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# Kirtlington Old Cement Works Quarry, Kirtlington, Oxfordshire

[SP 494 199]

## Highlights

Kirtlington Old Cement Works is the richest site in the world for small terrestrial vertebrates from the Bathonian. The diverse tiny bones of 30 frogs, salamanders, turtles, lizards, crocodilians, pterosaurs, dinosaurs, mammal-like reptiles and mammals have been found there, many of them representing the oldest occurrences of their groups in the world.

## Introduction

Kirtlington Old Cement Works Quarry has produced good faunas of fossil reptiles from the White Limestone and Forest Marble (Late Bathonian). The quarry was formerly worked for the manufacture of cement, and it closed about 1930. Although exposures were excellent (Odling, 1913; Arkell, 1931), some of the faces became obscured more recently (McKerrow *et al.*, 1969; Palmer, 1973; Freeman, 1979). Fossil amphibians, reptiles and mammals have been collected in recent years from the *fimbriatus-waltoni* Beds and from the Kirtlington Mammal Bed, a microvertebrate locality near the base of the Forest Marble (Freeman, 1976, 1979; Evans *et al.*, 1988, 1990; Evans, 1989, 1990, 1991, 1992a; Evans and Milner, 1991, 1994).

## Description

The succession in the quarry has been described by Odling (1913, pp. 493, 494), Arkell (1931, pp. 570–2), Douglas and Arkell (1932, pp. 123–4) and Richardson (1946, pp. 69–71, 78–9). Additional information has been provided by McKerrow *et al.* (1969) and Freeman (1979). The following composite section is based on these authors, and Richardson *et al.* (1946), in particular, with additions from Palmer (1973, 1979) and Torrens (*in Cope et al.*, 1980b, p. 36):

	Thickness (m)
Lower Cornbrash	
1. Limestone, rubbly and manly	1.07
2. Limestone, tough	0.76
3. Marl and rubbly limestone, in places nodular	0.23
4. <i>Astarte-Trigonia</i> Bed. Limestone, very hard, grey	0.61
5. Clay, brown, manly	0.30
Forest Marble Formation	
1. Clay, grey and buff, with some thin, irregular hard bands	1.53
2. Clay, dark grey (=beds 3w-z of Freeman, 1979)	0.69
3. Limestone, yellowish, flaggy, locally marly and 'shaly', oolitic, with occasional inclusions of white lithographic limestone; ripple marks, rain pits (?=bed 3v of McKerrow <i>et al.</i> , 1969; Freeman, 1979)	0.61–0.92
(White Limestone Formation)	
4. Clay, grey-blue, with three pale mudstone layers, one at the bottom (=beds 3p-u of McKerrow <i>et al.</i> , 1969; Freeman 1979; = 'Unfossiliferous Cream Cheese Bed' of Odling, 1913 and Arkell, 1931). The basal unconsolidated 0.04–0.25 m brown marl unit (Bed 3p) is the Kirtlington Mammal Bed of Freeman (1979)	2
(White Limestone Formation)	

5. *Coral–Epithyris* Limestone (Upper *Epithyris* Bed or Fossiliferous Cream Cheese Bed' of Odling, 1913 and Arkell, 1931; ? Beds 3n-o of McKerrow *et al.*, 1969). Limestone; at northern end an extremely hard white blue-hearted lithographic rock. Passes locally into unfossiliferous oolite 1.22–2.21
6. *fimbriatus–waltoni* Beds (=Bed 10 of Arkell 1931; Beds 3k, 1 of McKerrow *et al.*, 1969). Clay, grey-green to greenish black, with some white pellets at top; bed largely made up of bivalves; when bed 7 is absent, there is a lignite at the base 1.07
7. *Oyster–Epithyris* Marl (=Bed 9; Middle *Epithyris* Bed of Arkell, 1931; Bed 3k of McKerrow *et al.*, 1969). Marl, brown. 0–0.75  
Locally, a thin layer of corals occurs below
8. Limestone, hard, blue-hearted (?=Beds 3i,j of McKerrow *et al.*, 1969) 0.92m
9. Marl (?=Bed 3h of McKerrow *et al.*, 1969) 0.23m
- 10 Limestone, similar to 8 (?=Bed 3g of McKerrow *et al.*, 1969) 0.84–0.92 m
11. *Epithyris* Limestone (=Lower *Epithyris* Bed of Arkell, 1931; =Bed 3a-f, Bed 1e of McKerrow *et al.*, 1969). Limestones, white, at west end of pit a mass of *Epithyris*. 2.44  
Thins out eastwards and replaced from beneath by lenticular limestones
- 12 *Aphanoptyxis ardleyensis* Bed. Limestones, well bedded 0.46–0.61
- 13 *Nerinea eudesii* Beds. Limestones in three courses 1.68

