Chapter 5 British Early Jurassic fossil reptile sites

Introduction: Jurassic stratigraphy and sedimentary setting

In Britain, rocks of Jurassic age occur in England in a long, almost continuous outcrop, running from Dorset to Yorkshire, also in South Wales and in scattered patches in the islands off north-west Scotland, and in north-east Scotland (Figure 5.1). The Jurassic System is represented by rocks of predominantly shallow marine origin, with mainly fine-grained sediments such as marine shales, clays and mudstones. Shallower facies, marked by greater terrestrial input, include deltaic sequences of clays and sandstones, while those with little terrestrial input include shelf carbonates. The last are characteristic of the Mid Jurassic (Aalenian–Bathonian) and Late Jurassic (Oxfordian, Portlandian) and are commonly oolitic in character.

Rich faunas of ammonites allow precise biostratigraphic correlation for most of the Jurassic (Figure 5.2). Within the Early Jurassic, for example, a time span of about 25 Ma, 20 ammonite zones are recognized, and each is further subdivided into subzones. Where ammonites are scarce or lacking, as is the case in some British Mid and latest Jurassic terrestrial sediments, correlations have been attempted using other fossils, most commonly foraminiferans, ostracods, molluscs, dinoflagellates, spores and pollen, but these give a lower resolution.

The onset of marine conditions in Britain was marked by the Rhaetian transgression in the latest Triassic (documented in the rocks of the Penarth Group) and, by the Early Jurassic, fully marine conditions had become established. A shallow epicontinental sea (or epeiric sea) flooded much of northern Europe, forming a huge shelf sea. The extensive shelf area gave protection from strong tidal or storm influences, and distinctive facies of laminated bituminous shales and rhythmic sequences of lime mud and marl accumulated. Over shallow regions (swells), oolitic ironstones and condensed cephalopod limestones developed in the relative absence of terrigenous input.

Marine conditions continued through much of Jurassic time with two major regressive intervals, one during the Mid Jurassic and one at the close of the Jurassic, when the area of epeiric seas became significantly reduced, eventually giving way to the subaerial facies of the Portland and Purbeck beds.

The lowest units of the British Jurassic (Lias) consist primarily of marine clay-shale facies which in outcrop are more calcareous in the south and more sandy in the north. Two principal shale groups, those of the Lower and Upper Lias, are developed and are separated by the shallower-water facies of sandy shales, sandstones and oolitic ironstones of the Middle Lias. Fine-grained yellow sands of Upper Lias and earliest Bajocian age (e.g. Bridport sands), outcrop from Gloucester southwards to the Dorset coast. The biota of the Lias is dominated by a variety of marine benthic forms which indicate rather harsh bottom conditions. However, at times, environmental conditions appear to have deteriorated further so that only very low-diversity invertebrate fossil faunas occur. The sequences of unbioturbated bituminous laminated shales, characterized by the Jet Rock of Yorkshire, lack even protobranch bivalves, and represent the onset of sterile bottom conditions. Under these conditions, mid-water swimmers died and sank and were buried undisturbed; consequently such sequences contain some of the best examples of the marine reptiles of the time.

Bathonian times in the Mid Jurassic were characterized by regressive facies. Fluvio-deltaic deposits were laid down in southern Britain while, in west Scotland, the Great Estuarine Group accumulated under lagoonal conditions. At the same time, lagoonal-marsh and marginal-marine conditions appear to have developed in central England, where characteristic terrigenous deposits are found. The contemporaneous rocks in southern England are rather different, being dominated by marine carbonates with a lesser component of clays (e.g. the Great Oolite and the Fullers Earth), and these appear in the Cotswolds and the south Midlands to represent nearshore deposition, with signs of subaerial exposure. Ammonites there are consequently rare and correlation is difficult.

