Archosauria: Dinosauria: Ornithischia: Stegosauria: Stegosauridae	
Dacentrurus armatus Owen, 1875	1
Sauropterygia: Plesiosauria: Elasmosauridae	
Colymbosaurus trochanterius (Owen, 1840)	7
Cimoliasaurus brevior Lydekker, 1889	
Type specimen: BMNH 41955	1
Sauropterygia: Plesiosauria: Cryptoclididae	
Kimmerosaurus langhami Brown, 1981	1
Sauropterygia: Plesiosauria: Pliosauridae	
Pliosaurus brachydeirus Owen, 1841	5
Pliosaurus sp.	7
Liopleurodon macromerus (Phillips, 1871)	2
Ichthyopterygia: Ichthyosauria	
Brachypterygius extremus (Boulenger, 1904)	
Type specimen: BMNH R3177	1
Macropterygius thyreospondylus (Owen, 1840)	4
'*Ichthyosaurus* sp.'	27

Interpretation

The four genera of turtles from Weymouth are all cryptodires according to the classifications of Gaffney (1975b, 1976, 1979a) and Młynarski (1976). The cryptodires, which retract their head in a vertical plane, are the commonest forms today. The cryptodires arose in the Early Jurassic of North America, but only became reasonably abundant in the Late Jurassic of Europe and North America. *Tropidemys, Acichelys (Eurysternum)* and *Pelobatochelys* are grouped together in the Thalassemyidae and *Plesiochelys* in the Plesiochelyidae, both of which families arose in the Late Jurassic, and are known elsewhere from Germany and Switzerland, as well as the Portlandian of the Isle of Portland (see below).

Acichelys is represented by several remains of carapace and limbs in the BMNH, but these have not been described. *Pelobatochelys blakei* Seeley (1875) was established on the basis of 'fragments of a chelonian carapace' which could include the remains of one or more animals. A restoration showed a broad low carapace about 0.5 m long. The genus was characterized by the broad vertebral scutes which were strongly fluted underneath and by a pointed midline ridge along the neural plates. It is known only from Dorset and from the Smallmouth section in particular.

The material was reviewed by Lydekker (1889b, pp. 152–5) and Delair (1958, pp. 54–5). *Plesiochelys* is represented by some carapace remains and limb bones. The specimens presently ascribed to this genus in the BMNH were initially named *Tropidemys langi* and 'generically undetermined specimens' (Lydekker, 1889b, pp. 156–8) and require restudy. *Tropidemys langi* is represented by isolated carapace elements which were tentatively identified as such by Lydekker (1889b, pp. 156–7). These turtles are all of significance as some of the earliest cryptodires known, but skulls are lacking, and much current taxonomic work depends on cranial characters.

The crocodile remains from Smallmouth consist largely of teeth, and these have been ascribed (Lydekker, 1889a, pp. 94, 100–1; 1890a, p. 233) to *Dakosaurus, Metriorhynchus, Steneosaurus* and *Teleosaurus*, genera well known from the Kimmeridgian. Some vertebrae, scutes and skull fragments of *Steneosaurus* and *Metriorhynchus* have also been collected. The teleosaurs *Steneosaurus* and *Teleosaurus* were medium-sized, long-snouted, marine, fish-eating crocodiles. They are distinguished on the characters of skull shape and tooth arrangement. The metriorhynchid *Dakosaurus* was much larger (up to 4 m body length) and had a relatively short snout. *Metriorhynchus* had a longer snout and was highly adapted for aquatic life; both fore and hind limbs were shortened and paddle-like.

Several remains of pterosaurs from Weymouth have been described. They consist generally of articular ends of limb bones and skull elements, all of which are readily identifiable as pterosaurian. Owen (1874a, pp. 8–11) described two new species, *Pterodactylus manseli* and *P. pleydelli* on the basis of a humerus (proximal end) and wing phalanx and humerus (distal end) and wing phalanx, respectively. Some carpal bones were called '*Pterodactylus* sp. incert.' Lydekker (1888a, pp. 40–1) enumerated these specimens, and others, in the BMNH collections. He noted that there were three species present, distinguished from each other by size, *P. pleydelli* having 'somewhat inferior dimensions' to *P. manseli*, and 'species c' 'of considerably large size than either of the preceding forms'. Lydekker (1891, pp. 41–2) reinterpreted some of the bones he had earlier identified as metacarpals as pterosaur quadrates, and referred one of them to *Pterodactylus suprajurensis*, a species previously described from France. He also noted that *P. manseli* and *P. pleydelli* probably belonged to *Rhamphorhynchus*. Mansel-Pleydell (1888, p. 33) recorded that these specimens came from Kimmeridge, but Delair (1958, p. 70) confirmed Weymouth as the source. Wellnhofer (1978, p. 49) places the two Weymouth species in 'Pterodactylidae *incertae sedis*', but states that both were 'probably remains of rhamphorhynchids'. The lack of diagnostic skull, limb and vertebral remains means that the Weymouth specimens cannot even be confidently assigned to one or other of the two suborders of Pterosauria.

Theropod dinosaurs are represented by a fragment of megalosaurid maxilla (Powell, 1988). The sauropod dinosaur *Pelorosaurus humerocristatus* was based on 'a very large saurian limb-bone adapted for progression upon land', a left humerus originally 1.5 m long (Hulke, 1874a). Lydekker (1888a, p. 152) also referred the dorsal portion of a right pubis from Weymouth to this species. Damon (1884, pp. 69, 77) mentioned specimens of *Gigantosaurus megalonyx* Seeley (1869) from the gritty clay bed (his bed 12) in the Kimmeridge Clay, and Delair (1959, p. 82) suggested that this could include the type humerus of *P. humerocristatus*.

Galton (1975, p. 745) described a dentary tooth from the Kimmeridge Clay of Weymouth (University of California Museum of Paleontology) as that of a hypsilophodontid. Later, he (1980b, p. 85) tentatively suggested that the locality assignment might be wrong because he had seen a strikingly similar tooth from the Late Cretaceous of Wyoming. A stegosaur vertebra (BMNH 15910) has been ascribed to *Dacentrurus armatus* (Galton, 1985b), a stegosaur well known from the Kimmeridge Clay elsewhere in England. This consists of the neural arch of a mid-caudal vertebra, and the short neural spine is a diagnostic character for the species.

The plesiosaur remains from Weymouth are generally isolated vertebrae and limb bones. Most have been ascribed to the cryptoclidid *Colymbosaurus trochanterius* (Owen, 1840), the best-known and most abundant Kimmeridgian plesiosauroid (Brown, 1981), which attained a maximum length of 6.6 m. Lydekker (1889a, p. 243) established the species *Cimoliasaurus brevior* on the basis of six associated centra of immature middle cervical vertebrae from Weymouth; the relative length of the vertebrae was supposed to be diagnostic. Brown (1981, p. 322) noted this species as a *nomen dubium*. A third plesiosaur, represented by a fragmentary skull (BMNH R1798), consisting of an incomplete mandible, the squamosals, and fragments of the quadrates, jugals and postorbitals, was assigned to *Kimmerosaurus langhami* by Brown *et al.* (1986). The species had been named by Brown (1981) on the basis of a partial skull, from the Upper Kimmeridge Clay west of Freshwater Steps. Brown *et al.* (1986, p. 233) discuss the possibility that *Kimmerosaurus* might be synonymous with *Colymbosaurus*, which is the only other cryptoclidid known from the British Kimmeridgian, but the evidence for synonymy is ambivalent and both names are tentatively retained.

The pliosauroids are largely represented by vertebrae and teeth from Weymouth. These have been identified (Lydekker, 1889a, pp. 125, 128, 142, 147) as *Pliosaurus brachydeirus* and *Pliosaurus* sp., and some vertebrae as *Liopleurodon (Stretosaurus) macromerus*.

Ichthyosaurs are represented by abundant remains of vertebrae, limb bones, skull fragments and teeth that were ascribed to various species of '*Ichthyosaurus*' by Lydekker (1889a, pp. 25, 27, 30, 35–40). The most complete specimen (BMNH 44637) consists of 40 vertebrae of a medium-sized individual (Lydekker, 1889a, p. 38). McGowan (1976, p. 670) regards *Macropterygius thyreospondylus* and *M. trigonus* as *taxa dubia* since they were based upon poor material. However, they may be definable (A. Kirton, pers. comm., 1981). Boulenger (1904b) named the new species *Ichthyosaurus extremus* on the basis of a right anterior paddle characterized by its great breadth and by the humerus contacting the wrist bone (the intermedium) directly, and Huene (1922, pp. 91, 97–8) assigned it to the new genus *Brachypterygius*. Boulenger (1904b) did not know its locality, but suggested, on H.B. Woodward's advice, that it came from the Lower Lias of Weston, Bath, while Andrews (1910, p. 54) proposed that it was of Kimmeridgian age. Delair (1960, pp. 68–9) pointed out the surprising fact that the label on the specimen clearly states its provenance as 'Kimmeridge Clay of Smallmouth Sands'. Delair (1986, pp. 131–3) recognized that an isolated left forelimb in Woodspring Museum, Weston-super-Mare (WESTM 78/219) and the type specimen (BMNH R3177) in fact belonged to the same individual.

Comparison with other localities

Sites comparable to the Weymouth section, in having significant terrestrial faunas, include Swindon Brick and Tile Works (Lower Kimmeridge Clay) (SU 142838; *Plesiochelys, Bothriospondylus, 'Megalosaurus', Dacentrurus armatus*, crocodiles, ichthyosaurs, plesiosaurs, pliosaurs); Chawley Brick Pit, Cumnor Hurst, near Oxford, Oxfordshire (SP 475043; *Camptosaurus*, ichthyosaurs, plesiosaurs, pliosaurs); Ely, Cambridgeshire (probably one of several pits at TL 555808; *Thalassemys, Pelorosaurus*, crocodiles, ichthyosaurs, plesiosaurs, pliosaurs); Wootton Bassett, Wiltshire (SU 0638: *Dacentrurus armatus*) and Gillingham, Dorset (ST 809258; *Dacentrurus armatus*).

Of the turtles, *Pelobatochelys* is known also from the Late Kimmeridgian of Encombe Bay (see below), but is restricted to Dorset. *Tropidemys* is known best from the Late Jurassic of Switzerland and Germany and *Eurysternum* from Bavaria and Switzerland (Młynarski, 1976, p. 36). *Thalassemys*, a close relative, has been recorded from Devizes and Ely, as well as from localities in the Late Jurassic of Switzerland and Germany.

Various crocodiles are well represented at Kimmeridge Bay, Wootton Bassett, Swindon, Shotover Hill, Garsington, Cottenham and Ely. *Steneosaurus* and *Teleosaurus* are recorded from all stages of the Jurassic of Europe, *Dakosaurus* from the Late Jurassic to Early Cretaceous of Europe, and *Metriorhynchus* from the Callovian–Kimmeridgian of England and France (Steel, 1973).

Pterosaurs are rare in the British Kimmeridgian. Specimens from Kimmeridge Bay have been identified as '*Rhamphorhynchus* sp.' and *Germanodactylus* sp., and one from Swindon as '*Ornithocheirus* sp.'. These, and other, Late Jurassic pterosaur genera are better known from sites in Germany, France, East Africa and Wyoming, but these overseas sites are younger.

The sauropod *Pelorosaurus* is known from the Kimmeridgian of Kimmeridge Bay (q.v.) and Cottenham, Stretham and Ely, Cambridgeshire. Various species have also been described from the Wealden of Sussex and the Isle of Wight, and from the Kimmeridgian of Boulogne-sur-Mer and Wimille (near Boulogne) (Steel, 1970, pp. 68, 70). *Dacentrurus* is better known from sites in the Kimmeridgian at Gillingham, Wootton Bassett and Swindon, but these are no longer accessible. A specimen from the Late Kimmeridgian of Le Havre, France was destroyed during World War 2 (Buffetaut *et al.*, 1991).

Most of the ichthyosaurs, plesiosaurs and pliosaurs from Weymouth are known from other

British Kimmeridgian sites, so these will not be enumerated. The type of *K. langhami* and the only other referred material (BMNH R10042) is known only from Freshwater Steps (SY 924773).

Conclusions

The Lower Kimmeridge Clay of the Smallmouth Sands section has yielded one of the most varied Kimmeridgian reptile faunas known. It is the best site for turtles (four species) and pterosaurs (three species). The material includes type specimens of one turtle, two pterosaurs, one sauropod, one ichthyosaur and one plesiosaur. *K. langhami* is only the second occurrence of a plesiosauroid from the British Kimmeridgian. One of the best sites in Europe for Kimmeridgian age terrestrial reptiles. The importance of this faunal richness and diversity combined with some potential for future finds give its considerable conservation value.

ROSWELL PITS, ELY, CAMBRIDGESHIRE (TL 555808, TL 552807)

Highlights

Roswell Pits, Ely are famous for the remains of sauropod dinosaurs and of pliosaurs which have been found there. The site includes a mix of terrestrial and marine Kimmeridgian age reptiles, including turtles, crocodilians, dinosaurs, plesiosaurs and ichthyosaurs.

Introduction

The Roswell Pits, or Roslyn Hole, at Ely, excavated in Lower Kimmeridge Clay, have produced a large range of fossil reptiles that includes several type specimens and finds are still being made.

The large pit at Roswell (TL 555808) was excavated in the 19th century, largely for clay to repair the banks of the local fen dykes, and it was mentioned as a source of several reptiles by Seeley (1869a, pp. 100–1), Whitaker *et al.* (1891, p. 15) and Gallois (1988, pp. 40–2). H.B. Woodward (1895, pp. 170–1) noted that the large pit of 'Roslyn Hole' exposed 'about 30 feet of dark shales and clays, in places bituminous and arenaceous, with thin ochreous layers and bands of septaria'. He believed that 'both lower and upper portions of the Kimmeridge Clay are present'.

Description

Whitaker *et al.* (1891, pp. 15–16) described a section in the Roswell Pits, but this does not provide enough evidence for a link to be made with a modern zonation scheme. *Nanogyra virgula* is recorded in abundance in several beds in the upper 5–6 m of the section, and this suggests a position for these units in the *eudoxus* Zone (Early Kimmeridgian). Whitaker *et al.* (1891) and H.B. Woodward (1895) believed that the fossil evidence pointed to the presence of 2–3 m of Upper Kimmeridge Clay at the top of the section.

Arkell (1933, pp. 468–9) ascribed all the beds to the Lower Kimmeridge Clay: 'the opinion formerly held, that at the Roslyn (or Roswell) Pit, 1 mile north-east of Ely, some 8 ft of paper-shales and clays with *Orbiculoidea latissima* are above the limit of *Exogyra virgula*, is not sustained by recent work. Dr Kitchin and Dr Pringle inform me that they have carefully examined the highest beds there and found that their position is not above the zone of *Aulacostephanus pseudomutabilis*.' These beds occupy about 26 ft (8 m) and the main *N. virgula* bed is within 3 ft (1 m) of the top; Arkell (1933) also noted that the 'lowest 4 ft [1.3 m] of clay and shale exposed . . . are marked by a band crowded with *Astarte supracorallina*, and from this level Dr Pringle has recorded *Pararasenia desmonota* (Oppel), characteristic of the *mutabilis* zone' (Pringle, 1923, p. 135). *Nanogyra virgula* is abundant throughout the *eudoxus* Zone, and particularly near the top, in the area of The Wash (Gallois and Cox, 1976), in the Warlingham borehole (Callomon and Cope, 1971), in the Oxfordshire–Buckinghamshire area (Cope, *in* Cope *et al.*, 1980b) and in Dorset (Cox and Gallois, 1981, pp. 5, 15). The ammonite zones present, then, appear to be from the *mutabilis* and *eudoxus* Zones. The second Roswell Pit (TL 552807) was excavated in the 1930s (Gallois, 1988). Several recent finds of teeth and vertebrae have been made on the north side of this pit.

The total thickness of Lower Kimmeridge Clay recorded by Arkell (1933) at Roswell is 8 m of *eudoxus* Zone and 1.3 m of *mutabilis* Zone, thus 9.3 m altogether. Gallois (1988, pp. 40–1) gives a section in the modern pit (TL 552807), comprising about 12 m of *eudoxus* Zone and 1.55 m of *mutabilis* Zone. Gallois and Cox (1976) note, from borehole data, that the Kimmeridge Clay thins southwards along its outcrop from an estimated 84 m in The Wash to 42.3 m at Denver Sluice (TF 591011), 20 km north of Ely.

The exact provenance of the reptiles has not been recorded. It can only be assumed that most of them came from sediments of the *eudoxus* Zone which are thicker. Recently found specimens have all come from these upper portions of the section. Specimens are generally fragmentary – isolated teeth, vertebrae or limb bones. However, some associated series of vertebrae and partial skulls are also known. The bones are generally well preserved, but may lack delicate processes. There has clearly been some post-mortem transport and disturbance of the skeletons.

Fauna

Newton (*in* Whitaker *et al.*, 1891, pp. 16–18) reviewed a collection of reptiles and fishes from Roswell Pits, and H.B. Woodward (1895, p. 171) specifies Roswell (Roslyn) pit as having yielded a large number of reptile and fish remains. It is also assumed that most of the reptiles labelled 'Ely' came from these pits (Gallois, 1988, p. 40). There were no other extensive pits at Ely, and early authors (e.g. Seeley, 1869a, pp. 92–108) specified nearby sites separately (e.g. Chettisham, Littleport, Stretham, Haddenham, Cottenham).

Type specimens are indicated below, and an estimate of the number of specimens from Roswell Pits is given for each species, based on collections in the BMNH and CAMSM.

	Numbers
Testudines: Cryptodira: Thalassemyidae	
Thalassemys hugii Rütimeyer, 1873	5
Archosauria: Crocodylia: Thalattosuchia	
Dakosaurus lissocephalus Seeley, 1869	
Type specimen: CAMSM J.29419	1
Dakosaurus maximus (Plieninger, 1846)	1
Dakosaurus sp.	3
Metriorhynchus hastifer (Deslongchamps, 1868)	1
Metriorhynchus sp.	2
Steneosaurus sp.	1+
Archosauria: Dinosauria: Saurischia: Sauropoda	
Pelorosaurus humerocristatus (Hulke, 1874)	4
Gigantosaurus megalonyx Seeley, 1869	
Paratype specimen: cast of claw (CAMSM)	1
Sauropterygia: Plesiosauria: Elasmosauridae	
Colymbosaurus trochanterius (Owen, 1840)	6
Colymbosaurus sp.	12
Sauropterygia: Plesiosauria: Pliosauridae	
Pliosaurus brachydeirus Owen, 1842	33
Pliosaurus brachyspondylus (Owen, 1840) (Figure 7.2)	
Neotype: CAMSM J.29564	4
Pliosaurus sp.	15
Liopleurodon macromerus (Phillips, 1871)	7
Ichthyopterygia: Ichthyosauria	
Macropterygius trigonus (Owen, 1840)	2
Ichthyosaurus sp.	24

Interpretation

The turtle *Thalassemys hugii* is represented by limb bones and carapace elements. This marine turtle, with a shell length of up to 1.2 m, is well known from the Late Jurassic of Germany and Switzerland (Młynarski, 1976, p. 35). The remains in CAMSM include those of *Enaliochelys chelonia* Seeley, 1869 (p. 108, *nomen nudum*)

The crocodilian remains consist of teeth, jaws and vertebrae, which have been ascribed to the genera *Dakosaurus*, *Metriorhynchus* and *Steneosaurus*. Seeley (1869a, pp. 92–3) erected the species *D. lissocephalus* on the basis of a partial skull, and he ascribed several vertebrae, ribs, limb bones and skull bones to it. He did not specify how this differed from the well-known *D. maximus*, and a restudy will probably show that the two forms are identical (Steel, 1973, p. 42). *Metriorhynchus hastifer* is represented by the anterior end of a snout which was identified by Watson (1911b, p. 9). *Dakosaurus* and *Metriorhynchus* are metriorhynchids, highly aquatic forms. *Steneosaurus*, represented by a vertebra and other remains, is a long-snouted marine fish-eating crocodilian. Without skull material, the identification is not certain.

Large sauropod dinosaurs are represented by several postcranial skeletal elements. The proximal end of a right tibia and a late caudal centrum (casts of CAMSM specimens in BMNH: Lydekker, 1890a, p. 241) were ascribed to *Pelorosaurus humerocristatus*. Seeley (1869a, pp. 94–5) erected the species *Gigantosaurus megalonyx* on the basis of various vertebrae and limb bones from Ely and other sites nearby. Lydekker (1890a, p. 241) ascribed some of these to *P. humerocristatus* and some to *P. manseli*. It is not clear whether all of the remains described by Seeley (1869a) pertain to the same species and which of them he regarded as the type specimen. Hulke (1869a, p. 389) mentioned a cast of the 'large tibia' in the BMNH, as well as 'great ungual phalanx from Ely', and introduced Seeley's name *Gigantosaurus megalonyx* in a footnote. Steel (1970, p. 70) suggests that *G. megalonyx* may be included in *P. humerocristatus*, while McIntosh (1990, p. 356) regards it as a *nomen dubium*. There is clearly a taxonomic problem here, exacerbated by the shortage of comparable material.