This section was recorded by Arkell (1931) in various parts of the quarry, which means that it is not a true log because of the large amount of lateral facies variation. The lower parts (beds 8–13 in particular) are hard to match with the logs given by McKerrow *et al.* (1969, p. 58) because certain units, such as the *Epithyris* Limestone (Bed 11; Bed 1e of McKerrow *et al.*, 1969), are laterally impersistent.

There are considerable problems with the lithostratigraphy of the units in this quarry and these particularly concern the placing of the boundary between the White Limestone and the Forest Marble. Odling (1913, pp. 493–4) placed it above his 'Bed 1. Fossiliferous Cream-Cheese Bed', thus between beds 4 and 5 of the section of Richardson *et al.* (1946). Arkell (1931) renamed and subdivided the Forest Marble into the Wychwood Beds (beds 1–3 of the section of Richardson *et al.*, 1946) and the Kemble Beds (beds 4–7). Thus, he moved the Forest Marble/White Limestone boundary to between beds 7 and 8 on the basis of correlations with supposedly similar lithologies and fossils in Oxfordshire and Wiltshire. Richardson *et al.* (1946, pp. 69–71) changed the Wychwood Beds/Kemble Beds boundary to lie between their beds 2 and 3, and moved the Forest Marble/White Limestones boundary to lie between their beds 5 and 6. Arkell (1947a, p. 57) interpreted the sequence as follows: Wychwood Beds (beds 1–3), Kemble Beds (beds 4–5), Bladon Beds (beds 6–7), ?Bladon Beds (beds 8–10), Ardley Beds (beds 11–13), the division of the White Limestone being based on gastropods.

More recently, McKerrow *et al.* (1969) attempted a definition based largely on the occurrence of oysters and took the basal bed of the Forest Marble to be the base of the Oyster–*Epithyris* Marl (bed 7), as Arkell (1931) had initially. Palmer (1973, p. 61) points out that at Kirtlington the *Coral–Epithyris* Limestone (bed 5) contains oysters, but otherwise shows a typical White Limestone fauna and lithology, and he proposed that the Forest Marble/White Limestone boundary should be moved to between beds 4 and 5. This view was also expressed by Barker (1976) on the basis of a study of the gastropods. Palmer (1979) further argued this point and divided the White Limestone Formation into three members, of which the Ardley Member (beds 8–13) and the Bladon Member (beds 5–7) are seen at Kirtlington. Palmer (1979, p. 208, fig. 5) makes it clear that his Bladon Member is intended to include both the *fimbriatus–waltoni* and Upper *Epithyris* Beds of the Cherwell valley which rest on the *A. bladonensis* Bed. In general, Torrens (*in* Cope *et al.*, 1980b, p. 36) recommends that the base of the Forest Marble be taken as 'the base of the clay overlying the *Coral–Epithyris* bed, or of

the bed above at Kirtlington' (i.e. the base of bed 3 or 4).

Reptiles occur in the *fimbriatus–waltoni* Beds (beds 2o, 3i, 4e, 6f of McKerrow *et al.*, 1969; base of the Bladon Member, Palmer, 1979) and the Kirtlington Mammal Bed. Arkell (1931, p. 572) noted that he saw the bones of *Cetiosaurus oxoniensis* Phillips (1871) associated with lignite at the base of the *fimbriatus–waltoni* Beds where they rest on the eroded surface of the underlying limestone. Richardson *et al.* (1946, p. 70) repeated this observation, but noted that the bones and lignite occurred when the *Oyster–Epithyris* Marl (bed 7) was absent and lay on the eroded top of bed 8. However (p. 71) they say that 'the main horizon for Ceteosauran [sic] remains appears to be between the clay and the Middle *Epithyris* Bed, although here at Kirtlington and elsewhere the remains are often enclosed by the clay'. *Cetiosaurus* has been found elsewhere in Oxfordshire in the *fimbriatus–waltoni* Beds (Phillips, 1871; Arkell, 1931; Richardson *et al.*, 1946). The bones in this unit are usually disarticulated, but appear to have been associated (Phillips, 1871, p. 250).