The succeeding rocks demonstrate a resumption of marine clastic sedimentation following commencement of the second major transgressive phase during the Callovian. The facies are predominantly monotonous, laterally extensive, dark bituminous clays which, in essence, mark a return to restricted muddy marine environments like those of the Early

Jurassic (Duff, 1975). In southern Britain, these beds are represented by the Lower Oxford Clay. The deeper-water Kimmeridge Clay (clays, mudstones and shales) is comparable, being rich in preserved organic material (including kerogen), and in containing a restricted marine benthos.

The Portland Group shows evidence of shallowing and renewed regression, and preserves a range of facies. The Cherry Beds are rich in sponge spicules and seem to have been deposited in calm marine water. The upper parts of the succession include shallow-water oolites, micrites and eventually evaporites (represented by halite and anhydrite) and soils, which document the progress of the regression. Marine incursions, including the Cinder Bed 'event', occur in the mid to Late Purbeck beds which are predominantly non-marine, and which span the Jurassic–Cretaceous boundary.

Reptile evolution during the Jurassic

Marine reptile evolution during the Jurassic is essentially the story of the radiations of the ichthyosaurs and the sauropterygians (Benton 1990a, 1990d). Ichthyosaurs had arisen in the Triassic, and they are known abundantly from the Muschelkalk of central Europe and, further afield, from Japan, Spitsbergen and Canada. Late Triassic ichthyosaurs are known from all parts of the world, but they are represented in Britain only in the Rhaetian 'Bone beds'. However, by Early Jurassic times, ichthyosaurs are found abundantly in Britain, and all phases of their evolution may be followed. Ichthyosaurs in the Jurassic were dolphin-like animals that for the most part fed on cephalopods, fishes and other reptiles, judging from the evidence of stomach contents and coprolites, and they show relatively little morphological diversification. Elsewhere, Jurassic ichthyosaurs are well known from the Early Jurassic of Germany (especially from Holzmaden in Baden-Württemberg) and from the Late Jurassic of Germany and France, but they are rare elsewhere.

Plesiosaur evolution in the Jurassic is also well documented in Britain (Brown, 1981), with complete specimens known from the marine formations. An apparent split into long-necked plesiosauroids and short-necked pliosauroids may be traced back into the British Lias, and comparative materials are known only from Germany.

Other marine niches were occupied during Jurassic times by pleurosaurs, relatives of the sphenodontids (lepidosaurs), which are known mainly from Germany, with no British representatives, and by crocodiles. The steneosaurs and teleosaurs of the British Early and Mid Jurassic are excellently preserved and compare very well with the Early Jurassic German and the Mid Jurassic French material respectively. These crocodiles were slender gavial-like fish-eating animals with long slender snouts and evidently marine habits. The Late Jurassic metriorhynchids (geosaurs), known from the Late Jurassic of Britain and Germany, were even more aquatically adapted, having fully formed paddles for limbs and a tail fin.

On land, the Jurassic Period heralded the rise of the dinosaurs which came to dominate all terrestrial tetrapod faunas (Benton 1989, 1990a, 1990d). Early Jurassic faunas worldwide were still dominated by Triassic holdover groups, such as the prosauropods and the basal ornithischians. However, new groups appeared in the Mid Jurassic, such as the sauropods, large theropods, avialan theropods (bird-relatives), stegosaurs and ankylosaurs. During the Late Jurassic, the huge sauropods dominated as top herbivores and the theropods occupied a range of niches as carnivores. Among the ornithischian dinosaurs, the thyreophorans (armoured dinosaurs) were the most important.

Other diapsid reptiles diversified during the Jurassic into a wide range of new forms, and many Triassic groups continued to radiate (Benton 1990a, 1990d). Archosaurs were the most abundant diapsids on land. Apart from the dinosaurs, crocodilians radiated extensively, and a range of carnivorous and piscivorous forms evolved: these are represented in Britain only in the Mid Jurassic. Lepidosaurs such as sphenodontids and squamates (lizards) remained generally small. Choristoderes, an enigmatic diapsid group hitherto known mainly from the Late Cretaceous and Palaeogene, appeared by Mid Jurassic times, and possibly in the Rhaetian (see Aust Cliff report, above).