Among the commonest remains from Roswell Pits are plesiosaur vertebrae, teeth, and limb bones. The common Kimmeridgian species *Colymbosaurus trochanterius*, up to 6 m long, is well represented. All three Kimmeridgian pliosaurs recognized as valid by Tarlo (1960) are present in the Ely fauna. The Ely material formed the basis for much of the revision carried out by Tarlo (1958, 1959b, 1959c, 1960). *Pliosaurus brachydeirus* is represented by teeth, jaw remains, vertebrae and limb bones (Figure 7.2). It is distinguished from *P. brachyspondylus* on the basis of characters of the vertebrae. This latter species was based on some vertebrae from Headington Pits, near Oxford, which have since been lost, and Tarlo (1959b) selected as neotype a closely matching vertebra from Ely. More important was a skeleton collected at Ely in 1889 (CAMSM J.35991) which consisted of 'numerous teeth, the complete mandible, the greater part of the vertebral column, two limb bones, and fragments of limb girdles' (Figure 7.2). Tarlo (1959b) described this specimen in detail and used it in a revision of pliosaur taxonomy. Characters of the jaw, limbs and limb girdles showed that there

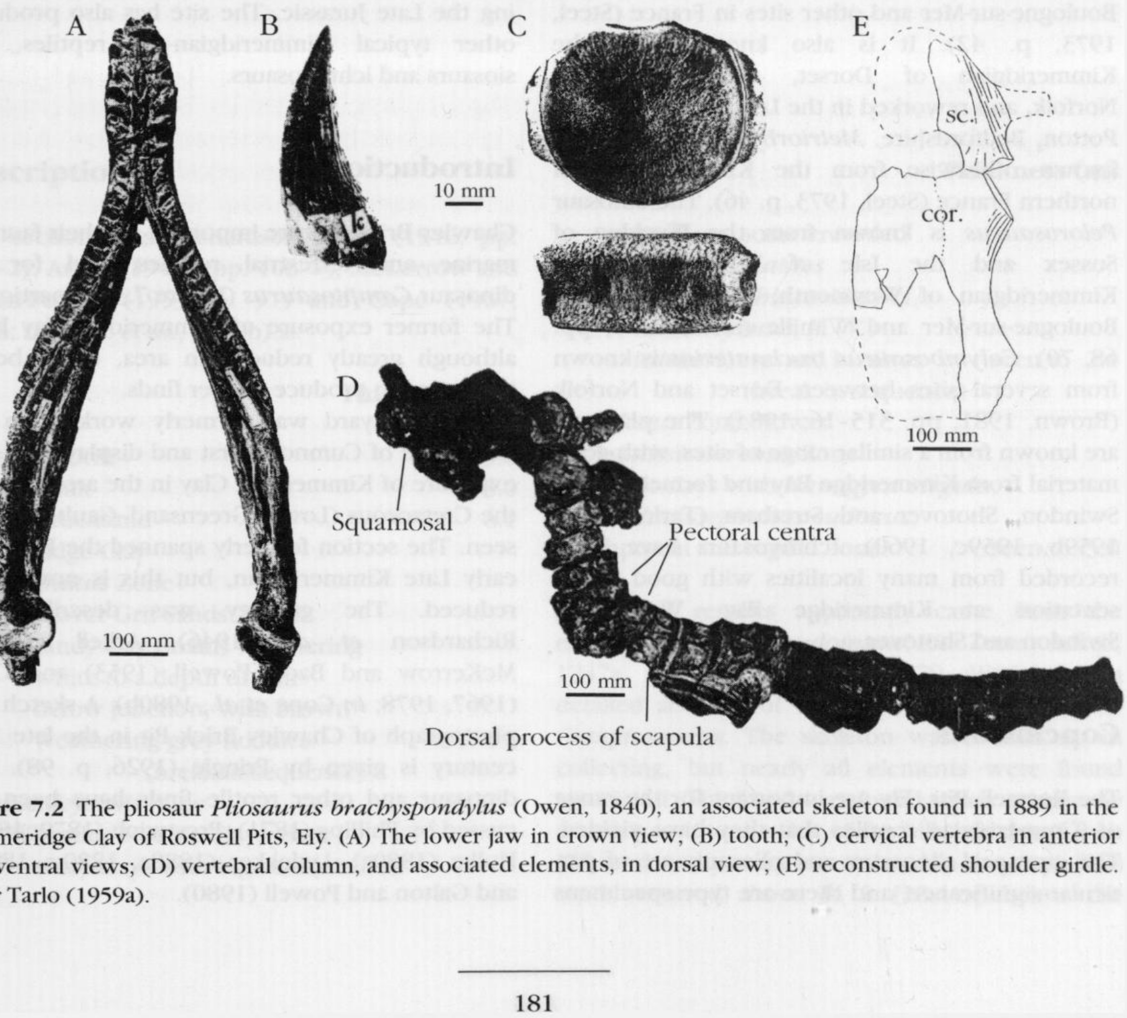


Figure 7.2 The pliosaur *Pliosaurus brachyspondylus* (Owen, 1840), an associated skeleton found in 1889 in the Kimmeridge Clay of Roswell Pits, Ely. (A) The lower jaw in crown view; (B) tooth; (C) cervical vertebra in anterior and ventral views; (D) vertebral column, and associated elements, in dorsal view; (E) reconstructed shoulder girdle. After Tarlo (1959a).

were two genera of Kimmeridgian pliosaur and Tarlo (1959c) erected the genus *Stretosaurus* for *P. macromerus*, but this has since been synonymized with *Liopleurodon*. Some teeth, vertebrae and limb elements of this form are also known from Ely.

Roswell Pits have yielded several ichthyosaur vertebrae, teeth, skull elements and limb bones. Lydekker (1889a, p. 27) mentioned some specimens of *Macropterygius trigonus*, but other bones have not been identified.

Comparison with other localities

Reptiles from the Kimmeridge Clay are known from many other sites in the Wash area, largely old brick-pits, in Northamptonshire, Cambridgeshire and Norfolk, all of which have produced smaller faunas of similar marine and non-marine reptiles (listed at the beginning of this chapter).

Thalassemys hugii is best known from the Late Jurassic of Switzerland and Germany (Młynarski, 1976, p. 35). *Dakosaurus maximus* is also abundant in the Late Jurassic of Switzerland and Germany (Baden-Württemburg), as well as Boulogne-sur-Mer and other sites in France (Steel, 1973, p. 42). It is also known from the Kimmeridgian of Dorset, Oxfordshire and Norfolk, and reworked in the Lower Greensand of Potton, Bedfordshire. *Metriorhynchus hastifer* is known otherwise from the Kimmeridgian of northern France (Steel, 1973, p. 46). The dinosaur *Pelorosaurus* is known from the Wealden of Sussex and the Isle of Wight, and the Kimmeridgian of Weymouth, Kimmeridge Bay, Boulogne-sur-Mer and Wimille (Steel, 1970, pp. 68, 70). *Colymbosaurus trochanterius* is known from several sites between Dorset and Norfolk (Brown, 1981, pp. 315–16; 1984). The pliosaurs are known from a similar range of sites, with good material from Kimmeridge Bay and former sites at Swindon, Shotover and Stretham (Tarlo, 1958, 1959b, 1959c, 1960). Ichthyosaurs have been recorded from many localities with good representation at Kimmeridge Bay, Weymouth, Swindon and Shotover.

Conclusions

The Roswell Pits, Ely are important for the range of Kimmeridgian reptiles that they have yielded. The sauropod dinosaurs and pliosaurs are of particular significance, and there are type specimens of three species from this site. The sauropods are important because of their rarity elsewhere in the European Kimmeridgian, and the pliosaurs from Roswell formed the basis for the taxonomic status of the group in the Late Jurassic. The selection of reptiles present at Ely differs from other good faunas from Dorset and Oxfordshire in the dominance by pliosaurs, and in the apparent absence of pterosaurs. The high conservation value of the site lies in its having yielded one of the richest and most varied Kimmeridgian reptile faunas, being the best site in the northern part of the outcrop of the Kimmeridge Clay and having considerable potential for future finds.

CHAWLEY BRICK PITS, CUMNOR HURST, OXFORDSHIRE (SP 475042)

Highlights

Chawley Brick Pits, Cumnor Hurst are famous for the dinosaur *Camptosaurus*, an important genus that proves a close link with North America during the Late Jurassic. The site has also produced other typical Kimmeridgian-age reptiles, plesiosaurs and ichthyosaurs.

Introduction

Chawley Brick Pits are important for their fauna of marine and terrestrial reptiles, and for the dinosaur *Camptosaurus* (Figure 7.3) in particular. The former exposure of Kimmeridge Clay here, although greatly reduced in area, could be re-excavated to produce further finds.

The brickyard was formerly worked on the north side of Cumnor Hurst and displays the only exposure of Kimmeridge Clay in the area. Parts of the Cretaceous (Lower Greensand–Gault) are also seen. The section formerly spanned the Early and early Late Kimmeridgian, but this is now much reduced. The geology was described by Richardson *et al.* (1946), Arkell (1947a), McKerrow and Baden-Powell (1953) and Cope (1967, 1978; *in* Cope *et al.*, 1980b). A sketch of a photograph of Chawley Brick Pit in the late 19th century is given by Pringle (1926, p. 98). The dinosaur and other reptile finds have been discussed by Phillips (1871), Prestwich (1879, 1880), Hulke (1880a), Lydekker (1888a, 1889c, 1890a) and Galton and Powell (1980).

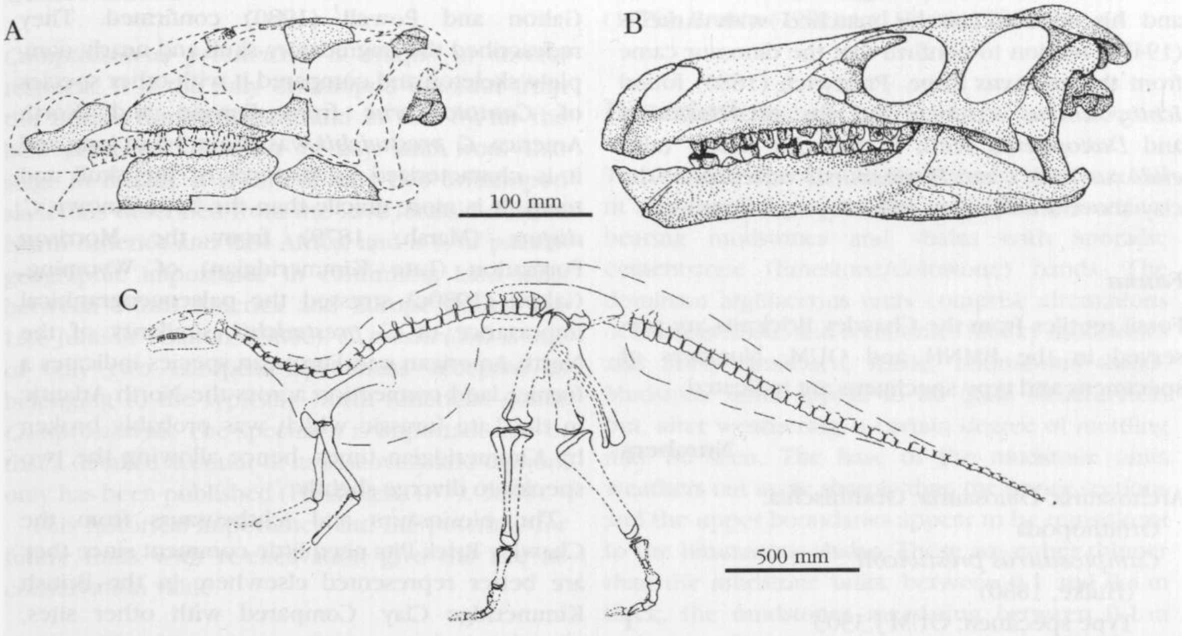


Figure 7.3 The ornithopod dinosaur *Camptosaurus*. (A) Partial restoration of the skull of *C. prestwichii* (Hulke, 1880) showing the known fragments of bone; (B) restored skull of the North American *C. dispar* Marsh, 1879; (C) restoration of the skeleton of *C. prestwichii* (Hulke, 1880): the bones present include parts of the skull, much of the vertebral column, forelimbs and hindlimbs. After Galton and Powell (1980).

Description

The section after Richardson *et al.* (1946, pp. 100–2), Arkell (1947a, pp. 106–7), McKerrow and Baden-Powell (1953, p. 97) and Cope (1967, 1978; *in* Cope *et al.*, 1980b) is:

	Thickness (m)
Northern Drift	3.0
Lower Gault	3.0
Lower Greensand	6.1
Kimmeridge Clay	
?*pectinatus* Zone	
Shotover Grit Sands: bluish sandy clay (loam) weathering white to a depth of 1 m below junction, with brown weathering grey nodules	*c*. 4.3
(break in sequence)	
wheatleyensis Zone	
Wheatley Nodule Clays; dark shaly clays with big cementstone crackers, some crowded with *Pectinatites (Virgatosphinctoides)* cf. *wheatleyensis, P. (V.) tutcheri*, etc. and bivalves	seen to 2.4
(break in sequence)	
eudoxus Zone, ?lower *autissiodorensis* Zone	
dark clays with *Nanogyra virgula, Aulacostephanus eudoxus*, aptychi and reptile bones	seen to 3.0

The fossil reptiles apparently came from the *eudoxus* Zone ('*pseudomutabilis* Zone' Arkell, 1947a, p. 106). Prestwich (1879, 1880) gave a detailed account of the finding of the dinosaur *Camptosaurus*. The skeleton was broken up in collecting, but nearly all elements were found associated. The fossil was found when a tramway was driven into the side of the hill 'in a thin 3 inch [75 mm] sandy seam intercalated in the clay'. This sand occurred about 34 ft (10.4 m) below the

Lower Greensand, according to Prestwich (1880), and his section can be matched with Arkell's (1947a) section to confirm that the dinosaur came from the *eudoxus* Zone. Prestwich (1880) found *Ichthyosaurus* vertebrae and ribs and *Pliosaurus* and *Dakosaurus* teeth in the clay below (also *eudoxus* Zone), and *Plesiosaurus* vertebrae in the clay above (*eudoxus* or *wheatleyensis* Zone).

Fauna

Fossil reptiles from the Chawley Brickpits are preserved in the BMNH and OUM. Numbers of specimens and type specimens are indicated.

	Numbers
Archosauria: Dinosauria: Ornithischia:	
Ornithopoda	
Camptosaurus prestwichii (Hulke, 1880)	
Type specimen: OUM J.3303	1
'dinosaur limb'	1
Sauropterygia: Plesiosauria:	
Elasmosauridae	
Colymbosaurus trochanterius (Owen, 1840)	
Including 'type specimens' of *Plesiosaurus validus* Phillips, 1871, OUM J.2854–6	*c.* 5
Sauropterygia: Plesiosauria: Pliosauridae	
Pliosaurus brachydeirus Owen, 1841	1
Pliosaurus sp.	8
Liopleurodon macromerus (Phillips, 1871)	3
Ichthyopterygia: Ichthyosauria	
Macropterygius thyreospondylus (Owen, 1840)	2
Macropterygius trigonus (Owen, 1840)	3
ichthyosaur indet.	5

Interpretation

The ornithopod *Camptosaurus prestwichii* (see Figure 7.3) was named *Iguanodon prestwichii* by Hulke (1880a). Seeley (1888c) placed it in the new genus *Cumnoria* because of its differences from *Iguanodon*, but Lydekker (1888a, p. 196) questioned the validity of the new genus and returned the species to *Iguanodon*. Then Lydekker (1889c, p. 46; 1890a, p. 258) noted its provisional assignment to *Camptosaurus* because of close resemblance to *C. leedsi* Lydekker, 1889 from the Oxford Clay of Peterborough, which Galton and Powell (1980) confirmed. They redescribed the fragmentary skull and nearly complete skeleton and compared it with other species of *Camptosaurus* from Europe and North America. *C. prestwichii* was about 3.5 m long and it is characterized by features of the skull and teeth. It is more gracile than the better-known *C. dispar* (Marsh, 1879) from the Morrison Formation (Late Kimmeridgian) of Wyoming. Galton (1980c) stressed the palaeogeographical importance of *C. prestwichii*: similarity of the North American and European species indicates a former land connection across the North Atlantic in the Late Jurassic which was probably broken by Kimmeridgian times, hence allowing the two species to diverge slightly.

The plesiosaurs and ichthyosaurs from the Chawley Brick Pits need little comment since they are better represented elsewhere in the British Kimmeridge Clay. Compared with other sites, Chawley lacks crocodiles and turtles. The plesiosaurs, represented by vertebrae and skull remains, probably all belong to *Colymbosaurus trochanterius* (Owen, 1840), the commonest valid Kimmeridgian genus (Brown, 1981). The species *P. validus* Phillips (1871) was based on vertebrae from Shotover, Cumnor and Baldon (Phillips, 1871, pp. 370–2), but Brown (1981, p. 324) regarded the species as a *nomen dubium*. The rarer ichthyosaur remains include several species regarded as *taxa dubia* by McGowan (1976), but a detailed revision is required (A. Kirton, pers. comm., 1981).

Comparison with other localities

The plesiosaurs, pliosaurs and ichthyosaurs from Chawley are typical of other British Kimmeridgian Clay sites. The dinosaur *Camptosaurus* has been recorded elsewhere in the European Kimmeridgian only from Portugal (a femur, Galton, 1980c). Dinosaur bones have been recorded elsewhere in the British Kimmeridge Clay from Kimmeridge Bay (*Pelorosaurus*); Smallmouth Sands, Dorset (*Pelorosaurus, Dacentrurus*); Gillingham, Dorset (*Dacentrurus*); Foxhangers, Wiltshire (?*Megalosaurus*); Rodbourne, Wiltshire (ankylosaur); Wootton-Bassett, Wiltshire (*Dacentrurus*); Swindon, Wiltshire (*Bothriospondylus, Dacentrurus*), Cottenham, Cambridgeshire (*Pelorosaurus*) and Ely, Cambridgeshire (*Pelorosaurus, Dacentrurus*), all but the first two and the last are lost as collecting sites.

Conclusions

Camptosaurus prestwichii is unique in several respects. It is the only ornithopod dinosaur from the British Kimmeridgian, and in fact by far the best preserved dinosaur of any kind from that stage in Britain. It is one of only two ornithopod skeletons described from the Late Jurassic outside North America and East Africa, and it is of palaeogeographic importance in confirming land links between North America and Europe during the Late Jurassic (Galton, 1980c). *C. prestwichii* is one of only two European specimens accepted as belonging to the typically North American genus *Camptosaurus*. The specimen is important also in that a detailed account of its discovery and taphonomy has been published (Prestwich, 1879, 1880).

This historical importance and the potential for future finds with re-excavation give the site its conservation value.

KIMMERIDGE BAY (GAULTER GAP–BROAD BENCH), DORSET (SY 898789–SY 908787)

Highlights

Gaulter Gap–Broad Bench includes the famous fossil reptile sites of Kimmeridge Bay (Figure 7.4). Nearly 20 species of crocodilians, pterosaurs, dinosaurs, plesiosaurs and ichthyosaurs have been found there, including the original specimens of seven species.

Introduction

The Kimmeridge Clay of Kimmeridge Bay, Dorset, is world-famous for its marine reptiles (see Figure 7.8). Several fine ichthyosaur skeletons have been collected, as well as skulls, vertebrae and limb bones of a variety of other fossil reptiles. The cliffs and foreshore reefs of Kimmeridge Bay are subject to continuing erosion, and several finds have been made in recent years. It clearly has considerable potential for future discoveries. The geology of the site has been recorded by many authors, but in most detail by Cope (1967; *in* Torrens, 1969a; *in* Cope *et al*., 1988b). The fossil reptiles have been described by Owen (1869, 1884a), Hulke (1869a, 1869b, 1870a, 1870b, 1870c, 1871a, 1871b, 1872a, 1874a), Woodward (1885), Lydekker (1888a, 1889a), Huene (1922), Tarlo (1960), McGowan (1976), Brown (1981) and Unwin (1988a).