The Kirtlington Mammal Bed (bed 3p of McKerrow *et al.*, 1969) is an impersistent lens, 21.5 m long and 0.04–0.25 m thick in the northeastern corner of the quarry (Freeman, 1979, p. 136). The contacts of this bed with the Coral-*Epithyris* Limestone below (bed 3o of McKerrow *et al.*, 1969) and another limestone above (bed 3q) are extremely sharp and probably erosional. Associated fossils (Evans and Milner, 1994) include microscopic freshwater charophytes, indeterminate plant fragments, and ostracods, as well as the dissociated remains of a variety of bony fishes (cf. *Lepidotes*, pycnodontoid, ?amioid) and sharks (*Asteracanthus*, *Hybodus*, *Lissodus*, batoid). The tetrapod remains include a variety of amphibians, reptiles and mammals (Evans and Milner, 1991, 1994). Most of these animals are represented only by their more durable parts — teeth, scutes, jaws and vertebral fragments. By contrast, a few genera (possibly those which have been least transported) have most of their skeletal elements preserved.

## Fauna

The older reptile specimens labelled 'Kirtlington' in collections are assumed to come from the *fimbriatus–waltoni* Beds, since the Mammal Bed was not exploited before the work of Freeman (1976, 1979) and its fossils are generally small.

### 1. *fimbriatus–waltoni* Beds

#### Archosauria: Crocodylia: Thalattosuchia: Steneosauridae

*Steneosaurus brevidens* (Phillips, 1871) BMNH R5149

'*Steneosaurus*' aff. *larteti* (J.A. Deslongchamps, 1866) OUM J.1413

*Steneosaurus* sp. BMNH R4809, R6323; OUM J.10597, J.12007; CAMSM J.21949–51, J.21954

*Teleosaurus* sp. BRSMG Cb1271 (specimen destroyed in World War 2)

#### Dinosauria: Saurischia: Theropoda: Megalosauridae

*Megalosaurus* sp. BMNH R5797

#### Dinosauria: Saurischia: Sauropoda

*Cetiosaurus* sp. BMNH R5152–3, R5156–7; OUM J.13526–57, J.13596

*Bothriospondylus* sp. BMNH R5150–1

#### Sauropterygia: Plesiosauria

?*Plesiosaurus* sp. BMNH R2986, R5154

### 2. Kirtlington Mammal Bed (data from Freeman, 1979 and Evans and Milner, 1991, 1994)

**Anura: Discoglossidae**

*Eodiscoglossus oxoniensis* Evans, Milner and Mussett, 1990 Holotype: BMNH R11700

**Caudata: Albanerpetontidae**

*Albanerpeton* sp.

Caudata: *inc. sed.*

*Marmorerpeton freemani* Evans, Milner and Mussett, 1988 Holotype: BMNH R11364

*Marmorerpeton kermacki* Evans, Milner and Mussett, 1988 Holotype: BMNH R11361

Salamander A

Salamander B

**Testudines: Cryptodira**

cf. Pleurosternidae

Lepidosauromorpha: *inc. sed.*

*Marmoretta oxoniensis* Evans, 1991 Holotype: BMNH R12020

**Lepidosauria: Sphenodontida**

Sphenodontian (Evans, 1992a)

**Lepidosauria: Squamata: Sauna**

*Saurillodon* sp.

Scincomorphs

Anguimorph

?Gekkotan

**Archosauromorpha: Choristodera**

*Cteniogenys* sp.

**Archosauria: Crocodylia: Ncosuchia**

?*Goniopholis/Nannosuchus* sp.

atoposaurid

**Archosauria: Pterosauria**

Rhamphorhynchoid

Pterodactyloid

**Archosauria: Saurischia**

*Megalosaurus* sp.