British Jurassic reptile sites

Most fossil reptiles obtained from the Jurassic of Britain are marine forms, but these are supplemented by important terrestrial reptiles (dinosaurs and others) collected from the subaerial facies of the Mid Jurassic (e.g. Forest Marble, Stonesfield Slate), but also from all the representative marine units (Figure 5.1) and (Figure 5.2). The most spectacular

remains, including those of plesiosaurs, ichthyosaurs and marine crocodilians, derive from bituminous shale units, and important collections have come from the Early and Late Has (Hettangian–Sinemurian), the Oxford Clay (Callovian) and the Kimmeridge Clay (Kimmeridgian). These remains are commonly complete, or nearly complete, articulated skeletons, the result of their original deposition on undisturbed stagnant bottom waters unique to the northern European Jurassic shelf sea. The marine reptiles from the Oxford Clay (Callovian) are uniquely well preserved and form a centre-point of all international taxonomic studies.

Well articulated Early Jurassic (Hettangian–Sinemurian) plesiosaurs and ichthyosaurs from Lyme Regis are unique, including forms apparently intermediate between the long-necked elasmosaurids and the shorter-necked pliosauroids typical of the later Jurassic and Cretaceous. Plesiosauroids and pliosauroids from the Mid and Late Jurassic are also well represented in British Jurassic rocks. The ichthyosaurs from Britain are among the best in the world and contain many unusual forms marking the wide diversity of a group otherwise adapted for fast marine locomotion (e.g. the swordfish-like forms *Eurhinosaurus* and *Excalibosaurus*).

British Jurassic sites also provide good coverage of terrestrial reptiles, particularly the Early Jurassic dinosaur *Scelidosaurus* from Lyme Regis, the oldest thyreophoran and the unique Mid Jurassic dinosaurs: these are matched only in China. The Mid Jurassic sauropods (*Cetiosaurus*). theropods (*Megalosaurus*). thyreophorans (*Lexovisaurus, Dacentrurus*) and other less well-known forms fill an important gap in terrestrial records of Europe and North America.

The Mid Jurassic sites of central England and north-west Scotland contain the earliest members of several groups including choristoderes (unless the Rhaetian *Pachystropheus* is a choristodere; see Aust Cliff report), possible squamates, as well as some of the youngest known mammal-like reptiles (tritylodontids). British Jurassic squamates are particularly important, with the oldest in the world having been recognized recently in the Middle Jurassic rocks of the Cotswolds (Evans and Milner, 1991, 1994). In addition, the fauna of Late Jurassic/Early Cretaceous lizards from the Purbeck of Dorset is the most diverse of this age in the world. Comparable forms are known from Portugal, Germany and North America (Estes, 1983). Jurassic sphenodontids are less well represented in Britain than in Germany. Turtles are also reported from the British Mid and Late Jurassic, and the latter are important (especially those from Portland) as some of the best preserved of their age. Comparable material is known from the Late Jurassic of Switzerland and North America.

Early Jurassic

The Early Jurassic (Lias) of Britain is famous for its faunas of marine reptiles. Hundreds of good specimens have been obtained from localities along the entire length of the outcrop which stretches in a continuous belt between Dorset and the Yorkshire coast. Sites, other than Lyme Regis, that have yielded Early Jurassic reptiles are listed below. The listings are based on material in BATGM, BMNH, BRSMG, CAMSM, LEICS, OUM, SDM, YORYM, and Hawkins (1840), Woodward and Sherborn (1890), Fox-Strangways (1892), H.B. Woodward (1893, 1894, 1895), Arkell (1947a), Delair (1958, 1959, 1960, 1968, 1973) and Macfadyen (1970). Reptile-bearing fissures of Early Jurassic age from the areas of Bristol and South Wales are listed in the Triassic chapter. Note that the use of the names *Ichthyosaurus* and *Plesiosaurus* is based on old documentation: all specimens require revision.