Description

The Kimmeridge Clay in Kimmeridge Bay is a 138 m sequence of grey to dark grey-blue, ammonite-bearing mudstones and shales with sporadic cementstone (limestone/dolostone) bands. The dominant argillaceous units comprise alternations of homogeneous and sometimes blocky mudstones and finely laminated, fissile, bituminous shales. Mudstone units appear to be quite structureless but, after weathering, a certain degree of mottling may be seen. The base of the mudstone units weathers out more sharply than the upper sections and the upper boundaries appear to be transitional to the bituminous shales. These are rather thinner than the mudstone units, between 0.1 and 0.4 m thick, the mudstones measuring between 0.1 m and about 1 m in thickness. Erosion of the mudstones and shales is rapid, but the cementstone bands resist erosion and stand out.

At Kimmeridge Bay, the beds dip south-east and there are several faults. The general sequence, based on Cope (1967; *in* Torrens, 1969a; *in* Cope *et al*., 1980b) is:

	Thickness (m)
Late Kimmeridgian (formerly Mid Kimmeridgian)	
wheatleyensis Zone	
Grey Ledge Stone Band	0.7
scitulus Zone	
Upper Cattle Ledge Shales	10.8
Cattle Ledge Stone Band	0.5
Lower Cattle Ledge Shales	15.0
Yellow Ledge Stone Band	0.4
	27.4
elegans Zone	
Hen Cliff Shales	21.5
Double band of cementstone with shale	1.1
	22.6
Lower Kimmeridgian	
autissiodorensis Zone	
Maple Ledge Shales	22.5
Maple Ledge Stone Band	0.3
Gaulter's Gap Shales	32.0
Washing Ledge Stone Band	0.35
Washing Ledge Shales (upper part)	8.0
	63.15

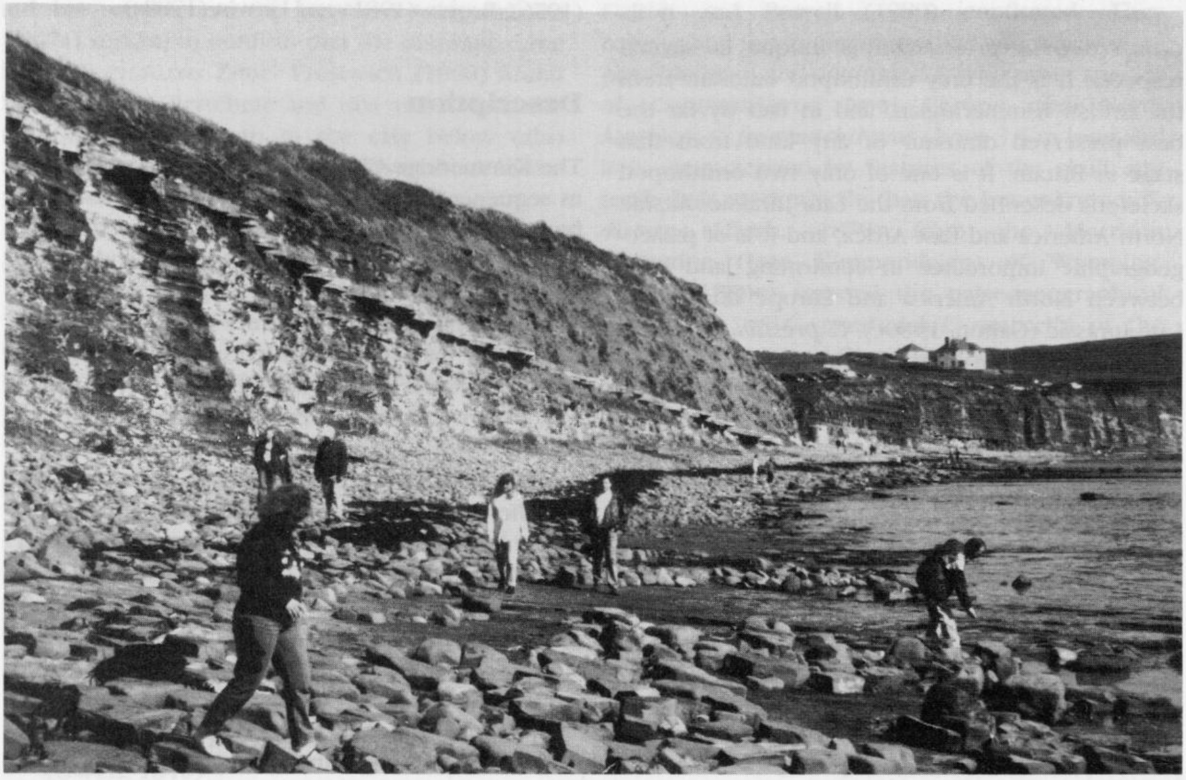


Figure 7.4 The Kimmeridgian of Kimmeridge Bay, showing dipping limestone and shale units, facing south. (Photo: M.J. Benton.)

	Thickness (m)
eudoxus Zone	
Washing Ledge Shales (lower part)	5.0
The Flats Stone Band	0.5
Shales	3.0
Nannocardioceras Bed	0.02
Shales	1.0
Shales	seen to 15.0
	24.52

The sediments of the *Aulacostephanus eudoxus* and *A. autissiodorensis* Zones are exposed between Broad Ledge and Maple Ledge. The named stone bands reach shore level as follows: The Flats at Broad Bench (SY 897787) and at The Flats (SY 905792); Washing Ledge (SY 907791); Maple Ledge (SY 909789). Hen Cliff, between Clavell Tower and Cuddle, exposes the *elegans, scitulus* and *wheatleyensis* Zones (the *Pectinatites* Zones). The stone marker bands include the Yellow Ledge which reaches the shore at Yellow Ledge (SY 912782), and the Cattle Ledge and the Grey Ledge higher in the cliff.

The fauna of the Kimmeridge Clay is restricted to the mudstones and bituminous shale units and in both units is essentially the same, being dominated by infaunal bivalves, including *Lucina* and *Protocardia*. There is also an encrusting epifauna, but this is restricted, consisting only of oysters (*Liostrea* and *Nanogyra*). Minor elements include *Discina, Lingula, 'Gervillia', Entolium* and aporrhaid gastropods. The other biofabrics in the mudstones are quite different from those in the bituminous shales, indicating different post-mortem histories of the fauna and thus different environmental conditions (Aigner, 1980). This limited biota indicates somewhat oxygen-depleted bottom conditions, and that the reptiles must have occupied a mid-water zone.

Most specimens bear the locality and horizon description 'Kimmeridge'. However, a few more specific references indicate that reptiles have been found at all points round Kimmeridge Bay and in Hen Cliff (see Figure 7.6), and at various levels in the *Aulacostephanus* Zones and *Pectinatites* Zones. Arkell (1933, p. 451) considered that most specimens came from the Early

Kimmeridgian and noted that the types of *Steneosaurus manseli* and *Ichthyosaurus enthekiodon* were found embedded in reefs exposed at low water in the bay. Delair (1986, p. 133) notes parts of a disarticulated specimen of the ichthyosaur *Ophthalmosaurus* from 'a level approximately 2.5 feet below the base of the *wheatleyensis* Subzone' at Rope Lake Head. Hulke (1869a, p. 386) reported a large 'saurian humerus' (the type of *Ornithopsis manseli* Hulke, 1869a) from 'amongst the layers of shale immediately above the band of cement-stone which rises from East to West on the west side of Clavell's Tower, between Kimmeridge Bay and Clavell's Head'. This probably refers to the Maple Ledge Shales above the Maple Ledge Stone Band (thus *autissiodorensis* Zone), at a site around SY 909789. Clarke and Etches (1992) record a fine mandible of *Liopleurodon macromerus* from the *autissiodorensis* Zone of 'Kimmeridge Bay'. Hulke (1871b, p. 442) described a crocodile snout (the type of *Teleosaurus megarhinus* Hulke, 1871) that had fallen from the cliff in the bay. The exact locality is uncertain, but it must have come from one of the *Aulacostephanus* Zones. A specimen of *Plesiosaurus* collected in 1971 (CAMMZ T962) is recorded to have come from 5 ft below The Flats Stone Band at Broad Bench (SY 898789), thus in shales of the *eudoxus* Zone. Likewise, Unwin (1988a) reports vertebrae and limb elements of the pterosaur *Germanodactylus* from '5 m below the Flats Stone Band (*eudoxus* Zone ... at Charnel (NGR 899789))'.

Several finds have been reported from the early portion of the Late Kimmeridgian. Hulke (1870c) described some *Plesiosaurus* vertebrae (the types of *P. manseli* Hulke, 1870) from the cliffs east of Clavell Tower, thus probably *scitulus* Zone. Brown (1981, p. 315) ascribes these to the *pectinatus* Zone (Late Kimmeridgian), but this is unlikely since that zone only appears in the cliffs between Rope Lake Head and Encombe Bay, 2–3 km south east of the Clavell Tower. Cope (1967, p. 10) mentions further remains from the Late Kimmeridgian, the anterior part of a skeleton of *Ophthalmosaurus* 12 ft (4 m) above the Cattle Ledge Stone Band (*scitulus* Zone), and a pliosaur tooth about 5 ft (1.5 m) above the Yellow Ledge Stone band (*scitulus* Zone). A limb bone of *Pliosaurus* (DORCM G187) was found on the foreshore below Clavell Tower.

All of the finds appear to have been made in the shales. Hulke (1869b, p. 390) characterized the matrix of a *Steneosaurus* as 'hard pyritic claystone'. The skeletal elements are frequently disarticulated, but not particularly worn; teeth may be in place and delicate bone processes unbroken. The only nearly complete skeletons found appear to be those of ichthyosaurs (Hulke, 1871a; Cope, 1967, p. 10; Macfadyen, 1970, p. 126). The pterosaur *Germanodactylus* consisted of partially disarticulated bones, some of which were heavily crushed (Unwin, 1988a).

Fauna

Mansel-Pleydell (1888) and Delair (1958, 1959, 1960) gave long lists of reptiles from Kimmeridge Bay, totalling 33 or more species. As a result of recent revisions of the ichthyosaurs (McGowan, 1976; Angela Kirton, pers. comm.), pliosaurs (Tarlo, 1960) and the plesiosaurs (Brown, 1981), many of these species have been synonymized. A revised list of the reptiles is given here, with the repository numbers of type specimens. The approximate numbers of specimens of each species in major British collections are appended in order to give an impression of the relative abundance of each form.

	Numbers
Archosauria: Crocodylia: Thalattosuchia	
Dakosaurus maximus (Plieninger, 1846) Type specimen of *Steneosaurus manseli* Hulke,1870; BMNH 40103	1
Machimosaurus mosae Sauvage and Lienard, 1879	1
Steneosaurus megarhinus (Hulke, 1871) Type specimen: BMNH 43186	1
Archosauria: Pterosauria	
'*Rhamphorhynchus* sp.'	1
Germanodactylus sp.	1
Archosauria: Dinosauria: Saurischia: Sauropoda	
Pelorosaurus manseli (Hulke ms. Lydekker, 1888) Type specimen: BMNH 41626	1
Sauropterygia: Plesiosauria: Elasmosauridae	
Colymbosaurus trochanterius (Owen, 1840) Includes type of *Plesiosaurus manseli* Hulke, 1870: BMNH 40106	6
'*Plesiosaurus brachistospondylus*' Hulke, 1870	

	Numbers
Type specimen: BMNH 45869	3
'*Plesiosaurus*' sp.	4
Sauropterygia: Plesiosauria: Pliosauridae	
Pliosaurus brachydeirus Owen, 1841	2
Pliosaurus brachyspondylus (Owen, 1840)	1
Pliosaurus sp.	9
Liopleurodon macromerus (Phillips, 1871)	8
Ichthyopterygia: Ichthyosauria	
Macropterygius dilatatus (Phillips, 1871)	1
Macropterygius ovalis (Phillips, 1871)	
Type specimen: OUM J.12487	1
Macropterygius trigonus (Owen, 1840)	1
Nannopterygius enthekiodon (Hulke, 1870)	
Type specimen: BMNH 46497, a	1
Ichthyosaurus sp.	1

Interpretation

The Kimmeridge Clay marks a period of widespread clay sedimentation in north-west Europe in environments that were clearly fully marine. The thick series of clays and bituminous shales are considered to have been deposited in calm bottom waters, and anaerobic conditions may have prevailed in a stratified water column (Aigner, 1980), an environment similar to the present-day Black Sea. The sediments are essentially terrigenous in origin, indicating considerable erosion from a nearby landmass (?the London–Ardennes island and Cornubia), although there are no obvious plant macrofossils.

The remains of crocodiles from Kimmeridge Bay are mainly partial skulls with occasional associated vertebrae. *Dakosaurus*, a large animal, often up to 4 m long, is represented by a partial skull of a relatively short-snouted form (BMNH 40103). Hulke (1870a) described it as the type specimen of *Steneosaurus manseli*. Owen (1884a) referred this species to a new genus, *Plesiosuchus*, but Woodward (1885) included it in *Dakosaurus*.

Machimosaurus and *Steneosaurus* are long-snouted teleosaurs, common in marine deposits from the Early Jurassic to the Early Cretaceous of Europe and other continents. *M. mosae* was based on specimens from the Kimmeridgian of Issoncourt (near Verdun), and Lydekker (1888a) referred to this species the occipital region of a cranium and an associated mandible from Kimmeridge Bay (BMNH R1089). These specimens were originally figured by Owen (1869) as *Pliosaurus trochanterius*, but Deslongchamps (1869, p. 329) realized their crocodilian nature and ascribed them to *Metriorhynchus*, a determination followed by Woodward (1885). The species *M. mosae* was apparently based on heterogeneous material, some of it probably mosasaurian, and it is probably invalid (Krebs, 1967; Steel, 1973, p. 25). Thus the Dorset material could be ascribed to the type species, *M. hugii* Meyer, 1837. *Steneosaurus megarhinus* (Hulke, 1871b) was based on a slender rostrum, 430 mm long and with greatly expanded premaxillae each containing five alveoli (Figure 7.5A). Hulke originally ascribed this to *Teleosaurus*.

The pterosaur '*Rhamphorhynchus*' is represented by a single specimen (BMNH R1936), and *Germanodactylus* likewise (Etches Collection K96; Unwin, 1988a). Both finds extend the ranges of these taxa from Germany to England, and into even earlier Kimmeridgian strata than those at Solenhofen. Pterosaurs are better known from the Kimmeridge Clay of Weymouth, but the Kimmeridge Bay *Germanodactylus* is the oldest of the family Germanodactylidae in the world, and possibly the oldest pterodactyloid pterosaur (Unwin, 1988a).

The sauropod *Pelorosaurus* is represented by a large humerus (BMNH 41626). This 'stupendous bone' (Hulke, 1869a), when pieced together, had a length of 0.8 m. Hulke (1869a, 1874a) considered that it belonged to a great crocodile. He named it *Ischyrosaurus* Hulke, 1874, and Lydekker (1888a, p.152) later placed it with the large sauropod dinosaurs in *Ornithopsis manseli* Lydekker, 1888. *Ornithopsis*, and many other generic names given to large dinosaur bones from the Late Jurassic and Early Cretaceous of Europe, have been synonymized with *Pelorosaurus* (Steel, 1973, pp. 68, 70; McIntosh, 1990). *Pelorosaurus* is placed in the Brachiosauridae, but familial assignment of such isolated elements is clearly problematic.

The most abundant remains from Kimmeridge Bay are plesiosaurs (Figure 7.5B). *Colymbosaurus trochanterius* (Owen, 1840), of which *Plesiosaurus manseli* Hulke, 1870 is a synonym (Lydekker, 1889a; Brown, 1981, pp. 316–17, 337), is the largest Late Jurassic plesiosauroid, with an estimated total length of 6.15 m for the type specimen of *P. manseli* (BMNH 40106). The

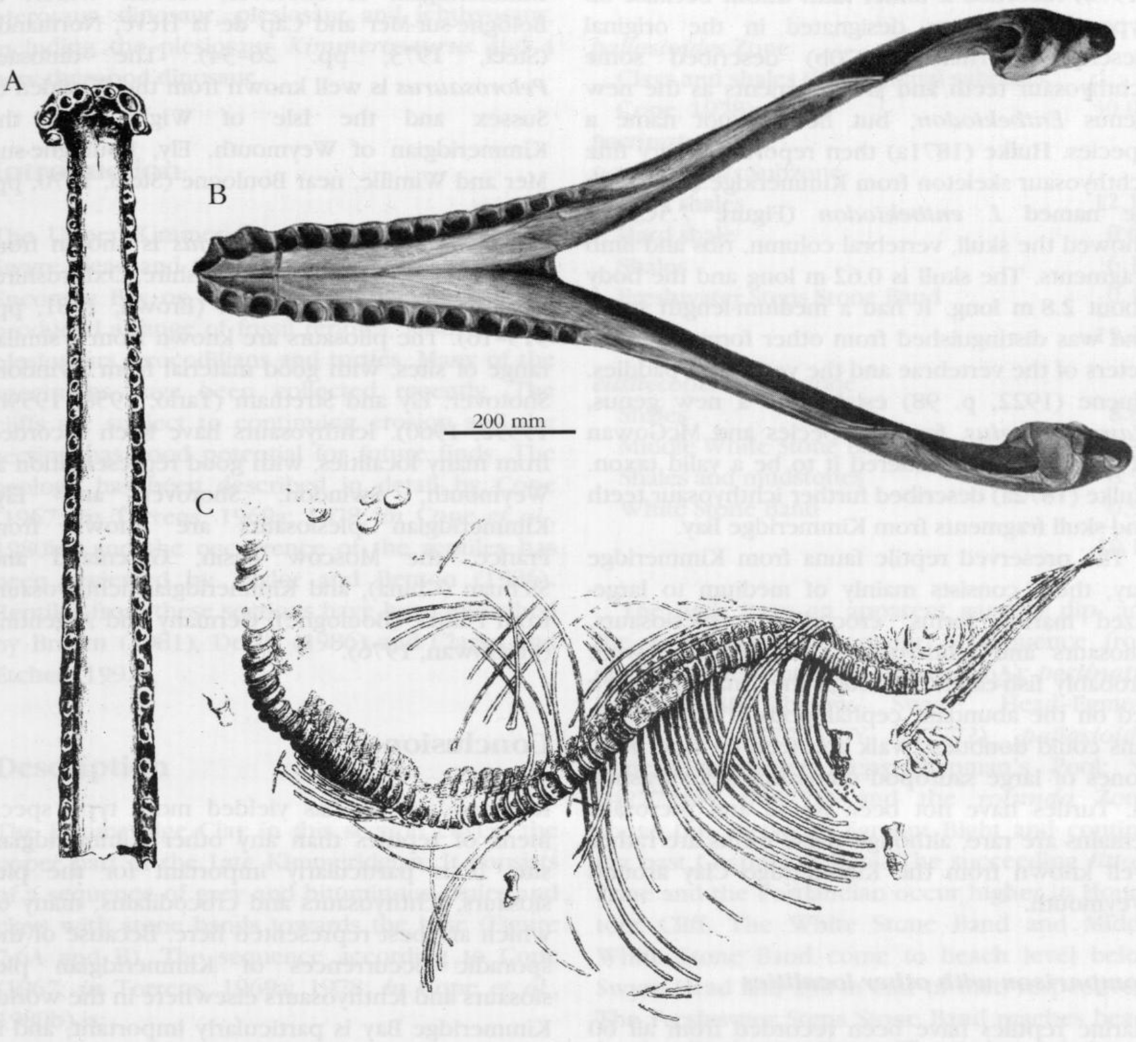


Figure 7.5 Kimmeridgian reptiles from Kimmeridge Bay, Dorset. (A) The elongate slender snout of the marine crocodile *Steneosaurus megarhinus* (Hulke, 1871) in ventral view; (B) lower jaw of *Colymbosaurus trochanterius* (Owen, 1840) in crown view; (C) skeleton of the ichthyosaur *Nannopterygius (Ichthyosaurus) enthekiodon* (Hulke, 1871). (A) after Hulke (1871b); (B) after Owen (1861); (C) after Hulke (1871a).

specimen consists of an extensive series of vertebrae, pieces of two humeri and several paddle bones. Other specimens of *C. trochanterius* from Kimmeridge Bay are a series of vertebrae and isolated limb bones. The type specimen of *P. brachistospondylus* Hulke, 1870 consists of five compressed dorsal vertebrae, some rib fragments and finger elements. Hulke (1870a) regarded the great height and breadth of the vertebrae as unique, but Brown (1981, p. 322) considered the species a *nomen dubium*.

The pliosaurs are represented largely by jaw fragments and teeth, belonging to all three Kimmeridgian species recognized by Tarlo (1960) as valid. *P. brachydeirus* is distinguished from *P. brachyspondylus* on the basis of details of the vertebrae and from *Liopleurodon macromerus*, with its short mandibular symphysis, as well as characters of the vertebrae and tooth arrangement. The assignments of many of the Dorset specimens were made before Tarlo's work and revisions may be necessary.