'maniraptoran' and other small theropods

?*Cetiosaurus*

**Archosauria: Ornithischia: Ornithopoda**

Fabrosaurid, cf. *Alocodon*

**Synapsida: Therapsida: Cynodontia:**

Tritylodontidae

*Stereognathus ooliticus* Charlesworth, 1855

**Mammalia: Triconodonta: Morganucodontidae**

*Wareolestes rex* Freeman, 1979

**Mammalia: Docodonta: Docodontidae**

*Simpsonodon oxfordiensis* Kermack, Lee, Lees and Mussett, 1987

**Mammalia: Symmetrodonta: Kuehneotheriidae**

*Cyrtlatherium canei* Freeman, 1979

**Mammalia: Eupantotheria: Penunuridae**

*Palaeoxonodon ooliticus* Freeman, 1979

**Mammalia: Eupantotheria: Dryolestidae**

?Dryolestid

## Interpretation

The biostratigraphy of the Bathonian at Kirtlington is difficult since no ammonites have been found locally, and very few elsewhere in comparable rocks (Torrens, 1969a; *in Cope et al.*, 1980b). Finds of ammonites in the White Limestone of the Oxford area have permitted correlation of this unit with the *subcontractus* and *morrisi* Zones (Mid Bathonian), and the *hodsoni* and lower *aspidoides* Zones (Late Bathonian), while the Forest Marble Formation is largely *aspidoides* and basal *discus* Zones (Late Bathonian), on the basis of correlation of beds above and below.

The approximate zonal assignments of the three members of the White Limestone Formation are: Shipton Member, ?*subcontractus*, *morrisi* Zones, Ardley Member, ?lower *hodsoni* Zone, and Bladon Member, ?upper *hodsoni*–lower *aspidoides* Zones (Palmer, 1979; Torrens, *in Cope et al.*, 1980b). However, the evidence for zonation of these members is 'not compelling' (Torrens, *in Cope et al.*, 1980b, p. 37). Ostracod zonation (Bate, 1978) places the White Limestone of the Oxford area in ostracod zones 5–8, the Forest Marble and Cornbrash resolving to the top of zone 8 and above (=upper *discus* Zone).

The reptile-bearing *fimbriatus*–*waltoni* Beds (base of the Bladon Member) are dated as ?upper *hodsoni* Zone (basal Late Bathonian) (Torrens, *in Cope et al.*, 1980). However, the occurrence of the ostracod *Glyptocythere penni* in the *fimbriatus*–*waltoni* Beds led Bate (1978) to suggest that this unit belongs to the *discus* Zone. The Kirtlington Mammal, Bed falls within the *aspidoides* or *discus* Zone (Freeman, 1979, p. 136).

Environmental interpretations have been made on the basis of the sedimentology of the *fimbriatus-waltoni* Beds. McKerrow *et al.* (1969, pp. 61–4, 80) noted the abundance of lignite and occasional caliche-like nodules which they interpreted as indicating shallow water with occasional subaerial exposure. The nodules appear to be distinct from the small pellets of 'race' common in many calcareous clays close to the ground surface, which are produced by recent weathering. Klein (1965, p. 173) considered that similar nodules from other Great Oolite clays represent caliche, indicating emergence, although Palmer (1979, p. 210) regarded them as pebbles formed by erosion of an incompletely cemented limestone bed. Palmer (1979, pp. 210–11) noted the complex channelled interdigitations of this unit at Shipton [SP 47 17], and suggested that deposition of some of the clays was local and catastrophic, and that the nodules were derived from elsewhere. There is a non-sequence at the top of the *fimbriatus-waltoni* Beds, and localized emergence at this level is probable, which may be related to nodule formation. Palmer (1979) supposed a quiet-water lagoonal environment subject to periodic current activity and influx of new sediment, perhaps during storms.

The marl sediment of the Kirtlington Mammal Bed contains subangular pebbles of oolitic limestones, comminuted shell debris, individual ooliths and rare silica sand grains, all of which suggest a temporary freshwater pool that received periodic influxes of poorly sorted sediment derived from local erosion of earlier Mid Jurassic limestones (Freeman 1979, p. 139). The ostracods, charophytes and fishes lived in the pool, and the plants, amphibians, reptiles and mammals presumably lived nearby. Freeman (1979) noted that the mammal and theropod teeth were distributed in clumps, and that this might indicate their concentration in the faeces of larger animals, such as carnivorous dinosaurs ('coprocoenoses').