Lower Lias

The British Lower Lias has yielded remains of ichthyosaurs and plesiosaurs from dozens of localities from Dorset to Yorkshire. Many of these finds are only isolated bones, so that the majority of sites may be classed as not significant. Other reptiles include two dinosaurs, a possible sphenodontid and a pterosaur. Ichthyosaurs and plesiosaurs have been collected from at least 40 localities in the Lower Lias of England, along the entire length of its outcrop from Dorset to the Yorkshire coast. Abundant remains have come from the quarries around Street, Somerset [ST 48 36] and Barrow-upon-Soar, Leicestershire [SK 58 18], but there is very little chance of more finds unless excavations are resumed. All other sites have produced only sparse remains and those that still offer exposure can be said to have only low potential for future finds. These other sites, listed by county from the south-west to the north-east, are:

DEVON: Axminster, Tolcis Quarry ([SY 280 010]; *Ichthyosaurus,* shale between half foot and foot limestone).

SOMERSET: Street — 18 or more quarries ([ST 48 36]; *planorbis* Zone; Thomas Hawkins' Sea-Dragons'; two species of ichthyosaur, .including neotype of *Leptopterygius tenuirostris* (McGowan, 1989a), type of *Protichthyosaurus protaxalis* and five species of plesiosaur, including types of *Plesiosaurus arcuatus, P. eleutheraxon* and *P. hawkinsi*); Street on the Fosse, south-east of Glastonbury (type of *Plesiosaurus megacephalus*); Walton, near Street ([ST 46 36]; *Ichthyosaurus, Plesiosaurus*); Somerton, near Street ([ST 48 28]; *Plesiosaurus*); Glastonbury ([ST 50 39]; *Ichthyosaurus*); West Pennard ([ST 54 38]; *Ichthyosaurus*); Keinton Mandeville ([ST 55 30]; *Ichthyosaurus*, from *planorbis* Zone); Watchet ([ST 07 43]; *Ichthyosaurus, Plesiosaurus* from Blue Lias on shore); Kilve, St Audrie's Bay ([ST 144 447]; *Ichthyosaurus*, Deeming *et al.,* 1993; Lilstock foreshore ([ST 196 463]; *Excalibosaurus;* McGowan, 1986).

SOUTH GLAMORGAN: Penarth ([ST 18 71]; *Plesiosaurus*).

GWENT: Sedbury Cliff ([ST 559 930]; possible sphenodontid (M J. Simms, pers. comm.).

AVON: Bath ([ST 47 65]; *Ichthyosaurus, Plesiosaurus*); Weston, near Bath ([ST 72 67]; *Ichthyosaurus, Plesiosaurus*); Saltford, near Bath ([ST 68 67]; *Ichthyosaurus* from railway cutting; donated to BRSMG by Brunel); Keynsham ([ST 65 68]; *Ichthyosaurus, Plesiosaurus* near station); Bitton, Keynsham ([ST 68 69]; *Plesiosaurus*); Nempnett ([ST 53 60]; *Ichthyosaurus*); Barrow Gurney ([ST 53 67]; *Plesiosaurus*); Banwell ([ST 59 59]; *Ichthyosaurus*); Willsbridge, near Bitton ([ST 66 70]; *Ichthyosaurus, Plesiosaurus*); Westfield, Radstock ([ST 68 54]; *Ichthyosaurus*); Stoke Gifford ([ST 62 79]; *Ichthyosaurus*); Bristol (exact locality uncertain; *Ichthyosaurus, Plesiosaurus*); Ashley Hill, Bristol ([ST 60 69]; *Plesiosaurus*); Hengrove, Bristol ([ST 60 69]; *Plesiosaurus*).