Finally, at least five specimens of ichthyosaurs have been collected. Phillips (1871, p. 339) described the new species *Ichthyosaurus ovalis* on the basis of some vertebral centra from Kimmeridge Bay which have never been figured (identified as OUM J.12487 on labels). McGowan

(1976) recorded it under *taxa dubia* because no type material was designated in the original description. Hulke (1870b) described some ichthyosaur teeth and jaw fragments as the new genus *Enthekiodon*, but he did not name a species. Hulke (1871a) then reported a very fine ichthyosaur skeleton from Kimmeridge Bay which he named *I. enthekiodon* (Figure 7.5C). It showed the skull, vertebral column, ribs and limb fragments. The skull is 0.62 m long and the body about 2.8 m long. It had a medium-length snout and was distinguished from other forms by characters of the vertebrae and the very small paddles. Huene (1922, p. 98) established a new genus, *Nannopterygius*, for this species and McGowan (1976, p. 671) considered it to be a valid taxon. Hulke (1872a) described further ichthyosaur teeth and skull fragments from Kimmeridge Bay.

The preserved reptile fauna from Kimmeridge Bay, then, consists mainly of medium to large-sized marine forms: crocodilians, plesiosaurs, pliosaurs and ichthyosaurs. All of these were probably fish-eaters, although they may also have fed on the abundant cephalopods. The crocodilians could doubtless walk and feed on land. Rare bones of large sauropod dinosaurs were washed in. Turtles have not been found and pterosaur remains are rare, although these forms are rather well known from the Kimmeridge Clay around Weymouth.

Comparison with other localities

Marine reptiles have been recorded from all 60 sites in the Kimmeridge Clay of Dorset, Wiltshire, Oxfordshire, Buckinghamshire, Cambridgeshire, Norfolk, Lincolnshire and Yorkshire (listed at the start of the chapter). However, most sites have yielded little more than a few vertebrae or limb elements of one or two species. Sites comparable to Kimmeridge Bay include Smallmouth Sands, Weymouth (SY 6697–SY 672771), and other sites listed under that locality.

The crocodile *Dakosaurus* (Jurassic–Early Cretaceous of Europe) occurs in the Kimmeridge Clay of Ely, Shotover, Norfolk and Boulogne-sur-Mer (Steel, 1973, pp. 42–4). *Machimosaurus* has been recorded from the Kimmeridgian of Shotover, Boulogne-sur-Mer, Verdun and Hanover, as well as the Late Jurassic of Portugal and the Portlandian of Switzerland and Austria (Steel, 1973, p. 25). *Steneosaurus* is known from the Jurassic of many localities in Europe and elsewhere. It has been recorded from the Kimmeridgian of Shotover, Moulin Wibert at Bologne-sur-Mer and Cap de la Hève, Normandy (Steel, 1973, pp. 26–34). The dinosaur *Pelorosaurus* is well known from the Wealden of Sussex and the Isle of Wight, and the Kimmeridgian of Weymouth, Ely, Boulogne-sur-Mer and Wimille, near Boulogne (Steel, 1970, pp. 68, 70).

Colymbosaurus trochanterius is known from several former localities in Wiltshire, Oxfordshire, Cambridgeshire and Norfolk (Brown, 1981, pp. 315–16). The pliosaurs are known from a similar range of sites, with good material from Swindon, Shotover, Ely and Stretham (Tarlo, 1958, 1959b, 1959c, 1960). Ichthyosaurs have been recorded from many localities, with good representation at Weymouth, Swindon, Shotover and Ely. Kimmeridgian plesiosaurs are known from France, the Moscow Basin, Greenland and Sichuan (China), and Kimmeridgian ichthyosaurs from France (Boulogne), Germany and Argentina (McGowan, 1976).

Conclusions

Kimmeridge Bay has yielded more type specimens of reptiles than any other Kimmeridgian site. It is particularly important for the plesiosaurs, ichthyosaurs and crocodilains, many of which are best represented here. Because of the sporadic occurrences of Kimmeridgian plesiosaurs and ichthyosaurs elsewhere in the world, Kimmeridge Bay is particularly important, and it has figured prominently in recent reviews of marine reptiles (Tarlo, 1960; McGowan, 1976; Brown, 1981). The pterosaurs *Rhamphocephalus* and *Germanodactylus*, although more poorly preserved than the original material from Bavaria, are significantly older (Unwin, 1988a). The conservation value lies in the international importance of the site and its considerable potential for future finds.

ENCOMBE BAY, SWYRE HEAD–CHAPMAN'S POOL, DORSET (SY 937773–SY 955771)

Highlights

Swyre Head to Chapman's Pool includes an important array of late Kimmeridgian reptile sites.

These have produced various species of turtle, pterosaur, dinosaur, plesiosaur and ichthyosaur, including the plesiosaur *Kimmerosaurus* and a new theropod dinosaur.

Introduction

The Upper Kimmeridge Clay exposed between Swyre Head and Chapman's Pool also known as Encombe Bay or Egmont Bight (Figure 7.6) has produced a range of fossil reptiles, ichthyosaurs, plesiosaurs, crocodilians and turtles. Many of the specimens have been collected recently. The cliffs are subject to continuing erosion and the section has good potential for future finds. The geology has been described in detail by Cope (1967; *in* Torrens, 1969a; 1978; *in* Cope *et al.*, 1980b), and the occurrence of the reptiles has been reviewed by Taylor and Benton (1986). Reptiles from these sections have been described by Brown (1981), Delair (1986) and Clarke and Etches (1992).

Description

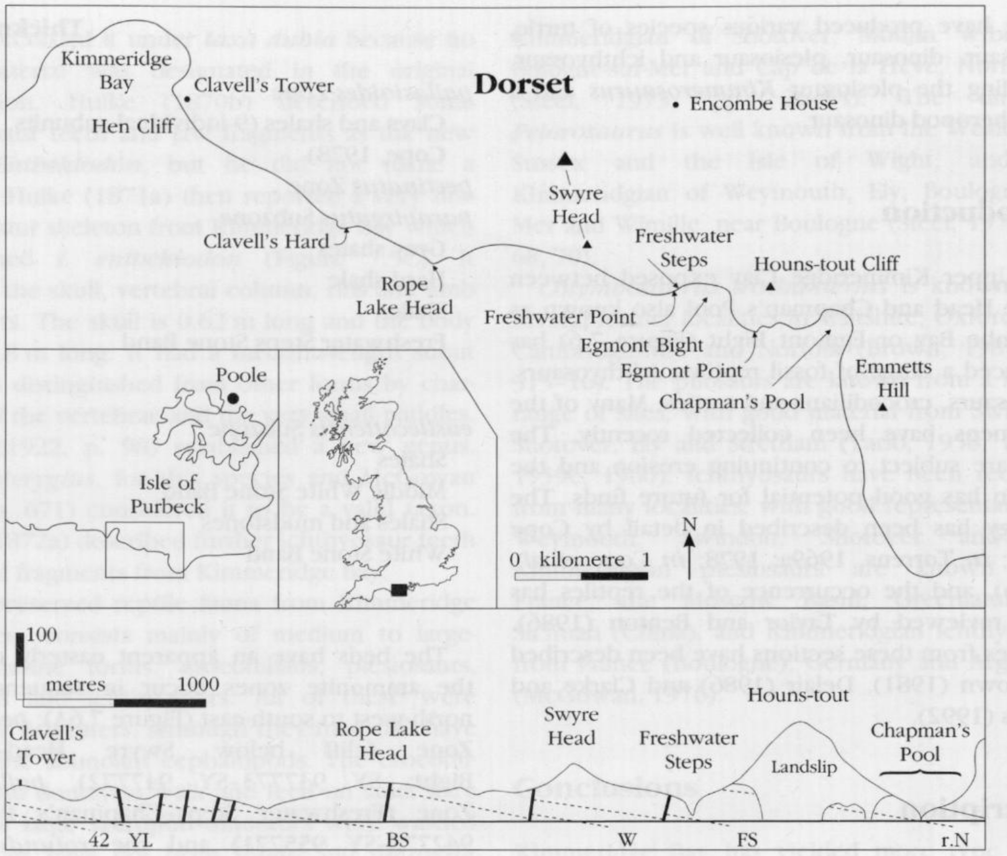
The Kimmeridge Clay in this section covers the upper part of the Late Kimmeridgian. It consists of a sequence of grey and bituminous shales and clays with stone bands towards the base (Figure 7.6A and B). The sequence according to Cope (1967; *in* Torrens, 1969a; 1978; *in* Cope *et al.*, 1980b) is:

	Thickness (m)
Portland Sand, Massive Bed	
Upper Kimmeridgian	
fittoni Zone	
Hounstout Marl	21.00
Hounstout Clay	8.35
Rhynchonella and *Lingula* Beds (upper part)	8.00
	37.35
rotunda Zone	
Rhynchonella and *Lingula* Beds (lower part)	15.00
rotunda Shales	13.50
rotunda Nodule Bed	1.80
Shales and clays	4.25
Hard bituminous shales	1.25
	35.80
pallasioides Zone	
Clays and shales (9 individual subunits, Cope, 1978)	30.00
pectinatus Zone	
paravirgatus Subzone	
Grey shales	12.10
Hard shale	0.60
Shales	6.10
Freshwater Steps Stone Band	0.40
	19.20
eastlecottensis Subzone	
Shales	8.80
Middle White Stone Band	0.45
Shales and mudstones	8.90
White Stone Band	0.95
	19.10

The beds have an apparent easterly dip, and the ammonite zones occur in sequence from north-west to south-east (Figure 7.6A): *pectinatus* Zone (cliff below Swyre Head–Egmont Bight; SY 937773–SY 947772), *pallasioides* Zone (Freshwater Steps–Chapman's Pool; SY 942772–SY 955771) and the *rotunda* Zone, above this, between Egmont Bight and continuing past Chapman's Pool. The succeeding *fittoni* Zone and the Portlandian occur higher in Hounstout Cliff. The White Stone Band and Middle White Stone Band come to beach level below Swyre Head and 250 m east of that, respectively. The Freshwater Steps Stone Band reaches beach level at Freshwater Steps. The shales and clays of the *pallasioides* and lower *rotunda* Zones (i.e. between the top of the *pectinatus* Zone and the *rotunda* Nodule Bed) are sometimes known as the Crushed Ammonoid Shales.

The reptile specimens have apparently been collected largely at beach level either in the wave-cut platform west of Freshwater Steps, or in Chapman's Pool (Figure 7.6A). Although Hounstout Cliff is accessible, no reptile remains have been reported above the lower parts of the *rotunda* Zone.

Specific localities in the *pectinatus* Zone include the 'ledges below Swyre Head, SY 939773' for a partial *Teleosaurus* specimen (DORCM G.347, label), thus *eastlecottensis* Subzone. Arkell (1947c, p. 78) noted that the White Stone Band occasionally contains 'saurian vertebrae and bones'. A plesiosaur centrum (DORCM G.172) is noted as '*pectinatus* Zone, A



B

Zones	Description	Code
Upper Kimmeridgian		
fittoni		
rotunda	*rotunda* Nodules (L)	r.N
pallasioides		
pectinatus	White S.B. (B); Freshwater Steps S.B. (M)	W FS
hudlestoni		
wheatleyensis	Blackstone (T)	BS
scitulus	Yellow Ledge S.B. (B); Cattle Ledge S.B. (U)	YL
elegans	Blake's Bed 42 (B)	42
Lower Kimmeridgian		
autissiodorensis		
eudoxus		
mutabilis		
cymodoce		
baylei		

Figure 7.6 (A) Locality map and vertical section of the Swyre Head–Chapman's Pool Kimmeridge Clay site on the Isle of Purbeck, Dorset. The beds dip gently southwards, and the shales and mudstones are punctuated by distinctive limestone beds ('stone bands') which have been named. These may also be matched with the (B) tabulation of the ammonite zones of the Kimmeridgian. Abbreviations: (42) Blake's Bed 42; (BS) Blackstone; (FS) Freshwater Steps Stone Band; (r.N) *rotunda* Nodules; (SB) Stone Band; (W) White Stone Band; (YL) Yellow Ledge Stone Band; (in the zonal chart, B, L, M, U and T refer to basal, lower, middle, upper and topmost parts of the zones). After Taylor and Benton (1986); based on Cope (1967, 1978); Cope *et al*. (1980b); Cox and Gallois (1981).

above highest White Stone Band, west of Freshwater Steps on shore ledge', thus above the Freshwater Steps Stone Band in shales of the *paravirgatus* Subzone.

Recent finds confirm the occurrence of reptiles in the *pectinatus* Zone. A vertebra and ribs of a crocodilian were found by R.A. Langham in the White Stone Band, thus base of the *eastlecottensis* Subzone, to the west of Freshwater Steps. The same collector also found some limb bones of a pterosaur just above the Freshwater Steps Stone Band at Freshwater Steps, thus *paravirgatus* Subzone. Finally, P.A. Langham found some turtle remains (BMNH R8699) from a horizon in the shales just above the Freshwater Steps Stone Band, about 300 m west of Freshwater Steps, thus *pectinatus* Zone also.

Brown (1981, p. 301) reported a skull and isolated teeth of the plesiosaur *Kimmerosaurus langhami* (BMNH R8431) from 'Endcombe Bay' (also known as Egmont Bay) in the Crushed Ammonoid Shales (Figure 7.7). R.A. Langham (pers. comm. to M.J.B., 1982) gave further information on the find stating that it came from a location '*in situ* in shale at the base of the cliff approximately 270 m west of Freshwater Steps', thus perhaps shales of the *eastlecottensis* Subzone at SY 924773. If the find site is generally in the vicinity of Encombe Bay then the specimen could, in fact, come from the upper *pectinatus* Zone, the *pallasioides* Zone, or the *rotunda* Zone; Brown (1981, p. 301) suggested the *rotunda* Zone. However, Brown *et al*. (1986) revise the horizon as 'about 2 m above the Middle White Stone Band' in the upper part of the *eastlecottensis* Subzone of the *pectinatus* Zone (Cope *et al*., 1980b; Cox and Gallois, 1981). A second partial skull and mandible with some associated postcranial remains (BMNH R10042) belonging to *K. langhami* was reported by Brown *et al.* (1986, pp. 225–34) from the type locality and horizon, *in situ* about 3 m east of the site of R8431. This was collected by P.A. Langham in 1976.

Other records include phalanges of a pliosauroid (DORCM G639) from 'below Encomb(e) House at ... SY 942772', thus just west of Freshwater Steps, and probably the *pectinatus* Zone. Some plesiosaur vertebrae and a rib (DORCM G5093; BGS(GSM)) came from around SY 940773, also presumably *pectinatus* Zone. A partial ichthyosaur skeleton (BMNH R8693) came from a water-worn platform exposed at low tide, 400 m east of the Yellow Ledge, thus *scitulus* Zone, much lower down. Clarke and Etches (1992) note a plesiosaur limb bone from a higher horizon, the *rotunda* Zone, at Chapman's Pool. Other plesiosaur and ichthyosaur specimens are not so well localized (Taylor and Benton, 1986).

All of the finds, as at Kimmeridge Bay, appear to have been made in the shales; Brown (1981, p. 304) notes that BMNH R8431 was preserved in a clay matrix. The preservation of this skull was generally good, and surface ornament was visible. Parts of the skull were slightly crushed and the dentary somewhat 'eroded'. Other specimens from this area are generally isolated postcranial elements (vertebrae and limb bones) or slightly disturbed partial skeletons. Fuller details are given by Taylor and Benton (1986).

Fauna

Testudines: Cryptodira: Thalassemyidae
Pelobatochelys sp.
BMNH R8699
Archosauria: Crocodylia: Thalattosuchia
'*Teleosaurus* sp.'
DORCM G.347
Dakosaurus/Metriorhynchus
R.A. Langham collection
Archosauria: Pterosauria
Unnamed
R.A. Langham collection
Archosauria: Dinosauria: Theropoda
Gracile theropod (OUM)
Sauropterygia: Plesiosauria: Cryptoclididae
Kimmerosaurus langhami Brown, 1981
Type specimen: BMNH R8431; also BMNH R10042
Sauropterygia: Plesiosauria: Elasmosauridae
'*Colymbosaurus* sp.'
DORCM G.172, G.184
Sauropterygia: Plesiosauria: Pliosauridae
Pliosaurus sp.
DORCM G.186, G.639; Etches collection
Ichthyopterygia: Ichthyosauria
Grendelius sp.
BRSMG
'*Ophthalmosaurus* sp.'
DORCM G.8, BMNH R8693

Interpretation

The turtle *Pelobatochelys* is represented by a partial carapace, about 0.4 m long, with remains of limbs (BMNH R8699). The genus is known only from Dorset and was founded on carapace plates from Weymouth. If this undescribed specimen from Encombe Bay belongs to *Pelobatochelys*, the remains include the first record of its limbs.

The partial skeleton of '*Teleosaurus*' (vertebrae, ribs, jaws; DORCM G.347) may belong to one of several Kimmeridgian crocodile genera (e.g. *Dakosaurus, Machimosaurus, Steneosaurus, Teleosaurus*). Exact identification depends on snout length and features of the skull roof which is not preserved.

A gracile theropod dinosaur is represented by a partial skeleton of the hip region in the OUM.

The only fossil reptile from Encombe Bay that has been described is *Kimmerosaurus langhami* (Brown, 1981, pp. 300–14; Brown *et al.*, 1986). The type specimen (BMNH R8431; Figure 7.7) consists of the posterior part of a skull roof, an occiput, partial braincase, partial lower jaws and 11 isolated teeth. The referred material from Freshwater Steps (BMNH R10042) consists of a braincase, mandible, atlas–axis complex and five cervical vertebrae. The skull is 0.3 m long. *Kimmerosaurus* differs from all other plesiosaurs by the nature of the teeth, which lack the usual longitudinal ridges, and are greatly recurved and elliptical rather than circular in cross-section. The skull is the most lightly built of all species known from the Late Jurassic and there is no sagittal crest on the parietals, a clear difference from all other plesiosaurs. *Kimmerosaurus* is one of only five genera of Late Jurassic plesiosauroids recognized as valid by Brown (1981), and one of only two species from the Kimmeridgian. The other, *Colymbosaurus trochanterius* Owen, known from five postcranial skeletons and a number of isolated propodials, is the longest and heaviest English plesiosauroid, measuring 6 m from the tip of the snout to the end of the tail. Brown (1981) referred the two genera to different families, tentatively placing *Kimmerosaurus* with *Cryptoclidus* in the Cryptoclididae and *Colymbosaurus* in the Elasmosauridae. The possibility that *Kimmerosaurus* might be synonymous with *Cryptoclidus* was discussed by Brown *et al.* (1986). Among the available material, the only elements shared by both forms are the anterior cervical vertebrae (in *Kimmerosaurus*, only in specimen R10042), and these appear closely comparable. Should this be the case, the wider taxonomic status of Elasmosauridae and Cryptoclididae would need to be reviewed.

The elasmosaurids have very long necks, produced by increases both in the number of cervical vertebrae and in the lengths of centra, particularly among the anterior cervicals. The anterior cervicals possess a further distinguishing character, in the development of a lateral keel and an articular face which has either a single shallow concavity or an open V-shape (Brown, 1981). The cryptoclidids, by contrast, have medium-length necks (28–32 cervical vertebrae), and the anterior cervical centra have a deep concavity with a convex rim.

The other plesiosaur remains from Encombe probably belong to *Colymbosaurus* (DORCM G172, G184, G5093) and *Pliosaurus* (DORCM G186, G639) respectively.

The ichthyosaur remains (BMNH R8693; DORCM G.8) could belong to one of several genera that occur elsewhere in the British Kimmeridgian (e.g. *Macropterygius, Grendelius, Nannopterygius, Ophthalmosaurus*). Identification is based on the shape of the skull (e.g. snout length, shape, size and position of openings) or on features of the paddles. A new specimen of *Grendelius* in the BRSMG will be described shortly (McGowan, in prep.). The taxonomy of Late Jurassic ichthyosaurs is controversial (McGowan, 1976; A. Kirton, pers. comm., 1981), and fragmentary remains are hard to identify.

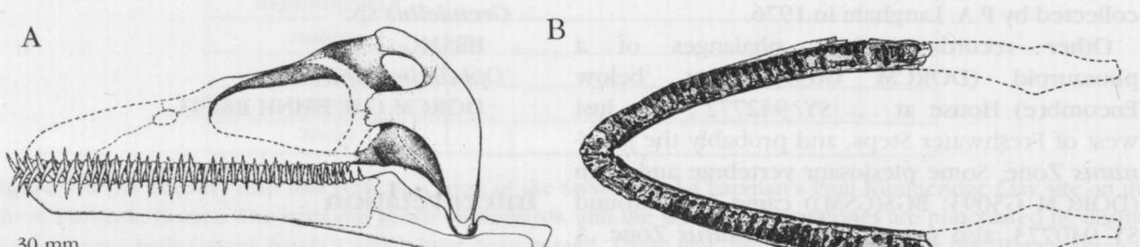


Figure 7.7 The plesiosauroid *Kimmerosaurus langhami* Brown, 1981, from the Upper Kimmeridge Clay of Egmont Bay. (A) Restoration of the skull in lateral view; (B) lower jaws viewed from above. After Brown (1981).