As outlined by Evans (1990, p. 234), in Bathonian times Kirtlington lay on or near the south-west shore of a small island barrier some 30 km from the coast of the Anglo-Belgian landmass at a subtropical latitude of about 30°N (Palmer, 1979). Lignite, charophytes and freshwater ostracods and gastropods in the marly sediments suggests a coastal environment, which had low relief, with creeks, lagoons and freshwater lakes, rather like the Florida Everglades (Palmer, 1979). The vertebrate fauna of the Kirtlington Mammal Bed, with its amphibians and aquatic reptiles (choristoderes, crocodilians and turtles), agrees well with such a palaeoenvironmental scenario. Terrestrial elements are rather rare, being largely represented by reptile jaw fragments and teeth; these components may have been reworked from localities further inland.

The faunas of the two reptile-bearing beds at Kirtlington are rather different, which probably relates to preservational and environmental conditions rather than to the very slight age difference. They will be discussed separately.

The *fimbriatus-waltoni* Beds fauna is dominated by crocodilians and sauropod dinosaurs. The long-snouted crocodilians *Steneosaurus* and *Teleosaurus* are represented by vertebrae, teeth and jaws. Their long recurved teeth, strong jaws and adaptations for swimming suggest that they were fish-eaters in fresh or marine water. The taxonomy of these forms is complex (Steel, 1973), so that the species assignments may be incorrect. These crocodiles are relatively common in the Bathonian of England and France (see above). In the Late Bathonian of England specimens are known from the upper White Limestone of a few localities elsewhere in Oxfordshire and in the Blisworth Limestone (=White Limestone) and Blisworth Clay of Northamptonshire.

The carnivorous dinosaur *Megalosaurus* is represented only by a tooth. However, a variety of vertebrae, limb bones and skull elements (including the brain case) of the large sauropod *Cetiosaurus* have been found. More than 10 species of this genus have been erected for Jurassic and Cretaceous material (Steel, 1970, p. 64). The Mid Jurassic forms are *C. rugulosus* (Owen, 1845) from Wiltshire, *C. oxoniensis* Phillips (1871) and *C. glymptonensis* Phillips (1871) from Oxfordshire and Northamptonshire and *C. mogrebiensis* Lapperant (1955) from the Moyen Atlas of Morocco. The morphological distinctions between these species have not been elucidated (*C. rugulosus* is based on a tooth, *C. glymptonensis* on a caudal vertebra and the other two on incomplete postcranial skeletons). Further, many other generic names have been applied to large sauropod bones, and the differences have often not been made clear. Nevertheless, most of the Mid Jurassic English material may be placed in *C. oxoniensis*, the best-known species. This animal had a 1.65 m femur, and was about 15 m long overall. The braincase resembles that of the Triassic *Plateosaurus*, the neck was relatively short and the vertebrae showed primitive features (almost solid construction, and no bifurcation of the neural spines).

Two vertebrae of another sauropod, *Bothriospondylus*, have also been found at Kirtlington. This genus is known mainly from the Late Jurassic and Early Cretaceous, but two forms occur in the Bathonian, *B. robustus* Owen (1875) from Wiltshire and *B. madagascariensis* Lydekker (1895) from Madagascar. The vertebrae of *Bothriospondylus* are deeply excavated, presumably to reduce their weight. Its total body length was 15–20 m.

Two vertebrae have been named as those of a plesiosaur. If correctly identified, these may belong to the genera 'Cinioliasaurus' of *Muraenosaurus*, known from the Bathonian of sites in Northamptonshire, Cambridgeshire, Leicestershire and Eigg, western Scotland. Assuming their correct identification, the presence of plesiosaurs in the *fimbriatus-waltoni* Beds would indicate marine conditions, but their rarity here may connect with a predominantly lagoonal/coastal situation.

The amphibians, reptiles and mammals from the Kirtlington Mammal Bed have been summarized by Freeman (1979) and Evans and Milner (1991, 1994). Details of the collecting and preparation techniques are given in Freeman (1976, 1979), Kermack *et al.* (1987) and Evans (1989). The amphibians and reptiles (Figure 6.12) are described here (the mammals will be detailed in the GCR Fossil Mammals and Birds volume).