GLOUCESTERSHIRE: Gloucester ([SO 85 18]; *Ichthyosaurus, Plesiosaurus*); Cheltenham: Battledown Brickworks ([SO 967 225]; *Plesiosaurus* from *ibex* Zone); Hock Cliff, Saul ([SP 73 10]; *Ichthyosaurus, Plesiosaurus*); Stenehouse, Strand ([SO 80 05]; *Plesiosaurus*); Westbury-on-Severn ([SO 85 05]; *Ichthyosaurus, Plesiosaurus*); Eastington ([SO 77 05]; *Ichthyosaurus* from *bucklandi* Zone); Tewkesbury (various localities: Woolbridge ([SO 80 23]), Brockridge Common [SO 89 38], Hill Croome [SO 89 40], Defford Common [SO 90 43]: *Ichthyosaurus, Plesiosaurus* in the 'saurian beds' Q. Buckman)); Bredon ([SO 92 37]; *Ichthyosaurus* from *semicostatum/obtusum* Zone); Blockley ([SP 16 35]; *Plesiosaurus*).

HEREFORD AND WORCESTER: Bengeworth ([SO 94 43]; *Ichthyosaurus*); Himbleton ([SO 94 58]; *Ichthyosaurus, Plesiosaurus*); Grafton ([SO 98 37]; *Ichthyosaurus*); Bickmarsh ([SP 10 49]; *Ichthyosaurus*); Honeybourne ([SP 11 43]; *Ichthyosaurus, Plesiosaurus* from *turneri* Zone).

WARWICKSHIRE: Stratford-upon-Avon (exact locality uncertain, around [SP 15 59]; *Ichthyosaurus*); Wilmcote ([SP 168 583]; *Ichthyosaurus, Plesiosaurus,* ?exact locality; *Megalosaurus tibiaangulata* Zone, near railway station (Woodward, 1908b)); Harbury, Portland Cement Co. Quarry ([SP 39 59]; *Ichthyosaurus, Plesiosaurus,* type of *Macroplata tenuiceps* (plesiosaur) from *angulata* Zone (Swinton, 1930)); Temple Graften Quarry ([SP 121 539]; 'reptiles'); Shipston-on-Stour ([SP 25 40]; ichthyosaur, dinosaur); Southern ([SP 41 61]; *Ichthyosaurus, Plesiosaurus*); Little Lawford ([SP 46 77]; *Ichthyosaurus*); Rugby, Victoria Quarry ([SP 49 76]; *Ichthyosaurus, Plesiosaurus*); Newbold ([SP 49 77]; *Ichthyosaurus, Plesiosaurus*); Stockton, Nelson's Quarry and others ([SP 43 63]; *Ichthyosaurus, Plesiosaurus*).

LEICESTERSHIRE: Barrow-upon-Soar, quarries around and in the town ([SK 595 163], [SK 598 161], and many others; *Ichthyosaurus, Stenopterygius, Temnodontosaurus, 'Plesiosaurus', Rhomaleosaurus* and type of the megalosaur *Sarcosaurus woodi* (Andrews, 1921a; Martin *et al.,* 1986)); Normanton Hills ([SK 539 245]; ichthyosaur remains; LEICS).

LINCOLNSHIRE: Long Bennington ([SK 84 45]; *Plesiosaurus*).

NOTTINGHAMSHIRE: Elston ([SK 77 48]; *?Plesiosaurus*); Barnstone Quarry ([SK 736 356]; *Ichthyosaurus, Plesiosaurus* from bed 3S in the *pre-planorbis* beds); Cropwell Bishop, near Barnstone (?pliosauroid).

NORTH YORKSHIRE: Robin Hood's Bay ([NZ 96 04]; *Ichthyosaurus, Teleosaurus',* plesiosaurs, bed 18 of *bucklandi* Zone).