Comparison with other localities

Late Kimmeridgian reptile sites are rare, and none has been highly productive. Some ichthyosaurs, plesiosaurs and crocodilians have come from units equivalent to those described here at Ringstead Bay, Dorset (SY 7581), and rare remains from the Hartwell Clay of Buckinghamshire (*pallasioides* Zone). A referred specimen of *Kimmerosaurus* (BMNH R1798) came from Weymouth, probably from a cliff exposure between Sandsfoot Castle and the old Portland Ferry Bridge and therefore Early Kimmeridgian in age (Damon, 1884; see Smallmouth Sands report). The disused Kimmeridgian pits on Shotover Hill, Oxfordshire (SP 558065, SP 560066, SP 562066, SP 564066, etc.) have yielded some reptiles from the *pectinatus* Zone (Shotover Grit Sands, Shotover Fine Sands), as well as more abundantly from the Early Kimmeridgian.

Conclusions

The whole coast section from Swyre Head to Chapman's Pool (Encombe Bay) represents the best British Late Kimmeridgian (=Early Tithonian) reptile site. It has produced a selection of marine reptiles that have not yet been described in full. One undescribed turtle may be the first specimen of the poorly known genus *Pelobatochelys* with limb remains. The two partial skulls and some postcranial remains of *Kimmerosaurus langhami* Brown, 1981 show that this was a plesiosaur with several unique features that may form part of a lineage separate from the commoner plesiosaurid–elasmosaurid and pliosaur groups. Marine faunas of this age are rare elsewhere in the world, with similarly isolated remains known from France and Germany. At the same time in North America and Africa, the only known faunas are of terrestrial organisms. This potential for future discoveries gives the site its conservation value.

LATE JURASSIC (PORTLANDIAN) OF ENGLAND

Portlandian (=Upper Tithonian) reptile sites are generally rare in Britain, the only productive ones being on the Isle of Portland and near Swanage, both in Dorset, and in Buckinghamshire. Apart from their taxonomic significance, many of the faunas are interesting from the viewpoint of their palaeoecology in that they occur in a variety of facies ranging from lacustrine and lagoonal to shallow marine, which in addition cross the Jurassic/Cretaceous (Portlandian–Berriasian) boundary (Figure 7.8). The sites selected as GCR sites cover the main Isle of Portland localities, Durlston Bay (Swanage) and a quarry near Hartwell (Buckinghamshire) important for its remains of dinosaurs.

ISLE OF PORTLAND REPTILE SITES

Highlights

The Isle of Portland is riddled with old quarries and cliffs that have been the source of a diverse array of fossil marine reptiles (Figures 7.9 and 7.10). The fossil turtles have proved to be particularly important, including some of the oldest known well preserved marine turtles.

Introduction

The latest Jurassic Portlandian limestone of the Isle of Portland has long been famous for its marine reptiles. Many skeletons and individual bones of these reptiles (Figure 7.11), plesiosaurs and ichthyosaurs were collected in the 19th century when the equally famous stone quarries were more active than today, but there have been some important finds in recent years. The island has yielded type specimens of five species of reptile, and it is the best source of latest Jurassic marine reptiles in the world. Recent finds from several quarries show its continuing potential.

The Portland Beds of the Isle of Portland has been described by Damon (1884, pp. 79–97), H.B. Woodward (1895, pp. 196–202), Strahan (1898, pp. 60–71), Arkell (1933, pp. 492–7; 1947c, pp. 118–22), Cope (*in* Torrens, 1969a, pp. A53–A57), Cope and Wimbledon (1973), and Wimbledon (*in* Cope *et al.*, 1980b, pp. 88–9). Portland reptiles have been described by Owen (1842b, 1869, 1884b), Lydekker (1889a, 1889b, 1890a), Gaffney (1975a, 1976), McGowan (1976) and Brown (1981), and summarized by Delair (1958, 1959, 1960, 1966, 1992).

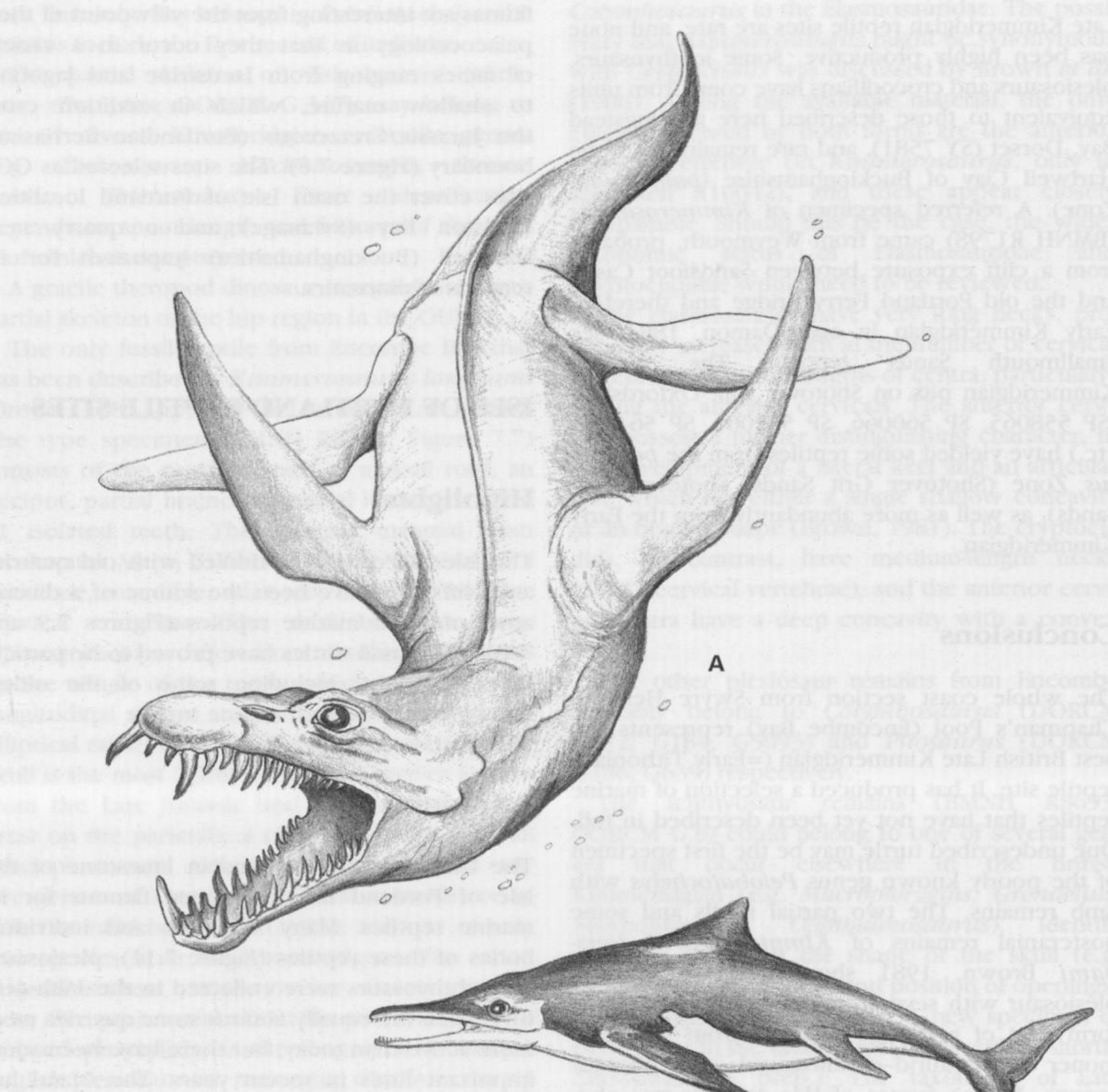


Figure 7.8 Some typical marine reptiles of Late Jurassic times in southern England. (A) The pliosaur *Liopleurodon*, one of the largest marine predators of all time at 12 m long. (B) The ichthyosaur *Ophthalmosaurus*, which was 2–4 m long. (C) The plesiosauroid *Cryptoclidus*, which was 4 m long. These animals occur typically in the Oxford Clay and Kimmeridge Clay faunas. Drawn by John G. Martin, copyright City of Bristol Museums and Art Gallery.

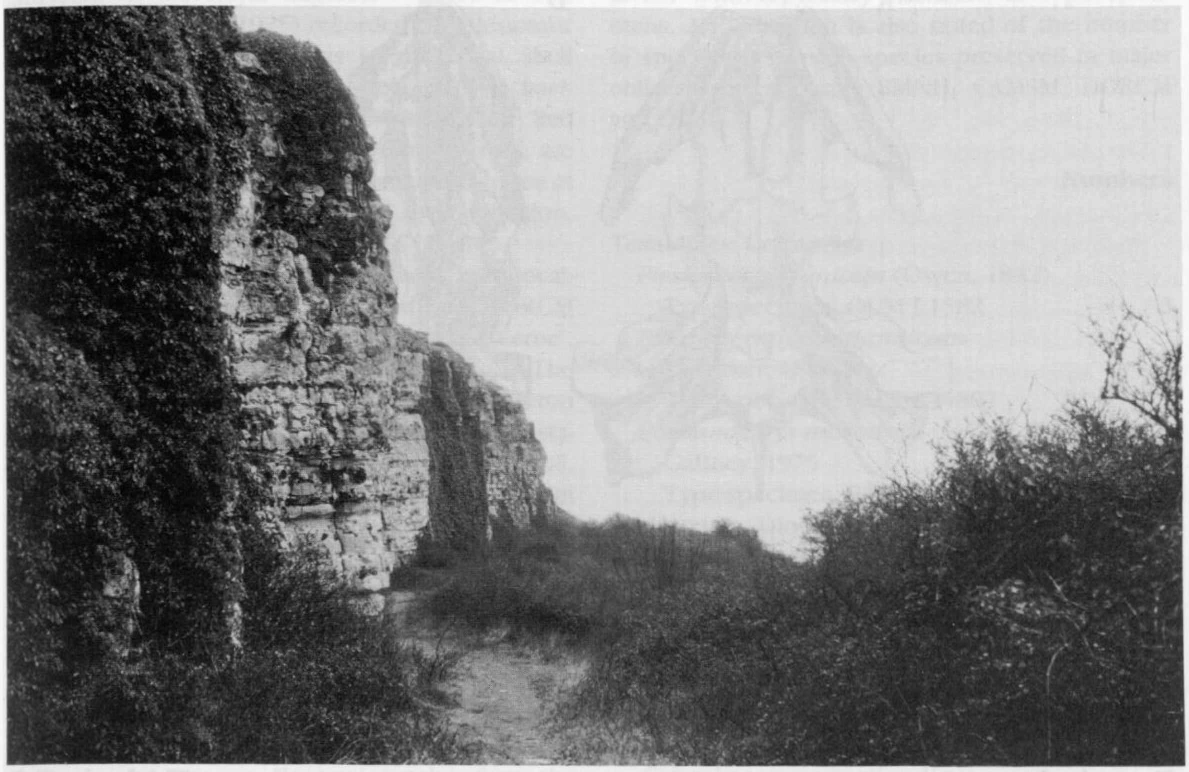


Figure 7.9 Nicodemus Nob on the eastern side of the Isle of Portland, showing the partly overgrown quarried cliffline. Upper parts of the Portland sequence are exposed. (Photo: M.J. Benton.)

Figure 7.10 Broadcroft Quarries on the Isle of Portland, showing large blocks quarried for building stone. Fossil reptiles have been found in most of the inland and cliffline quarries. (Photo: M.J. Benton.)

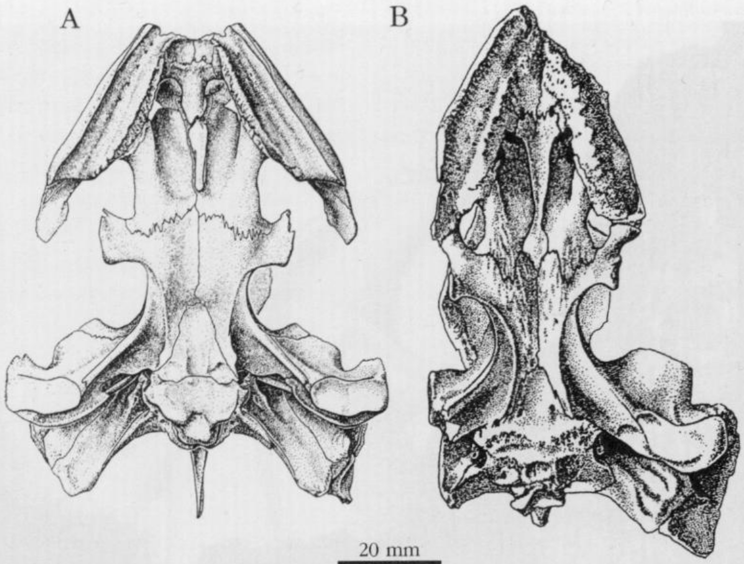


Figure 7.11 Turtles from the Portlandian of the Isle of Portland. (A) *Plesiochelys planiceps* (Owen, 1842), skull in partially restored ventral view; (B) *Portlandemys mcdowelli* Gaffney, 1975, partial skull in ventral view. In both cases, the toothless jaws are directed to the top, and the palate and braincase extend to the bottom. The top of both skulls is missing. After Gaffney (1975a).

Description

The sequence, based on Arkell (1947c) and Wimbledon (*in* Cope *et al.*, 1980b) is:

	Thickness (m)
Purbeck Limestone Formation	
'Lulworth Beds': algal limestone (caps) with dirt beds and plant remains, passing up into argillaceous and laminated limestones	*c.* 30
Portland Stone Formation	
Portland Freestone Member:	
Roach: cream-coloured oolite with moulds of bivalves, gastropods (northern half of island); Whit Bed Freestone: buff oolite; Curf and Chert: soft chalky micrite and micrite full of chert (northern half of island); Little Roach: shelly oolitic limestone; Base Bed Freestone: soft, white oolitic limestone	9
Cherty Beds: limestones, predominantly micrites, with nodules and beds of chert, with giant ammonites	15
Basal Shell Bed: hard micrite with a rich fauna (bivalves, gastropods, ammonites, echinoids, bryozoa, fish and reptiles)	2.7
Portland Clay	4–6
Portland Sand	
West Weare Sandstones: brown and grey dolomites and sandy cementstones	15
Cast Beds	1.3
Exogyra Bed: 'stiff' marl/limestone packed with *Nanogyra nana*	2.5
Upper Black Nore Beds: black silts/silty clays with lines of light grey limestone nodules	12
Black Nore Sandstone: hard, black argillaceous sandstone with intensely hard concretions	2

Most specimen labels, and published descriptions, have little more locality and horizon data than 'Portland'. However, several authors have pointed to the Cherty Beds and the Basal Shell Bed as source horizons. Damon (1884, p. 86) noted 'Saurian remains' from the Cherty Beds of the Verne district (north-eastern part of the Isle) and a partial skeleton of a plesiosaur in the

Museum of the Royal Engineer's Office at The Verne Works. Cox (1925) recorded the plesiosaur *Cimoliasaurus portlandicus* in the Basal Shell Bed. Savage (1958) noted a specimen of *C. portlandicus* 'probably from the Whit or Base Bed Freestone'. Centra, probably of ichthyosaurs, are not uncommon in the West Weare Sandstones at the top of the Portland Sand (W.A. Wimbledon, pers. comm. to M.J.B., 1992)

Several recently collected specimens have locality data. A centrum of *C. portlandicus* (DORCM G.177) is labelled 'Little Beach, NE of the Verne', thus a specimen that has probably fallen from The Verne. A further partial plesiosaur skeleton (DORCM G.181) is labelled 'below coastguard station, E. side, H. tide level – SY 706722 – coll. 1966–8'. Some bone fragments (BGS(GSM) Zm 7700–40) have an associated sheet with a geological section and the words 'bones and shells' inscribed against the (?) Basal Shell Bed and Cherty 'Series'. Delair (1966, p. 61) mentions these specimens as coming from the lower part of the Portland Stone, '2 or 3 feet above the Portland Sand'. Dr J.N. Carreck (pers. comm. to M.J.B., 1982) lists isolated discoveries of bones from the following horizons: a dinosaur vertebra from the Whit Bed at Parkfield Quarry (?=Perryfield Quarries, SY 695712, or disused quarries, unnamed on 6-inch OS map at SY 692714, near Park Road; a specimen in Portland Museum, noted by Delair (1992), parts of a plesiosaur femur from the Whit Bed at Bottom Coombe Quarry (SY 694715), a goniopholid crocodilian tooth from the Skull Cap (Lower Purbeck) or top of the Portland Stone, a large part of a plesiosaur skeleton and a turtle cranium from the base Bed Freestone, and a large ?femur from the Lower Purbeck (Great Dirt Bed/Cap) of Wakeham Quarries (SY 698713). The present location of all but one of these specimens is unknown. Delair (1992) also notes 'characteristic megalosaurid metatarsals' on show in Portland Museum, from the Whit Bed of the Bath and Portland Stone Co.'s Quarry.

On the basis of these scraps of information, it may be concluded that most of the fossil reptiles from Portland came from the Portland Stone, and from a variety of localities. A selection of exposures is chosen for the GCR site since no particular quarry has proved to be the single main source.

Fauna

Fossil reptiles from Portland are preserved in several major collections. A list of species recorded is given, with repository numbers of type specimens. An indication is also noted of the number of specimens of each species preserved in major collections (especially BMNH, CAMSM, DORCM and OUM).

	Numbers
Testudines: Cryptodira	
Plesiochelys planiceps (Owen, 1842)	
Type specimen: OUM J.1582	3
Pleurosternon portlandicum Lydekker, 1889	
Type specimen: BMNH 44807	1
Portlandemys mcdowelli Gaffney, 1975	
Type specimen: BMNH R2914	4
Archosauria: Dinosauria: Saurischia: Theropoda	
'Megalosaurid'	2
Archosauria: Dinosauria: Saurischia: Sauropoda	
Pelorosaurus sp.	1
Sauropterygia: Plesiosauria: Elasmosauridae	
Colymbosaurus portlandicus (Owen, 1869)	
Type specimen: BMNH 40640	33
Sauropterygia: Plesiosauria: Pliosauridae	
?*Pliosaurus brachydeirus* Owen, 1841	2
Ichthyopterygia: Ichthyosauria	
Macropterygius thyreospondylus (Owen, 1840)	2

Interpretation

The turtle remains from Portland have proved to be of some interest recently. *Plesiochelys planiceps* (Owen, 1842) was based on a single cranium and partial carapace (Owen, 1842b, pp. 168–70). It was a relatively large animal (skull 90 mm long) with the temporal fossa completely roofed by postfrontal and parietal bones and a deep notch immediately behind the maxilla (Figure 7.11A). Owen (1884b, vol. 2, pl. 8, figs 1–2) figured the skull without further description. Lydekker (1889b, pp. 232–3) erected the new genus *Stegochelys* for this form. The type specimen was mentioned as lost by Lydekker (1889b) and Parsons and Williams (1961), but Delair (1958, p. 55) located it, and Gaffney (1975a, 1976) redescribed it as *Plesiochelys*. Parsons and Williams (1961) tentatively referred some further turtle skulls from the Isle of Portland to *P. planiceps*. Gaffney (1975a, 1976) further described these specimens, and named them *Portlandemys mcdowelli* (Figure 7.11B). Gaffney (1975a, 1975b, 1976, 1979a, p. 281) ascribed the genera *Plesiochelys* and *Portlandemys* to the Plesiochelyidae, a family that he places in the Chelonioidea (living and extinct marine turtles).

The third Portland turtle is *Pleurosternon portlandicus* Lydekker, 1889b (pp. 215–16), a species based on a carapace which is only 250 mm long. Młynarski (1976, p. 120) mentioned the species briefly and referred the family Pleurosternidae to Testudines *inc. sed.*

Dinosaurs from the Isle of Portland are represented by some metatarsals and a damaged vertebra of a 'megalosaurid' (Delair, 1992), and by a tooth named *Ornithopsis* sp. by Delair (1959, p. 83). *Ornithopsis* is currently ascribed to *Pelorosaurus* (Steel, 1970, p. 68).