The amphibians include a frog referable to the family Discoglossidae (*Eodiscoglossus oxoniensis*) and five species of salamander (*Albanerpeton*, *Marmorerpeton kermacki*, *M freemani* and two unnamed forms). *Eodiscoglossus oxoniensis* ((Figure 6.12)A is the earliest identifiable discoglossid frog known, and one of the oldest frogs of any sort (Evans *et al.*, 1990). The specimens of *E. oxoniensis* from Kirtlington are comparable with *E. santonjae* from the Early Cretaceous of Montsech, Lerida, Spain, but they may be clearly distinguished by characters of the ilium and pre-maxilla. The only older frogs are the primitive *Triadobatrachus* from the Early Triassic of Madagascar and *Vieraella* from the Early Jurassic of Argentina.

The record of *Albanerpeton* is one of the oldest of this enigmatic family, the oldest being from the Bajocian of Aveyron, France (Evans and Milner, 1994). The albanerpetontids are also known from the Cretaceous of North America and the Miocene of France. *Marmorerpeton kermacki* ((Figure 6.12)B and *M freemani* are the earliest known salamanders (i.e. true Caudata; Evans *et al.*, 1988), more primitive than any other known forms by the absence of intravertebral spinal nerve foramina in the atlantal centrum. However, in other features these taxa resemble members of the family Scapherpetonidae, which comprises neotenous forms otherwise known only from the Late Cretaceous and Palaeocene. Salamanders A and B are yet to be described.

Turtles are represented by many specimens (Freeman, 1979; Evans and Milner, 1994) which augment the sparse Mid Jurassic record of that group. The oldest turtles, *Proterochersis* and *Proganochelys*, come from the Late Triassic of Germany and the oldest cryptodire, the main modern group is *Kayentachelys* from the Early Jurassic of North America. Turtle fragments are known from Stonesfield and other British Bathonian sites, but the Kirtlington material includes more diagnostic skull and carapace fragments of a pleurosternid (Evans and Milner, 1994).

Lepidosauromorphs are represented at Kirtlington by a variety of forms. The Lepidosauromorpha (Benton, 1985; Evans, 1988a; Gauthier *et al.*, 1988c) include the Lepidosauria (sphenodontids plus squamates) and a number of basal Permo-Jurassic groups. *Marmoretta oxoniensis* ((Figure 6.12)C is a small probably insectivorous form, apparently a common component of the fauna (Evans, 1991). True lepidosaurs are represented by some sphenodontids (Evans, 1992a) and squamates (two scincomorph lizards, one of which is *Saurillodon*, an anguimorph and a possible gekkotan). These are important since lepidosaurs are not well known in the Mid Jurassic: the nearest well-documented faunas are the sphenodontids from the Late Triassic and Early Jurassic fissures of the Bristol area and South Wales (see above) and from the Early Cretaceous of Durlston Bay (Purbeck). Sphenodontids are known also from the Late Jurassic of Germany (Solnhofen), France (Cerin) and North America (Morrison Formation) (Fraser and Benton, 1989). The first true lizards are known otherwise only from the Late Jurassic (Oxfordian of Guimarota, Leiria, Portugal; Kimmeridgian of Cerin, Ain, France; Portlandian of Solnhofen, Bavaria, Germany; Benton, 1993).

*Cteniogenys* ((Figure 6.12)D is represented by many isolated skull and postcranial elements. The genus was named on the basis of some isolated dentaries from the Late Jurassic of Wyoming by Gilmore (1928), who identified the bones as representing a lizard. This interpretation was also given for specimens from Guimarota in Portugal by Seiffert (1973) and

Estes (1983). The material from the Kirtlington Mammal Bed, however, demonstrates that *Cteniogenys* is a choristodere, an archosauromorph diapsid (Evans, 1989, 1990, 1991). It appears to be the smallest choristodere known but, allowing for its size, it appears to be related to the Rhaetian *Pachystropheus* (see Aust Cliff report), the gavial-like aquatic Late Cretaceous and Palaeocene *Champsosaurus* and *Simoedosaurus*, and a new form from the Oligocene of France. Comparison with known choristoderes suggests that *Cteniogenys* is the most primitive of the known genera (Evans, 1989). The available skull and postcranial material indicate that the Kirtlington form is represented by animals of more than one age class; the largest specimens are well ossified and can be assumed to be the adults.