Middle Lias

Ichthyosaurus has been reported from the Middle Lias of Golden Cap, near Charmouth, in Dorset; and from Ilminster and Dundas, in Somerset, but remains are so poor that the sites are not worth tracing. A recent find from the Middle Lias of Dorset probably comes from the Eype Clay at Thorncombe Beacon ([SY 436 912]; Ensom, 1989b). Three other sites include Houston Quarry, Ilminster, Somerset (?[ST 362 153]; *Stenopterygius hauffianus,* in upper *margaritatus* Zone (McGowan, 1978)); Wotton-under-Edge, Avon ([ST 75 93]; *Ichthyosaurus* in Middle Lias); Bugbrooke, Northamptonshire ([SP 67 57]; *Ichthyosaurus, Plesiosaurus*); Isle of Raasay, Inner Hebrides (Scalpa Sandstone Formation; articulated plesiosaur remains; Martill 1985a).

Upper Lias

A few sites in the Upper Lias of Somerset, Northamptonshire and North Yorkshire have yielded good specimens of ichthyosaurs, plesiosaurs, marine crocodiles and one pterosaur.

SOMERSET: Strawberry Bank, Ilminster ([ST 361 148]; 30 specimens of the marine crocodile *Pelagosaurus typus* from the 'Fish and Saurian Bed' (*exaratum* Zone, *falciferum* Subzone), quarry now filled (Duffin, 1979b)).

NORTHAMPTONSHIRE: Bugbrook(e) ([SP 67 57]; *Ichthyosaurus, Rhomaleosaurus;* Middle-Upper Lias); Greens Norton (?[SP 664 492]; *Steneosaurus*); Blisworth ([SP 72 53]; *Ichthyosaurus*); Crick ([SP 58 72]; *Thaumatosaurus,* from railway cutting); Market Harborough bypass, near Dingley ([SP 753 882]; ichthyosaur; LEICS); Kingsthorpe, Northampton ([SP 76 62]; *Ichthyosaurus, Thaumatosaurus, Steneosaurus,* type of *Rhomaleosaurus thorntoni* Andrews, 122 (BMNH R4853) — quarries at [SP 758 643] and [SP 765 653]); Wellingborough ([SP 89 69]; *Microcleidus* in *bifrons* Zone).

LEICESTERSHIRE: Rutland Water Dam excavations ([SK 93 07]; ichthyosaurs in LEICS).

LINCOLNSHIRE: Stibbington ([TL 092 991]; *Ichthyosaurus, Plesiosaurus, Steneosaurus* in *thouarsense* and *bifrons* Zones).

NORTH YORKSHIRE: Kettleness alum-works ([NZ 83 16]; types of *Thaumatosaurus cramptoni* and *Plesiosaurus propinquus,* and *Stenopterygyius, Steneosaurus* in *communis* Zone); Saltburn ([NZ 66 21]; *Plesiosaurus in capricornis* Beds); Staithes–Runswick Bay coast section [NZ 79 19]–[NZ 81 16], including Port Mulgrave; *Steneosaurus* (Walkden *et al.,* 1987)).