Pliosaurus portlandicus Owen, 1869 (pp. 8–12) was described on the basis of a right hind paddle with a 370 mm long femur. Lydekker (1889a, pp. 227–30; 1890a, pp. 274–5) ascribed *P. portlandicus* to *Cimoliasaurus* and listed many specimens of vertebrae and limb bones. Brown (1981, pp. 314–17, 324) synonymized *C. portlandicus* with many other Late Jurassic plesiosaurs as *Colymbosaurus trochanterius* (Owen, 1840). Savage (1958) reported a recent find of a femur of *C. portlandicus*. Lydekker (1890a, pp. 271–2) and Delair (1959, p. 70) note the head of an ischium and the distal portion of a propodial (BMNH R1679, R.1680) from Portland as *Pliosaurus brachydeirus*, but Tarlo (1960), in a review of British Late Jurassic pliosaurs, does not comment on these.

The ichthyosaur *Macropterygius thyreospondylus* is represented by a caudal vertebra from the 'Portland Oolite' (BMNH R1684; Delair, 1960, pp. 66–7). McGowan (1976) considered this species a *taxon dubium* because of the 'inadequate' type material, but it may be valid (A. Kirton, pers. comm. to M.J.B., 1982).

Comparison with other localities

Reptiles are relatively rare in the Portland Beds of Britain (listed near the beginning of the chapter). Of the turtles from the Isle of Portland, the genus *Plesiochelys* is known also from the Kimmeridge Clay of England, Switzerland, Bavaria and Hanover, the Portlandian (?) of eastern France, the Purbeck of Durlston Bay, the 'Upper Jurassic' of China, and the Wealden of the Isle of Wight and Sussex (Lydekker, 1889b; Gaffney, 1975a; Młynarski, 1976, pp. 55–7). *Portlandemys* is unique to the Isle of Portland. *Pleurosternon* is also known from the Purbeck Beds of Swanage (Lydekker, 1889b), and elsewhere in the Late Jurassic and Early Cretaceous of western Europe and Asia (?) (Młynarski, 1976, p. 120). *Colymbosaurus portlandicus* is unique to the Portlandian of England but, if synonymized as *C. trochanterius*, it is well known from many localities in the Kimmeridge Clay also (Brown, 1981). Delair (1966, pp. 66–7) regarded the Portland *M. thyreospondylus* as the only English Portlandian ichthyosaur, although there are some ichthyosaur vertebrae from Swindon (OUM J.1585–6; BGS(GSM) old number). *M. thyreospondylus* occurs in the Portlandian of the region of Boulogne (Huene, 1922, p. 91). The Portlandian fauna from the Isle of Portland is similar in many ways to the preceding Kimmeridgian faunas, but overall species diversity seems reduced, and turtles are perhaps relatively a little more diverse.

Conclusions

The Isle of Portland has yielded the best faunas of marine Portlandian reptiles in the world. Other marine faunas of this age are known from southern England, but the range of material is less. Better known faunas from elsewhere in the world (e.g. Morrison Formation, USA; Tendaguru, Tanzania) are dominated by terrestrial forms such as dinosaurs. The turtles from Portland include good skull material, and have formed the basis of recent reviews of early turtle anatomy and taxonomy. The plesiosaur material is good, and appears to have closest affinities with Kimmeridgian species. The sites include the best sources for marine reptiles of latest Jurassic age anywhere in the world and, with their continuing potential for new finds, they therefore have high conservation value.

BUGLE PIT, HARTWELL, BUCKINGHAMSHIRE (SP 793121)

Highlights

Bugle Pit, near Aylesbury is the source of a small number of important reptile specimens. These include teeth of a variety of dinosaurs, which are particularly important since most other Late Jurassic sites in England are marine.

Introduction

The Bugle Pit, Hartwell has produced teeth of megalosaur and sauropod dinosaurs and some other reptile species, and it has been the best source of dinosaur remains in the British Portlandian. The Bugle Pit is now filled in, but a new section was exposed a short distance to the south by the NCC in 1984 (Radley, 1991), which only shows the top of the Portland Stone and the Purbeck Beds, but it has potential to produce more finds after further excavation.

The Bugle Pit, named after the Bugle Horn Inn nearby, was first mentioned by Morris (1856). Geological sections have been published by at least 20 authors, including H.B. Woodward (1895, pp. 223–4), Arkell (1947a, p. 126), Barker (1966), Wimbledon (*in* Cope *et al.*, 1980b) and Radley (1991). The reptile remains were described by Hudlestone (1887), Lydekker (1893a) and A.S. Woodward (1895).

Description

The section after Barker (1966) is as follows:

	Thickness (m)
Purbeck Limestone Formation	
?*anguiformis* Zone	
BP 19–21. Fine-grained limestone and grey marl	2.08
BP 10–18. Marls, grey and greenish and bands of pale earthy limestone; dark clay at base; fishes and ostracods in lower units	2.93
BP 9. Laminated, blue-hearted cementstone with plant, insect and fish remains along partings	0.23–0.25
Portland Stone	
kerberus Zone	
Creamy Limestones	
BP 8. Tough, highly bituminous, shaly marl with large oysters and other bivalve casts	0.20
BP 7. Hard, fine-grained limestone with a band of trigoniid casts at the base	0.30
BP 6. Marly shales and black shale with a layer of bivalves near the base	0.15–0.20
BP 5. Blue-hearted, marly limestone with large bivalves	0.76
BP 4. Brown clay with serpulids	0.08
BP 3. Blue-hearted, rather soft, marly limestone, trigoniids etc.	0.91
BP 2. Hard, blue-hearted limestone with oysters, bottom 0.07 m fossil casts	0.60
Crendon Sand	
BP 1. Yellow-brown sand	seen to 0.23

Woodward (1895) and Arkell (1947a) continued the section down to the Upper Lydite Bed (now probably *glaucolithus* Zone), but these lower units have not been seen in Bugle Pit itself.

There are no records of the units from which the reptiles came, but the Purbeck facies seem to be the most likely source (Radley, 1991, p. 242): fishes occur in beds BP 9, 11a, 11b, 11c (H.B. Woodward, 1895; Barker, 1966). The ostracod record (Barker, 1966) indicates a predominance of freshwater and euryhaline conditions of deposition in beds BP 9–12, 14–21 (Purbeck Limestone Formation).

There is an old quarry at Stone (SP 783121), close to Hartwell, and there may have been small pits in the grounds of Hartwell House. However, there is no evidence of other Purbeck quarries in the immediate district and it seems likely that any Purbeck or Portland fossils labelled 'Hartwell' came from the once extensive Bugle Pit.

Fauna

The dinosaur teeth have been described by Lydekker (1893a) and Woodward (1895). These specimens were donated by their collector, J. Alstone, to the BMNH. Several reptile specimens in BUCCM probably came from the Bugle Pit. Delair (pers. comm., 1982) has a list of many reptiles from Bugle Pit.

Testudines: Cryptodira
'Turtle'
BUCCM Lee Coll. 3948
Archosauria: Dinosauria: Saurischia: Theropoda
Megalosaurus sp.
BMNH R2566, R2567, R2821 (teeth)

Archosauria: Dinosauria: Saurischia: Sauropoda
Pelorosaurus sp.
BMNH R2004, R2005, R2565 (teeth)
Archosauria: Dinosauria: Ornithischia: Ornithopoda
Iguanodon sp.
BUCCM 467.22
Archosauria: Dinosauria: Ornithischia: Stegosauria
?Stegosaur
BUCCM 9.43

Interpretation

The environment of deposition of the Portland Stone is essentially marine: the Creamy Limestones are marginal marine shelly limestones and mudstones that shallow upwards. The overlying Purbeck facies are restricted marine and non-marine marls, clays and fine-grained limestones, with evidence for two erosive episodes that resulted from emergence (Radley, 1991).

The turtle is represented by a poor scapula and is unidentifiable. It is labelled 'Purbeck Hartwell' and probably came from the Bugle Pit.

Hudleston (1887) recorded dinosaur bones from the Bugle Pit. Lydekker (1893a) described two sauropod teeth, a large crown with part of the root (55 mm long), and a smaller crown of similar appearance (25 mm long). The teeth are broad (35 and 15 mm respectively) and spatulate in shape. The slightly concave inner surface has rugose enamel and a mid-line ridge, and there is an offset ridge on the outer surface. Lydekker (1893a) compared these teeth with some very similar specimens from the Portlandian of Boulogne-sur-Mer. Lydekker (1890a, p. 241) had ascribed these to *Pelorosaurus humerocristatus* (Hulke, 1874), a species which had been based on a humerus from the Kimmeridge Clay of Smallmouth Sands, Weymouth. Earlier Lydekker (1888a, pp. 151–2; 1890a, p. 241) had ascribed a partial pubis, a fibula, a tibia, a phalanx and a caudal vertebra to this species. Lydekker's assignment of the Bugle Pit teeth to this species may have been the presence of similar limb bones and teeth in the Wealden (*Pelorosaurus conybeari* Mantell, 1850). A.S. Woodward (1895) reported one more sauropod tooth 'of the same animal'.

Two teeth from the Kimmeridgian of Portugal had been assigned to *P. humerocristatus*, but the assignment is doubtful (Steel, 1970, p. 70). Other similar teeth, now ascribed to species of *Pelorosaurus* (Steel, 1970, p. 70) include: *Oplosaurus armatus* Gervais, 1852 (=*Hoplosaurus armatus*, Lydekker, 1890a, p. 243) (BMNH R964; Wealden, Isle of Wight), *Ornithopsis hulkei* Seeley, 1870 (BMNH R751, R964; Lydekker, 1888a, pp. 146–8; Wealden, Isle of Wight), *Pelorosaurus conybeari* Mantell, 1850 (Lydekker, 1890a, pp. 240–1; Wealden, Kent); *Pelorosaurus (Iguanodon) precursor* (Sauvage, 1876) (Kimmeridgian of Wimille, near Boulogne-sur-Mer; 'Lusitanian' (Oxfordian–Kimmeridgian) of Ourem, Portugal).

The megalosaur teeth were described by A.S. Woodward (1895). Two of the specimens differ merely in size; both are high-crowned, compressed only on the posterior margin, which is clearly serrated, and without serrations on the anterior part, which is distinctively worn. The third specimen is shorter, broader and more laterally compressed. The tooth is less worn and serrations occur on both posterior and anterior borders, although only on the upper third of the latter. The teeth are 36, 30 and 31 mm long, respectively and 14, 12 and 16 mm broad. Woodward (1895) did not attempt to identify the species represented, and characterized them simply as 'megalosaurian'.

Ornithischian dinosaurs are represented by an *Iguanodon* toe bone (BUCCM 467.22) from 'Portland Stone of Mr Lee's pit, Hartwell', and a possible stegosaur (BUCCM 9.43) from 'Kimmeridge Clay of Bugle Pit, Hartwell'. The latter specimen (13 fragments of limb bones and other elements) cannot have the exact provenance stated. The Kimmeridgian is not represented in the Bugle Pit. The nearest site in the Hartwell Clay is Lockes' Pit, Hartwell (SP 805125), over 1 km to the north-east.

Comparison with other localities

Several localities in the Hartwell Clay (Upper Kimmeridgian, *pallasioides* Zone), have yielded tetrapod faunas that are comparable to those from Bugle Pit (e.g. *Megalosaurus*, Lydekker, 1893a; *Hoplosaurus*, Woodward, 1895a); these include Lockes Pit, Hartwell (1 km north-east of the Bugle Pit, filled in; basal Glauconitic Beds); Ward and Cannons, ?Beirton (extant) (basal Glauconite Beds, Portland facies well represented); and Websters and Cannon's (Hill's) Pit on Bierton Road, Aylesbury (overgrown).

In the course of discussion of the sauropod teeth, comparable specimens have been noted from the Kimmeridgian of Ourem, Portugal and of

Wimille and Boulogne-sur-Mer, France. The Wimille (Mont-Rouge) quarries, with Late Portland (=Portland Stone) equivalents, termed 'Wealden' (decalcified Portland sands, or equivalent to Upper–Middle Purbeck?) yielded bones of sharks, bony fishes, the turtles *Plesiochelys* and *Tropidemys*, an elasmosaurid tooth, teeth of the crocodilians *Steneosaurus, Goniopholis, Theriosuchus* and *Bernissartia*, a pterosaur and isolated dinosaur teeth (theropod, sauropod, ornithopod and nodosaurids) in a recent dig (Cuny *et al.*, 1991). Others have come from the Wealden of the Isle of Wight and the Weald. The Bugle Pit specimens appear to be the only Portlandian examples of *Pelorosaurus* known, and one of only a few European sauropods of this age. Other sauropods of Kimmeridgian to Portlandian age come from the Morrison Formation of the western United States (Kimmeridgian–Portlandian); *Haplocanthosaurus, Brachiosaurus, Camarasaurus, Apatosaurus, Diplodocus, Barosaurus* (Steel, 1970).

'*Megalosaurus*' is known from the Purbeck of Durlston Bay (*M. (Nuthetes) destructor*, Owen, 1854) and Swindon, and the Kimmeridgian of several sites near Boulogne-sur-Mer and Cap de la Hève, in France, from Pembal, in Portugal, and Foxhangers, Wiltshire as well as the Portlandian of Boulogne-sur-Mer (*M. insignis* Deslongchamps, 1870) (Steel, 1970). Other Portlandian carnosaurs include *Elaphrosaurus* from the Morrison Formation.

In the English Portlandian, dinosaur remains are known sparsely from the Isle of Portland, Dorset (see above), source of an '?*Ornithopsis* sp.' tooth and possible megalosaur remains, and from Garsington, Oxfordshire, source of caudal vertebrae named *Cetiosaurus longus* by Owen (1841), and referred to by Phillips (1871, p. 390; OUM, specimens not found). Recent digs at Chicksgrove Quarry, Wiltshire have also produced a variety of dinosaurian remains and teeth of 12 crocodilian, dinosaurian and pterosaurian taxa (W.A. Wimbledon, pers. comm. to M.J.B., 1992).

Conclusions

Bugle Pit, Hartwell has yielded a sparse, but important, dinosaur fauna. Portlandian dinosaur remains are rare in Britain and many are controversial or poorly identified. The sauropod teeth are some of the few recorded Portlandian sauropods from Europe, and they will be useful in comparisons with North American sauropods of the same age. The megalosaur and ornithischian teeth are also some of the few known from rocks of this age. Thus this small but significant reptile fauna and the potential for further discoveries with re-excavation gives the site its conservation value.

DURLSTON BAY, DORSET (SZ 035772 – SZ 039786)

Highlights

Durlston Bay is one of Britain's richest fossil reptile sites, the source of over 40 species of reptiles living in the earliest Cretaceous (Figure 7.12). The small reptiles are especially important, and Durlston Bay is unique worldwide for its diverse early lizards, its turtles, its small crocodilians and its pterosaurs.

Introduction

The mile stretch of coastal sea cliffs between Peveril Point and Durlston Head displays the finest sections of the Purbeck Limestone Formation in Britain which comprise the type locality for the formation (Figures 7.13 and 7.14). The Purbeck Limestone Formation here is famous for its exceptionally diverse fauna, which includes mammal remains unique to the Early Cretaceous of Britain (to be dealt with in a subsequent volume in the GCR series). The Durlston Bay section is also well known for its reptiles (Figures 7.15 and 7.16) and is arguably Britain's most important fossil reptile site. The reptile fauna is large and diverse, containing abundant lizards, turtles, crocodilians, pterosaurs and dinosaurs (36 species; 29 type species). The small size of many of the animals, and their fine preservation, give this locality a unique position in comparison with other reptile faunas of the same age worldwide.

Most of the reptiles from Durlston have been obtained from the natural cliff exposures, but some remains, especially the turtles, came largely from underground stone workings, the products of now extinct quarrying operations. Although the latter source for reptiles is no longer available, the extensive cliff exposures (Figure 7.13) have continued to yield new specimens. Many finds were made by Beckles in the course of his

Figure 7.12 The latest Jurassic and earliest Cretaceous sequences in Durlston Bay, showing marine limestones in the northern part of the section. (Photo: J.L. Wright.)

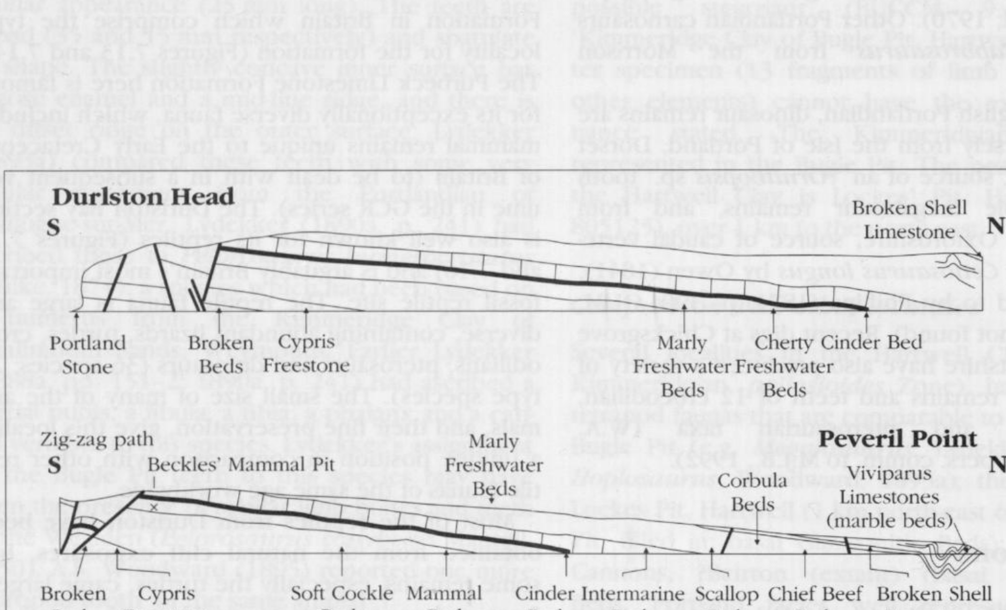


Figure 7.13 Cliff profiles of Durlston Bay showing the type section of the Durlston Beds (after Strahan, 1898).

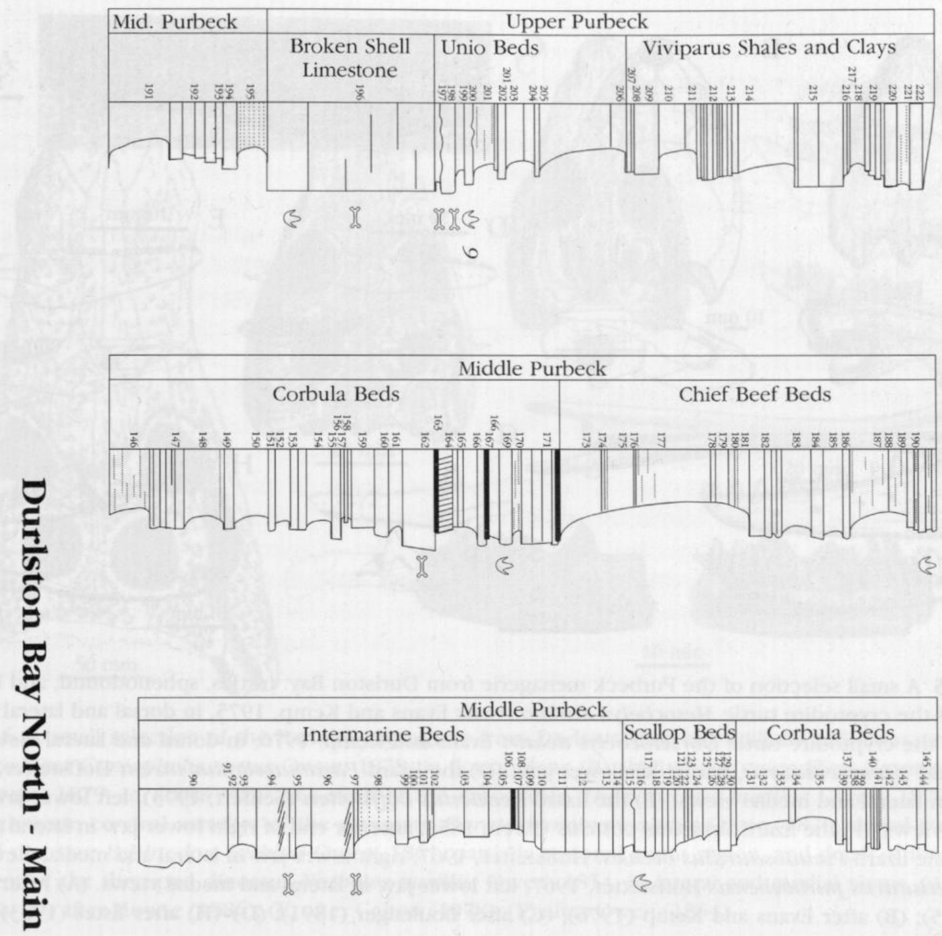


Figure 7.14 Sedimentary log of the reptile-bearing units at Durlston Bay. Bone and footprint symbols indicate fossiliferous horizons. Supplied by W.A. Wimbledon.