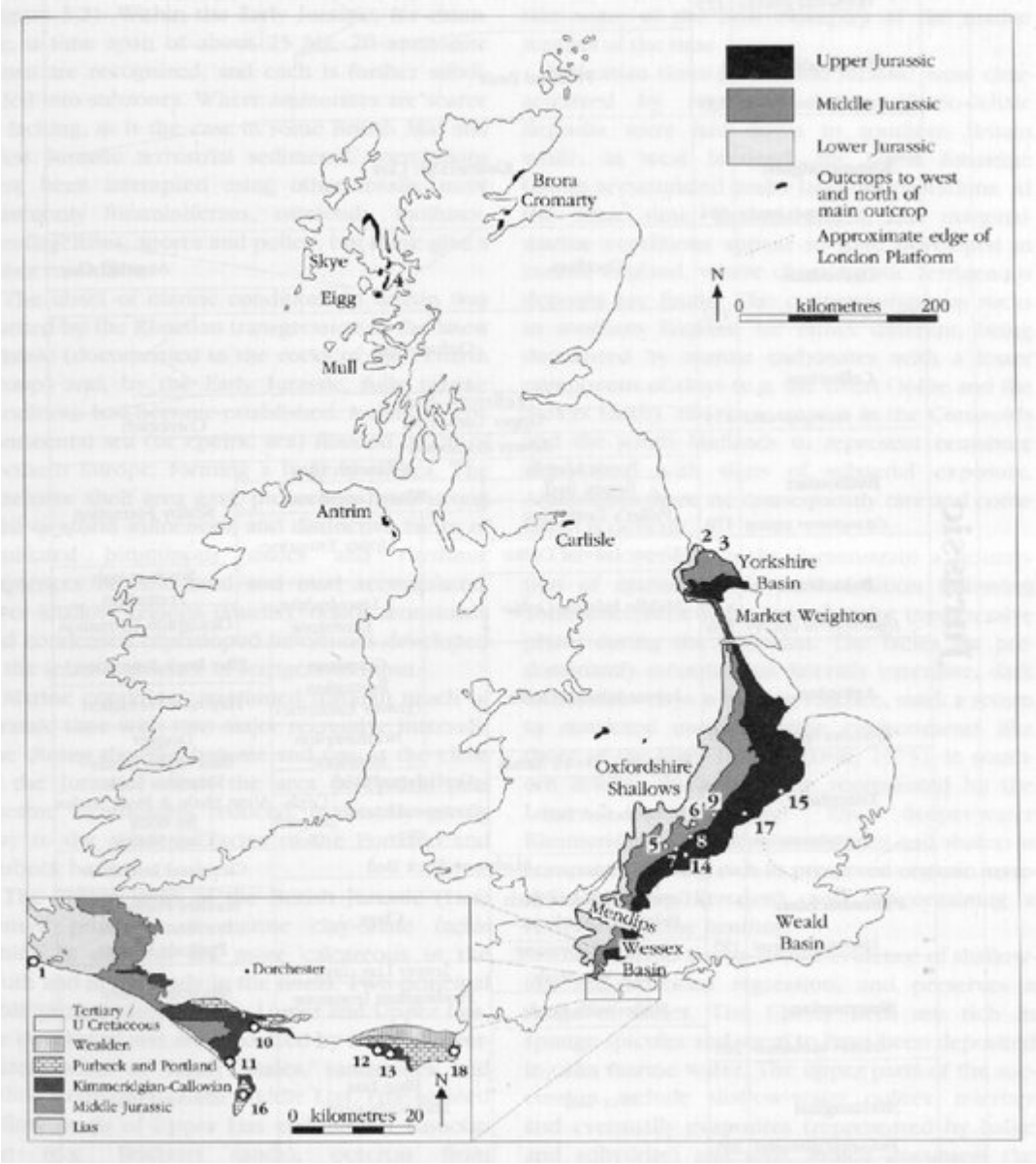
Three Lias localities, one from Dorset and two from Yorkshire, are selected for protection as GCR sites for their unusually prolific faunas of marine reptiles, as well as important terrestrial reptiles including pterosaurs and dinosaurs, some of which are not known outside Britain:

1. Lyme Regis coast (Pinhay Bay–Charmouth), Dorset [SY 32 91]–[SY 37 93]. Early Jurassic (Hettangian–Pliensbachian), Lower Lias (*Ostrea* Beds–Green Ammonite Beds).

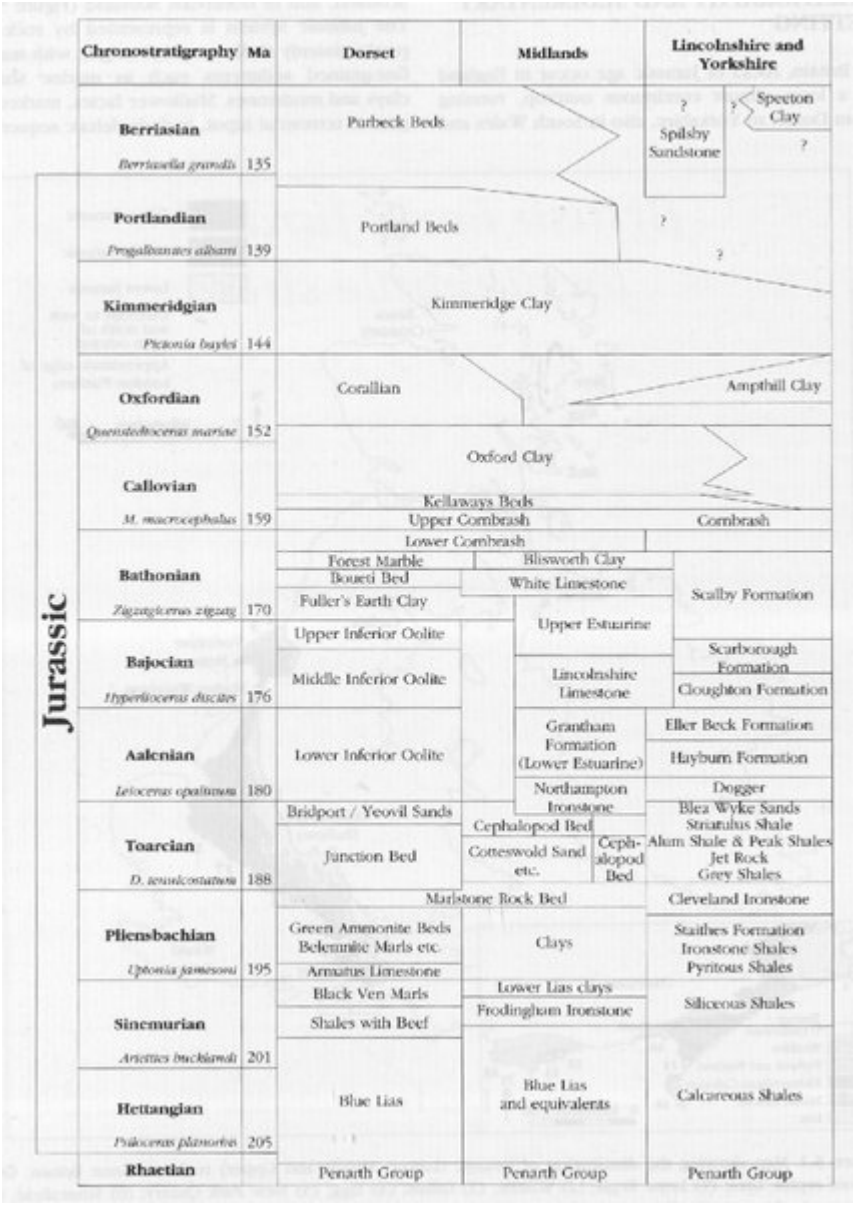
2. Whitby Coast (East Pier–Whitestone Point), Yorkshire [NZ 901 115]–[NZ 928 104]. Early Jurassic (Toarcian), Upper Lias (Grey Shales Formation, Jet Rock Formation, Alum Shale Formation).

3. Loftus, Yorkshire [NZ 736 200]–[NZ 757 193]. Early Jurassic (Toarcian), Upper Lias (Grey Shales Formation, Jet Rock Formation, Alum Shale Formation).

References



(Figure 5.1) Map showing the distribution of Jurassic (Lower, Middle and Upper) rocks in Great Britain. GCR Jurassic reptile sites: (1) Lyme Regis; (2) Whitby; (3) Loftus; (4) Eigg; (5) New Park Quarry; (6) Stonesfield; (7) Huntsman's Quarry; (8) Shipton-on-Cherwell Quarry; (9) Kirtlington Old Cement Works; (10) Furzy Cliff, Overcombe; (11) Smallmouth Sands; (12) Kimmeridge Bay; (13) Encombe Bay; (14) Chawley Brickpits; (15) Roswell Pits, Ely; (16) Isle of Portland; (17) Bugle Pit, Hartwell; (18) Durlston Bay.



(Figure 5.2) Summary of Jurassic stratigraphy, showing global standards and some major British formations (based on Harland et al., 1990).