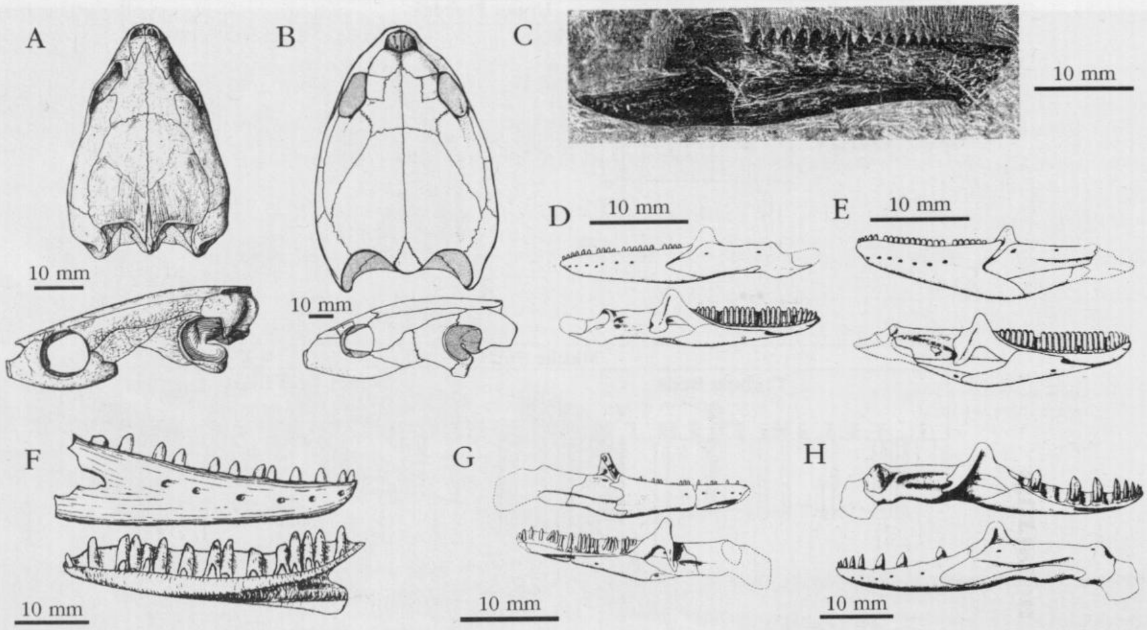


Figure 7.15 A small selection of the Purbeck menagerie from Durlston Bay: turtles, sphenodontid, and lizards. (A) The skull of the cryptodire turtle *Mesochelys durlstonensis* Evans and Kemp, 1975, in dorsal and lateral views; (B) the skull of the cryptodire turtle *Dorsetochelys delairi* Evans and Kemp, 1976, in dorsal and lateral views; (C) the sphenodontid ?*Homoeosaurus*, partial left lower jaw; (D) the lizard *Paramacellodus oweni* Hoffstetter, 1967, left lower jaw in lateral and medial views; (E) the lizard *Becklesius hoffstetteri* (Seiffert, 1973), left lower jaw in lateral and medial views; (F) the lizard *Saurillus obtusus* Owen, 1854, anterior end of right lower jaw in lateral and medial views; (G) the lizard *Pseudosaurillus becklesi* Hoffstetter, 1967, right lower jaw in lateral and medial views; (H) the lizard *Dorsetisaurus purbeckensis* Hoffstetter, 1967, left lower jaw in lateral and medial views. (A) After Evans and Kemp (1975); (B) after Evans and Kemp (1976); (C) after Boulenger (1891); (D)–(H) after Estes (1983), based on various sources.

excavation of the cliff in an area, just north of the Zigzag Path, that is well south of the outcrop of the Mammal Bed at beach level. Reports of the Durlston Bay vertebrates include Owen (1842b, 1853, 1854, 1855a, 1861b, 1871, 1874b, 1878a, 1878b, 1879a, 1879b), Mantell (1844), Owen and Bell (1849), Seeley (1869a, 1875a, 1893a, 1893b), Lydekker (1888a, 1889b), Boulenger (1891), Watson (1911b), Andrews (1913), Huene (1926), Nopcsa (1928), Hoffstetter (1967), Joffe (1967), Delair (1969b), Seiffert (1973), Evans and Kemp (1975, 1976), Gaffney (1976, 1979b), Galton (1978, 1981a), Estes (1983) and Howse (1986). Dinosaur footprints have been reported recently from Durlston Bay (Ensom, 1983, 1984b, 1985b, 1987c, 1987d; Nunn, 1990), as well as a new sphenodontid jaw bone (Evans, 1992c).

The Purbeck section at Durlston Bay has been described with varying degrees of accuracy by many authors (Austen, 1852, pp. 9–16; Bristow and Fisher, 1857, pp. 245–54; Strahan, 1898, pp. 91–6; Arkell, 1933, pp. 521–9; Clements, *in* Torrens, 1969a, figs A35–7; 1993). Cope and Clements (*in* Torrens, 1969a, pp. A57–A64) and Macfadyen (1970, pp. 134–52) give details of the history of research on the stratigraphy and palaeontology of the Durlston section. Parts of the coastline were formerly mined and quarried opencast for building stone, paving flagstone and gypsum.

Description

The section of the Purbeck Limestone Formation at Durlston Bay (Figures 7.13 and 7.14) is based on Wimbledon and Hunt (1983, p. 270, fig. 2) and new data from W.A. Wimbledon (pers. comm. to M.J.B., 1992), and using the numbering scheme of Clements (*in* Torrens, 1969a), where bed numbers are prefixed DB. A detailed map of the northern part of Durlston Bay, showing the occur-

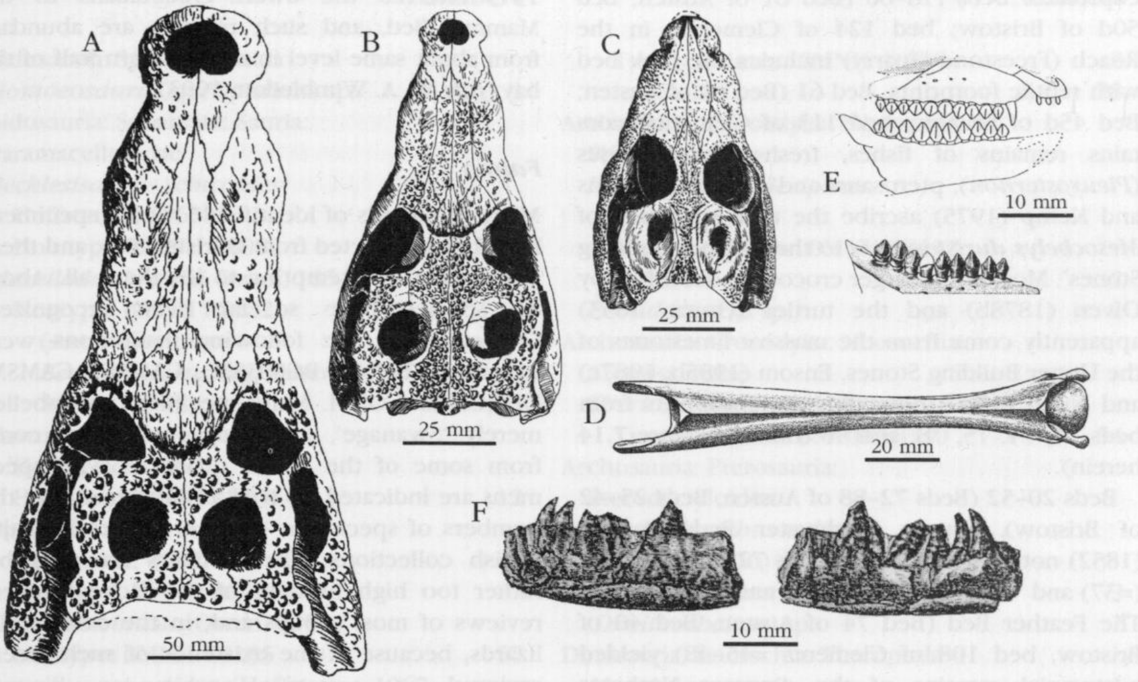


Figure 7.16 A small selection of the Purbeck menagerie from Durlston Bay: crocodilians and dinosaurs. (A) Skull of the crocodilian *Goniopholis simus* Owen, 1878, in dorsal view; (B) skull of the crocodilian *Nannosuchus gracilidens* Owen, 1879, in dorsal view; (C) skull of the crocodilian *Theriosuchus pusillus* Owen, 1879, in dorsal view; (D) elongate cervical vertebra of the pterosaur *Doratorhynchus validus* Owen, 1870, dorsal view; (E) the ornithopod dinosaur *Echinodon becklesi* Owen, 1861, partially restored snout region, and detail of lower jaw; (F) jaw fragment of the theropod dinosaur *Nuthetes pusillus* Owen, 1854, in lateral and medial views. (A)–(C) After Joffe (1967); (D) after Howse (1986); (E) after Galton (1978); (F) after Owen (1854).

rence of numbered Purbeck beds, has been published by Nunn (1992).

The Purbeck Limestone Formation is generally taken to span the Jurassic–Cretaceous (Portlandian–Berriasian) boundary, with the base of the Cretaceous taken in the *Cypris* Freestone, quite low in the formation (Allen and Wimbledon, 1992). Ammonites have not been found in these beds, and the stratigraphy is based on palynomorphs, ostracods and gastropods; the position for the boundary between the Cretaceous and Jurassic has been in dispute, but an integrated approach to correlation has made possible the positioning of the base of the Berriasian in the section.

Fossil reptiles have been recorded from several levels in the section (Figure 7.14) between the Mammal Bed (14 and 16) at the base of the Middle Purbeck beds and the *Unio* Beds and above (197+) in the Upper Purbeck beds:

197–224 *Unio* Beds, Upper *Cypris* Clays and Shales: Delair (1966, p. 60) noted specimens of the crocodile *Goniopholis* (BGS(GSM) Zm.7702) and of turtles (BGS(GSM) Zm. 7703–4) 'in and just above the *Unio* Bed at Peveril Point'.

200 (Bed 6 of Austen; Bed 81 of Bristow; bed 221 of Clements) Crocodile Bed: 'teeth of crocodile'; plants, coprolites, fish, turtles, crocodiles (*Goniopholis*).

196 (Bed 9 of Austen; Bed 78 of Bristow; bed 220 of Clements) Broken Shell Limestone Member (Soft Burr): fishes and turtles. Ensom (1983) noted dinosaur footprints in this bed.

191 in the Chief Beef Beds: Ensom (1983) noted dinosaur footprints from this horizon.

131–174 (Beds 24–44 (in part) of Austen; Beds 59–70 of Bristow; beds 154–174 of Clements); *Corbula* Beds: insects, fishes, turtles and footprints (West and El-Shahat, 1985).

58–114 Intermarine Beds (Beds 45–70, Turtle Beds of Austen; Beds 45–57, Intermarine Beds of Bristow; beds 112–144 of Clements) Upper Building Stones: DB133 (Bed 52 of Austen; Bed 54 of Bristow, Red Rag) yields fishes, turtles and coprolites. Beds ?78–80 (Bed 61 of Austen; Bed 50d of Bristow; bed 124 of Clements) in the Roach (Freestone Quarry) includes the pink bed with reptile footprints. Bed 61 (Bed 69 of Austen; Bed 45d of Bristow; bed 113 of Clements) contains remains of fishes, fresh-water tortoises (*Pleurosternon*), pterosaurs and crocodiles. Evans and Kemp (1975) ascribe the type specimen of *Mesochelys durlstonensis* to the '?Upper Building Stones'. Most of the larger crocodiles described by Owen (1878b) and the turtles (Owen, 1853) apparently come from the massive limestones of the Upper Building Stones. Ensom (1985b, 1987c) and Nunn (1990) note dinosaur footprints from beds 71, 74, 75, 78, and 96 (but see Figure 7.14 herein).

Beds 20–52 (Beds 72–88 of Austen, Beds 25–42 of Bristow). Cherty Freshwater Beds: Austen (1852) notes 'bones' in his beds 72 (=51) and 81 (=37) and 'turtle' in his beds 83 and 84 (=30–32). The Feather Bed (Bed 74 of Austen, Bed 40 of Bristow, bed 108 of Clements =45–48) yielded postcranial remains of the dinosaur Nuthetes (Owen, 1854, 1878a; Delair, 1959, p. 80), granicones (Owen, 1878a, 1879b), and the 'dwarf' crocodilians *Nannosuchus* and *Theriosuchus* (Owen, 1879a, 1879b; Joffe, 1967). Owen (1879b) also referred the small crocodilians *Goniopholis tenuidens, Oweniasuchus major, O. minor* and *Nannosuchus gracilidens* to the Feather Bed. However, Owen (1861b) stated that the type *Nuthetes* jaw came from Bed 93 of Austen (1852), namely the Mammal Bed (bed 14–16). The Under Feather (Bed 76 of Austen; Bed 38 of Bristow; 106 of Clements =43) yielded *Iguanodon hoggi* Owen, 1874b (p. 3). Ensom (1984b) reported dinosaur footprints from DB94, exposed south of the point where the Cinder Bed is present at shore level (SZ 03607835). A related pod of limestone (DORCM G7261) was discovered in the carbonaceous shale below (DB93). Ensom (1984b) noted isolated impressions on the base of DB103 and DB102 (Clements 1969).

The Mammal Bed ('Dirt Bed') of Beckles' excavations (Bed 93 of Austen; Bed 22 of Bristow; bed 83 of Clements): always equated with bed 14–16 (Figure 7.14) of the shore section, has yielded plant remains, ostracods, gastropods, bivalves, lizards (Macellodus, *Saurillus* etc; Owen, 1854, 1855a, 1861b; Hoffstetter, 1967), dinosaurs (*Echinodon*; Owen, 1861b; Galton, 1978; *Nuthetes*, type jaw; Owen, 1861b), and mammals (18 species). Certain authors (e.g. H.B. Woodward, 1895, p. 251; Macfadyen, 1970, p. 137) referred the dwarf crocodilians to the Mammal Bed, and such remains are abundant from about same level in the southern half of the bay (*fide* W. A. Wimbledon, 1993).

Fauna

Many thousands of identifiable reptile specimens have been collected from Durlston Bay, and there is no point in attempting to list them all. About 41 species have so far been recognized. Collections in the following institutions were examined: BMNH, BGS(GSM), CAMMZ, CAMSM, DORCM and OUM. Many specimens are labelled merely 'Swanage', and they could have come from some of the inland quarries. Type specimens are indicated, as well as an estimate on the numbers of specimens of each species in major British collections. The numbers are probably rather too high because of the lack of recent reviews of most groups and, in the case of the lizards, because of the existence of such recent reviews!

	Numbers
Testudines: Cryptodira: Pleurosternidae	
Mesochelys durlstonensis Evans and Kemp, 1975	
Holotype: CAMMZ T.1041	1
Pleurosternon bullocki (Owen, 1842)	
Type specimen: BMNH R911	70
Pleurosternon sp.	47
Tretosternon punctatum Owen, 1842	
Type specimen: lost	16
Testudines: Cryptodira: Plesiochelyidae	
Plesiochelys belli (Mantell, 1844)	2
Plesiochelys emarginata Owen, 1853	
Type specimen: DORCM G.16/ BMNH 46317(?)	7
Plesiochelys latiscutata (Owen, 1853)	
Type specimen: DORCM G.20	3
Plesiochelys sollasi Nopsca, 1928	
Type specimen: OUM J.13796	1
Plesiochelys sp.	13
Testudines: Cryptodira: *inc. sed.*	
Dorsetochelys delairi Evans and Kemp, 1976	
Holotype: DORCM G.23	1
'Chelonian indet.'	17
Testudines: Pleurodira	
Platychelys ?anglica Lydekker, 1889	
Type specimen: BMNH 48357	1

	Numbers
Lepidosauria: Sphenodontida	
Homoeosaurus sp./*Opisthias* sp.	3
Lepidosauria: Squamata: Sauria: Paramacellodidae	
Becklesisaurus scincoides Hoffstetter, 1967	
Holotype: BMNH R8082	1
Macellodus brodiei Owen, 1854	
Neotype: BMNH R8182 (some specimens = *Becklesisaurus hoffstetteri* Seiffert, 1973)	35
Paramacellodus oweni Hoffstetter, 1967	
Holotype: BMNH R8131–2	12
Pseudosaurillus becklesi Hoffstetter, 1967	
Holotype: BMNH R8095	27
Saurillus obtusus Owen, 1855	
Neotype: BMNH R8135	57
Saurillus robustidens Hoffstetter, 1967	
Holotype: BMNH R8130	2
Lepidosauria: Squamata: Sauria: Dorsetisauridae	
Dorsetisaurus purbeckensis Hoffstetter, 1967	
Holotype: BMNH R8129	32
Dorsetisaurus hebetidens Hoffstetter, 1967	
Holotype: BMNH R8109	1
Lepidosauria: Squamata: Sauria: *inc. sed.*	
Durotrigia triconidens Hoffstetter, 1967	
Holotype: BMNH R8122	1
Archosauria: Crocodylia: Neosuchia: Goniopholididae	
Goniopholis crassidens Owen, 1842	
Type specimen: BMNH 3798	15
Goniopholis simus Owen, 1878	
Type specimen: BMNH 41098	1
Goniopholis tenuidens Owen, 1879	
Type specimen: BMNH 48300	1
Goniopholis sp.	75
Nannosuchus gracilidens Owen, 1879	
Type specimen: BMNH 48217 (?= juvenile *G. simus*)	22
Oweniasuchus major (Owen, 1879)	
Type specimen: BMNH 48304	5
Oweniasuchus minor (Owen, 1879)	
Type specimen: BMNH 48328	2
Oweniasuchus sp.	1
Petrosuchus laevidens Owen, 1878	
Type specimen: BMNH 41099	2
'crocodile'	28
Archosauria: Crocodylia: Neosuchia: Pholidosauridae	
Pholidosaurus decipiens Watson, 1911	
Type specimens: BMNH 28432, R3956	2
Pholidosaurus sp.	2
Archosauria: Crocodylia: Neosuchia: Atoposauridae	
Theriosuchus pusillus Owen, 1879	
Type specimen: BMNH 48330	54
Archosauria: Pterosauria: Pterodactyloidea	
Doratorhynchus validus (Owen, 1870)	
Type specimen: BMNH 40653	2
'*Ornithocheirus*' sp.	7
Dinosauria: Saurischia: Theropoda	
Megalosaurus sp.	1
Nuthetes destructor Owen, 1874	
Type specimen: DORCM G.913	6
Dinosauria: Ornithischia: Ornithopoda	
Echinodon becklesi Owen, 1861	
Type specimen: BMNH 4820	13
Iguanodon hoggi Owen, 1874	
Type specimen: BMNH R2998	2
Sauropterygia: Plesiosauria: Plesiosauroidea	
'plesiosauroid'	1
Ichthyopterygia: Ichthyosauria	
'ichthyosaur'	1

Interpretation

Turtles are the commonest remains from Durlston. A 'petrified tortoise' was recorded in 1809 (Anon., 1809). Owen (1842b), and Owen and Bell (1849, pp. 62–6) described *Platemys bullocki* on the basis of a turtle supposedly from the London Clay of Sheppey. It was later shown to have come from Durlston (Lydekker, 1889b, p. 209). Meanwhile, Owen (1853, pp. 1–9) erected the genus *Pleurosternon*, with the new species *P. concinnum, P. emarginatum, P. ovatum* and *P. latiscutatum*, all from Durlston. The first three belong to *P. bullocki* (although *P. emarginatum* only in part; Lydekker, 1889b, pp. 206–15), as do four invalid species named by Seeley (1869a, pp. 86–8). *P. bullocki* was a medium-sized (400 mm long), probably freshwater, turtle. The carapace was oval and relatively low. The relationships of the Pleurosternidae are uncertain because of the general absence of skull material (Gaffney, 1975b; Młynarski, 1976). Gaffney and Meylan (1988) regard the family as the basal cryptodires in their cladogram.

Owen (1842b, pp. 165–7) also described *Tretosternon punctatum* on the basis of carapaces from the Purbeck Limestone Formation of Durlston and from the Wealden. The type specimens were lost, but a few others were identified (Lydekker, 1889b, pp. 141–3). *Tretosternon* was a moderate-sized form with a thick sculptured armour and a very flat, broad carapace about 500 mm long. It has been placed in the Pleurosternidae (Romer, 1956) and the Dermatemydidae (Cryptodira), but a restudy is required (Młynarski, 1976).

Several species of *Plesiochelys* have been described from Durlston: *P. latiscutata* (Owen, 1853), *P. emarginata* (Owen, 1853, in part), *P. belli* (Mantell, 1844) (see Lydekker, 1889b, p. 194) and *P. sollasi* Nopsca, 1928. *Plesiochelys* is a thick-shelled form, with a low carapace which is round to oval in outline. The limbs are adapted for aquatic and terrestrial life. Most of the species are defined on characters of the carapace, but their general relationships are not certain. All are moderate in size: *H. latiscutata* was 400 mm long, *H. emarginata* some 500 mm and *H. sollasi* had a carapace about 450 mm long and about 455 mm wide. Romer (1956) classed *Plesiochelys* in the Plesiochelyidae, with *Pleurosternon* in the Amphichelydia. Gaffney (1975a, 1975b, 1976) argued for the abolition of the Amphichelydia and placed the Plesiochelyidae in the Chelonioidea, a group of cryptodires (the large suborder of turtles that withdraw their heads in a vertical plane), but without reference to the Purbeck species. On the other hand, Młynarski (1976) associated the Plesiochelyidae with the Dermatemydidae (a group of primitive cryptodires). Gaffney and Meylan (1988) place the Plesiochelyidae in their Eucryptodira, between the Baenidae and the more derived cryptodires.

Platychelys (?) *anglica* Lydekker, 1889b (pp. 217–18) was a small turtle; the species was erected on a single carapace from Durlston. *Platychelys* is classed in the second turtle suborder, the Pleurodira (side-necked turtles) (Gaffney, 1975b; Młynarski, 1976; Gaffney and Meylan, 1988), but Lydekker's assignment of such a poor specimen may be incorrect.

Two recently described turtles are important. *Mesochelys durlstonensis* Evans and Kemp, 1975 is based on an excellent skull (Figure 7.15A) and partial skeleton. Evans and Kemp (1975) suggested that *Mesochelys* was related to the North American Late Jurassic *Glyptops*, a primitive cryptodire. The second specimen, *Dorsetochelys delairi* Evans and Kemp, 1976, also a cryptodire, is based on a good skull (Figure 7.15B). Evans and Kemp (1976) considered that it represented a group related to both Glyptopsidae and Baenidae. Gaffney (1979b) stressed the primitive nature of both genera and their importance in the classification of cryptodire turtles. *Mesochelys* is placed by Gaffney and Meylan (1988) in the Pleurosternidae, the basal cryptodire family.

A sphenodontid rhynchocephalian is represented only by three jaw fragments (Boulenger, 1891; Delair, 1960, pp. 77–8, Evans, 1992c) (BMNH R1765, R4808, DORCM G10831). These show the characteristic triangular acrodont teeth and squared-off symphysis found in the extant *Sphenodon*, and the new specimen has been ascribed to *Opisthias*, a sphenodontid known from the Late Jurassic of North America (Evans, 1992c). The earlier specimens (Figure 7.15C) are assigned to *Homoeosaurus* (Boulenger, 1891), a genus better known from the Late Jurassic of France and Germany, and a comparison of all the material is required.

The lizards from Durlston Bay are of particular significance in representing some of the earliest known types. Owen (1854) described several jaw fragments as *Macellodus brodiei*. He also referred some associated dermal scutes to *Macellodus*, but these probably pertained to a dwarf crocodile. Owen (1855a, 1861b) then described further jaws as *Saurillus obtusus*, but Lydekker (1888a, p. 289) synonymized this taxon with *Macellodus*.

The NHM, London later acquired the Beckles collection of 170 lizard specimens from Durlston Bay. Hoffstetter (1967) restudied these and erected five new genera and seven new species. He could not locate the type specimens of *Macellodus* and *Saurillus*, but considered that they were quite distinct. The new species were nearly all based on dentary or maxilla fragments, and the diagnostic characters were based on jaw shape and tooth morphology. The seven genera of Purbeck lizards recognized by Hoffstetter (1967) are: *Macellodus* and *Paramacellodus* (jaws 25 mm long; teeth tubular, peg-like, with rounded ends), *Saurillus* and *Pseudosaurillus* (jaws 12–25 mm long, teeth peg-like and pointed), *Becklesisaurus* (jaw 40 mm long, teeth peg-like, with rounded ends), *Durotrigia* (poorly known, teeth with multiple points) and *Dorsetisaurus* (jaw 40 mm long; teeth flattened, leaf-shaped and pointed). Most of the genera are represented by assorted skull bones, vertebrae and limb bones in addition to jaws, but there is not sufficient to reconstruct a complete skull or skeleton in any specimen. The lizards are referred to the extant groups Scincomorpha and Anguimorpha.

Seiffert (1973) reviewed Hoffstetter's (1967) work when he described new lizards from the Oxfordian of Guimarota, Portugal. He noted that Hoffstetter's (1967) interpretation of *Macellodus* differs from Owen's (1854, 1861b): Owen (1854) clearly showed the teeth as compressed, spade-shaped, with striations, and 8–10 mm wide, whereas Hoffstetter's (1967) neotype has peg-like rounded teeth without striations, and is 2 mm wide. Seiffert (1973) referred the '*Macellodus*' material of Hoffstetter (1967) to a new form, *Becklesisaurus hoffstetteri* Seiffert, 1973, and noted that '*Macellodus*' differs from *Becklesisaurus* only in the size of the jaws. Seiffert (1973) also expressed doubt about the validity of some other Hoffstetter taxa. Estes (1983) supported these views and erected the family Paramacellodidae for some taxa, and renamed others in Hoffstetter's (1967) Dorsetisauridae. Estes' (1983) list of taxa is as follows:

Family Paramacellodidae Estes, 1983
- *Paramacellodus oweni* Hoffstetter, 1967 (Figure 7.15D) (=*Saurillus robustideus*, *Becklesisaurus scincoides*).
- *Becklesius hoffstetteri* (Seiffert, 1973) (Figure 7.15E) (=*Macellodus brodiei* of Hoffstetter 1967)
- *Saurillus obtusus* Owen, 1854 (Figure 7.15F)
- *Pseudosaurillus becklesi* Hoffstetter, 1967 (Figure 7.15G)
- *Pseudosaurillus* sp. (=*Saurillus obtusus* of Hoffstetter, 1967)

Family Dorsetisauridae Hoffstetter, 1967
- *Dorsetisaurus purbeckensis* Hoffstetter, 1967 (Figure 7.15H)
- *D. hebetidens* Hoffstetter, 1967

Sauria *incertae sedis*
- *Durotrigia triconodeas* Hoffstetter, 1967

Not lizard
- *Macellodus brodiei* Owen, 1854 is crocodilian

The Purbeck beds of Durlston Bay have yielded nine crocodilian species. The best-represented forms belong to the Family Goniopholididae, which includes terrestrial–aquatic forms typical of the Purbeck and Wealden: broad-faced, with stout and rounded skulls, and with moderately long snouts reminiscent of modern crocodiles. *Goniopholis crassidens* was one of the first crocodilians recorded from Durlston, and was referred to as the 'Swanage crocodile' by Mantell (1837); the type skull and skeleton was described from one of the Swanage quarries (inland or coastal?) by Owen (1842b). *G. crassidens* was of large size, estimated at about 6 m long, with a 0.6 m long skull. The teeth are characteristic of the species, being remarkably stunted and thimble-shaped in outline. Owen (1878b) redescribed the type specimen from Swanage and reported abundant material from the Wealden. The species *G. simus* Owen, 1878 (Figure 7.16A) was smaller, about 2.5 m long, with more slender teeth and less tapering head. The type specimen also came from a 'Swanage quarry', and the remains include a fine 0.4 m skull. *Petrosuchus laevidens* Owen, 1878 was erected on the basis of a 0.25 m long partial skull and a mandible also from 'the Middle Purbecks, now quarried at Swanage'. The animal is estimated to have been of moderately large size. The skull is characterized by possessing slender teeth and a distinct angle between the slender rostrum and the temporal region that is almost as abrupt as that of a gavial. Watson (1911b) noted that the lower jaw and the skull described as associated by Owen (1878b) in fact belonged to different animals. He retained the lower jaw as the type of *Petrosuchus laevidens* Owen, 1878, and ascribed the poorly preserved skull to the new species *Pholidosaurus decipiens* Watson (1911), a member of the Family Pholidosauridae, an advanced long-snouted aquatic group. Andrews (1913) further described and figured *P. decipiens*.

Owen (1879b) described a partial fragmentary mandible from the Middle Purbeck as *Goniopholis tenuidens*, and further jaw remains as *Brachydectes major* Owen, 1879 and *B. minor* Owen, 1879. These were all distinguished on characters of the teeth and tooth arrangement. Woodward (1885) and Lydekker (1888a, pp. 79–83) accepted the validity of Owen's three species of *Goniopholis*. Woodward (1885, p. 506) noted that *Brachydectes* was pre-occupied and renamed it *Oweniasuchus*, and Lydekker (1888a, pp. 85–6) accepted the two species as valid. These five species are all small short-snouted forms (skulls 0.25–0.40 m long with stout teeth) and they are placed in the Goniopholididae. Steel (1973, pp. 15–19) accepted the validity of all five species, and of *Petrosuchus laevidens*.

The best-known Purbeck crocodilians are the so called 'dwarf', or small, crocodilians from the Feather Bed (?45–48). Owen (1879a, 1879b) described two forms, *Nannosuchus gracilidens* (Figure 7.16B) and *Theriosuchus pusillus* (Figure 7.16C), on the basis of good skulls and some post-cranial remains, noting (Owen, 1879b) the similarity of *Nannosuchus* to *Goniopholis*, and that *Theriosuchus* differed from the latter form in several respects. The skulls are 40–170 mm long, broad and short-snouted. *Nannosuchus* was like a miniature *Goniopholis*, but with long, slender, curved teeth adapted for catching fish. *Theriosuchus pusillus*, based on a nearly complete skeleton about 450 mm long, was discovered by Beckles in the Mammal Bed. Owen stated that its scattered teeth, scutes, vertebrae and limb bones are very numerous, and that a few skulls (about 90 mm long), mandibles and considerable portions of naturally articulated skeletons have also been found. The teeth of *T. pusillus* vary in shape and are consequently more specialized than those of any other Purbeck crocodilian in approaching a heterodont condition. Owen (1879a) argued at length that these small crocodilians captured the shrew-sized Purbeck mammals, and drowned them, just as crocodiles do today with larger mammals. Joffe (1967) re-examined the 'dwarf' crocodiles, and concluded that *Nannosuchus* was a juvenile *Goniopholis simus* and that *Theriosuchus* was a juvenile atoposaurid (a group of small, short-snouted crocodiles restricted to the Late Jurassic of the northern hemisphere).

A few pterosaur remains are recorded from Durlston Bay. Owen (1870, pl. 19, fig. 7) figured a phalanx from Swanage (Acton Quarries, Langton Matravers: SZ 990783) under the name *Ornithocheirus validus*. Although he appended no description, this is regarded as a valid characterization of the species. Seeley (1875a) erected the genus *Doratorhynchus* for a lower jaw and cervical vertebra (Figure 7.16D) from Durlston Bay. The jaw is long (300 mm+) with small close-set teeth. He associated these remains with Owen's specimen as *D. validus* (Owen, 1870). Lydekker (1888a, p. 26) returned the species to *Ornithocheirus*, and Wellnhofer (1978, p. 58) listed it among 'Ornithocheiridae *incertae sedis*'. Howse (1986) suggested that the *Doratorhynchus* vertebra (CAMSM J5341) is an elongated cervical, the oldest evidence of an azhdarchid pterosaur, a group of giant forms known otherwise only from the Late Cretaceous.

The Purbeck dinosaurs from Durlston are represented by limited, but important, material. A large theropod tooth (BMNH 44806) was ascribed by Lydekker (1888a, p. 163, 1890b) to *Megalosaurus dunkeri*, which Huene (1926) referred to *Altispinax*, a genus known otherwise from the Wealden of Germany, England and Belgium. This genus, like so many, is based on such an agglomeration of odds and ends from different sites that its true affinities cannot be determined (Molnar, 1990). It now seems that *Nuthetes* is also a megalosaur. The type species, *N. destructor*, was described by Owen (1854) on the basis of a small, partial, left mandibular ramus (Figure 7.16F) with pointed, recurved, double-rooted teeth with serrated edges from the Mammal Bed. Owen (1854) classified the specimen as a lizard, and ascribed to it some small scutes and limb bones from the Feather Bed. Owen (1861b, 1878a, 1879b) supplemented this description and argued that certain small, conical, granulated objects (granicones) found in the Feather Bed also were dermal ossifications of *Nuthetes* since they were found mixed with *Nuthetes* fragments. These conical dermal ossicles, of up to 14 mm height and 8 mm across the base, are now considered as belonging to an unknown ornithischian dinosaur. Lydekker (1888a, p. 247) and Seeley (1893a, 1893b) noted the dinosaurian character of *Nuthetes* and Swinton (1934, p. 214) identified it as a megalosaur. This assignment has been accepted by Romer (1956, p. 599), Delair (1959, p. 79), Steel (1970, p. 34) and Galton (1981a, p. 253), although Molnar *et al.* (1990) term it a carnosaur *taxon dubium*.

Several ornithischian dinosaurs have been described from Durlston Bay. Owen (1861b) noted some small fragmentary jaws with leaf-shaped teeth (Figure 7.16E) as *Echinodon becclesii* (ever since quoted as *E. becklesii*, but Owen (1861b) consistently misspelt the collector's name as S.H. 'Beccles'). Owen (1861b) interpreted the jaws as 'lacertilian', but noted similarities with dinosaurs. Lydekker (1888a, p. 247) noted the similarity of the teeth to those of *Scelidosaurus*, and *Echinodon* has generally been associated with it in the Stegosauria (Delair, 1959, p. 88; Steel, 1970, pp. 48–9). Galton (1978), on the other hand, argued that *Echinodon* is a fabrosaurid, one of a group of small bipedal ornithopods, and he later (Galton, 1981a) suggested that the granicones probably belong to *Echinodon* since an American fabrosaurid is known with small dermal ossicles possessing a similar structure. However, Coombs *et al.* (1990, p. 434) argue that *Echinodon* may well be a basal thyreophoran, related to *Scelidosaurus*, as had long been suspected.

Owen (1874b, pp. 3–4) described a small single imperfect mandible with teeth as *Iguanodon hoggii* on the basis of its tooth striations. Although clearly an *Iguanodon*, the differences from the better-known Wealden species have been regarded as slight (Delair, 1959, p. 85; Steel, 1970, p. 17). Nevertheless, it is probably a valid species (Norman and Weishampel, 1990, p. 530), and the oldest *Iguanodon* known. It is estimated to have been about 2.5 m long, small for an *Iguanodon*.

Marine reptiles have been described from Durlston, but their remains are poor. Lydekker (1889a, p. 227) noted a small, imperfect limb bone of a plesiosaur (BMNH 21974), and Delair (1969b) reported a series of postcranial remains of an ichthyosaur from the Purbeck of Swanage (OUM J.13795). The horizons of these marine reptiles are not known.

Finds of dinosaur trackways have been noted from Durlston Bay, and the earliest record found by P. Ensom (pers. comm., 1993) is in the minutes of the Purbeck Society for 1861, while W.T. Ord noted the discovery of tridactyl impressions 'near the Coastguard Station', observed during an excursion by the Bournemouth Natural History Society in 1912. A single print was found at nearby Peveril Point by G. Tyler in 1967 (Sarjeant, 1974, p. 357), and Delair and Sarjeant (1985, p. 148) suggested that this may have been an isolated fallen block related to the 1912 discovery. Ensom (1983, 1984b, 1985b, 1987c) and Nunn (1990) reported the discovery of poorly preserved tridactyl footprints preserved on the sole of DB103 in the Cherty Freshwater Beds at Durlston Bay.

Comparison with other localities

Durlston Bay is by far the richest Purbeck reptile site. The other recorded Purbeck locations producing significant finds of reptiles are listed near the beginning of the chapter.

The turtles *Dorsetochelys* and *Mesochelys* are unique to Durlston, although the latter genus is similar to *Glyptops* from the Late Jurassic (Kimmeridgian–Portlandian) of Wyoming, Utah and Colorado (Gaffney, 1979b). *Pleurosternon* is best known from Durlston, with some specimens also from the Isle of Portland (Portland Stone) and Asia (?) (Młynarski, 1976, p. 120). Other pleurosternids come from the Early Cretaceous of Kelheim, Bavaria (*Helochelys*) and the Late Jurassic to Early Cretaceous of China (*Changyuchelys*) (Młynarski, 1976, pp. 119–20). *Tretosternon* is well known from the English Wealden and from other parts of western and central Europe (Młynarski, 1976, p. 60). *Plesiochelys* is well known from the Late Jurassic of Solothurn, Switzerland and Szechuan, China and the Wealden of the Isle of Wight (Młynarski, 1976, pp. 55–6).

The sphenodontid *Homoeosaurus* is best known from the Kimmeridgian and Portlandian of Germany and France, and *Opisthias* from the Late Jurassic Morrison Formation of North America (Fraser and Benton, 1989). Comparable lizards to the Durlston genera are known from the Oxfordian of the Guimarota coal-mine, near Leiria, Portugal (Seiffert, 1973) and the Morrison Formation of Wyoming (Prothero and Estes, 1980). Kimmeridgian and Portlandian lizards belonging to other groups are also known from France (Bugey), Germany (Franconia, Bavaria), Spain (Catalonia) and Manchuria (Hoffstetter, 1967; Estes, 1983).

Goniopholid crocodiles were widely distributed in the Late Jurassic of Europe and North America, and worldwide in the Cretaceous. *Goniopholis* is well known from the Wealden of southern England and the Late Jurassic Morrison Formation of North America, as well as from many scrappy remains elsewhere (Steel, 1973, pp. 15–18; Buffetaut, 1982). *Oweniasuchus, Petrosuchus* and *Theriosuchus* are restricted to Swanage, except for a partial jaw and tooth of *Oweniasuchus* from Portugal (Steel, 1973, pp. 18–19). *Pholidosaurus* is better known from the Wealden of northern Germany (Buffetaut, 1982). Teeth of *Bernissartia* have been found at the Sunnydown Purbeck site (Ensom *et al.*, 1991), but not in Durlston Bay.

The pterosaur *Doratorhynchus* is unique to Durlston and, if correctly determined by Howse (1986), is the world's oldest azhdarchid, a group known otherwise only from the Late Cretaceous.

Megalosaurus is widely distributed throughout the Jurassic and Early Cretaceous of Europe (Lower Lias–Wealden of England, Portugal, France, Monaco, Germany, Transylvania) and Morocco (Steel, 1970, pp. 33–6), but this distribution is inflated by the identification as megalosaurids of a range of theropod taxa, most of which are indeterminate (Molnar, 1990). Early thyreophorans such as *Echinodon* are known from the Early Jurassic of Lyme Regis (*Scelidosaurus*), China (*Tatisaurus*) and Arizona (*Scutellosaurus*) (Coombs *et al.*, 1990). *Iguanodon* is known from the Early Cretaceous of southern England, Belgium, Portugal, possibly Bohemia, Mongolia and the Lakota Formation of North America (Norman and Weishampel, 1990).

Dinosaur footprints are preserved as moulds and casts in the limestones of the Middle and Upper Purbeck in several quarries on the Isle of Purbeck (Delair, 1960, 1963, 1966, 1982b; Charig and Newman, 1962; Walkden and Oppé, 1969; Delair and Lander, 1973; Delair and Brown, 1975; Ensom, 1982a, 1982b, 1984a, 1984b, 1985a, 1985b, 1986a, 1986b, 1987b, 1987c, 1988; West and El-Shahat, 1985; Newman, 1990). The prints have been attributed mainly to *Iguanodon* or some similar ornithopod, but also to *Megalosaurus* after the discovery of three-toed footprints in a quarry at Herston, near Swanage (Charig and Newman, 1962; Newman, 1990), and to sauropods (Ensom, 1987b).

Conclusions

The Purbeck beds of Durlston Bay have yielded one of the most important Mesozoic terrestrial faunas in the world. The 10 species of turtles are nearly all unique to Durlston, and they represent the earliest members of several important lineages. Durlston is the best early lizard site in the world, having produced so far a more diverse and better preserved fauna than other comparable Late Jurassic and earliest Cretaceous sites. The crocodilians include several genera unique to Durlston, and the small juvenile ('dwarf') specimens are unique. The pterosaur *Doratorhynchus*, if correctly determined, is the oldest azhdarchid, otherwise a Late Cretaceous group. The few dinosaur remains include the smallest known megalosaur, *Nuthetes*, an unusual armoured ornithischian, *Echinodon*, and perhaps the oldest known specimen of *Iguanodon*. All of these taxa have been restudied recently, or are in need of revision, and new finds continue to be made. The Durlston fauna occurs in marine and non-marine rocks which occupy a unique position at the Jurassic–Cretaceous boundary, it has yielded many unique genera (29 type species), and the range of small- to medium-sized reptiles gives it a position of international significance in vertebrate palaeontology and its high conservation value.