The abundant crocodile teeth are nearly all shed crowns; Freeman (1979, p. 140) reports only three with roots. They apparently show little resemblance to *Teleosaurus* and Freeman (1979, p.140) compares them with the small Late Jurassic goniopholid *Nannosuchus* from the Purbeck (?juvenile *Goniopholis*). Evans and Milner (1993) note also some rare *Theriosuchus*-like atoposaurid teeth, a form otherwise known from the Wealden. If the identifications are correct, these would be the oldest records in the world of goniopholidids and atoposaurids ((Figure 6.12) G,H).

The pterosaur teeth have been identified as of rhamphorhynchoid and pterodactyloid types (Evans and Milner, 1991, 1994), and similar identifications have been made from Hornsleasow. The long slender rhamphorhynchoid teeth ((Figure 6.12)E) could correspond to *Rhamphocephalus*, a form better known from the Mid Bathonian of Stonesfield and the Early Bathonian of sites around Eyford (see above). If the shorter blunter pterosaur teeth ((Figure 6.12)F) are truly pterodactyloid, this would be another oldest record, since pterodactyloid skeletons are reported first from the ?Oxfordian (Guimarota, Portugal) and the Kimmeridgian (Morrison Formation, Wyoming; Kimmeridge Clay, Dorset; Tendaguni Beds, Tanzania; Benton, 1993).

The theropod teeth are described by Freeman (1979, p. 142) as 'smaller than those of... *Megalosaurus bucklandi*, ranging in height from 1.6 to 7.4 mm. They may be the teeth of either juvenile *M bucklandi* or of coelurosaurs'. It is important to note their relative rarity here, especially since *Megalosaurus* teeth are among the commonest reptile finds at Stonesfield. Many of the smaller theropod teeth ((Figure 6.12)K) most closely resemble those of maniraptoran dinosaurs such as *Deinonychus* and *Troodon*, typically Cretaceous forms (Evans and Milner, 1991, 1994).

Ornithischian dinosaurs are represented by teeth similar to those of the ornithopod *Alocodon*, possibly a fabrosaurid (Evans and Milner, 1991, 1994, (Figure 6.12)O). Freeman (1979, p. 142) compared his ornithischian teeth with those of *Scelidosaurus* (Sinemurian, Charmouth, Dorset) or *Echinodon* (Berriasian, Durlston Bay, Dorset).

Finally, the rare tritylodont teeth (*Stereognathus*) described by Freeman (1979) and Evans and Milner (1994) are of considerable importance. The tritylodonts are best known from the Late Triassic and Early Jurassic of South Africa, China, Germany and some of the British fissures (Kühne, 1956, Savage, 1971). Mid Jurassic forms are known from the Stonesfield Slate of Stonesfield (*progracilis* Zone, Mid Bathonian; Simpson, 1928, pp. 22–6), the Ostracod Limestones of the Great Estuarine Group of Skye (Late Bathonian; Waldman and Savage, 1972) and the Forest Marble of Bridport, Dorset (Late Bathonian; Ensom, 1977). The Kirtlington specimens are the youngest known tritylodonts, and the last surviving mammal-like reptiles from Britain, and are superseded in age only by *Bienotheroides* from the Mid or Late Jurassic of China.

### **Comparison with other localities**

The reptiles from Kirtlington Cement works compare best with faunas collected nearby in the Mid and Late Bathonian. Sites around Shipton-on-Cherwell Quarry (see above) have yielded remains of turtles, the crocodylian *Steneosaurus*, and the dinosaurs *Megalosaurus*, *Lexovisaurus* and *Cetiosaurus* from the *fimbriatus*–*waltoni* Beds (upper White Limestone) and from the Forest Marble and Lower Cornbrash. However, none of these sites has yielded *Bothriospondylus*, plesiosaurs, choristoderes, lepidosaurs, tritylodontids or the other small vertebrates known from Kirtlington. This is probably because careful washing and sorting of large amounts of sediment has not yet been carried out. Other comparable, but less abundant, faunas have been collected from the Forest Marble of Wiltshire, the upper White Limestone Formation and Forest Marble of Gloucestershire and Oxfordshire, and the Blisworth Limestone and Blisworth Clay of Northamptonshire (see above).



Some older localities in the British Bathonian may be better for comparison because they have yielded rich faunas: Hornsleasow (earliest Bathonian), New Park Quarry (Early Bathonian), Stonesfield (early Mid Bathonian) and Huntsman's Quarry (early Mid Bathonian). None of these has yet turned up such an array of well-preserved microtetrapod material.

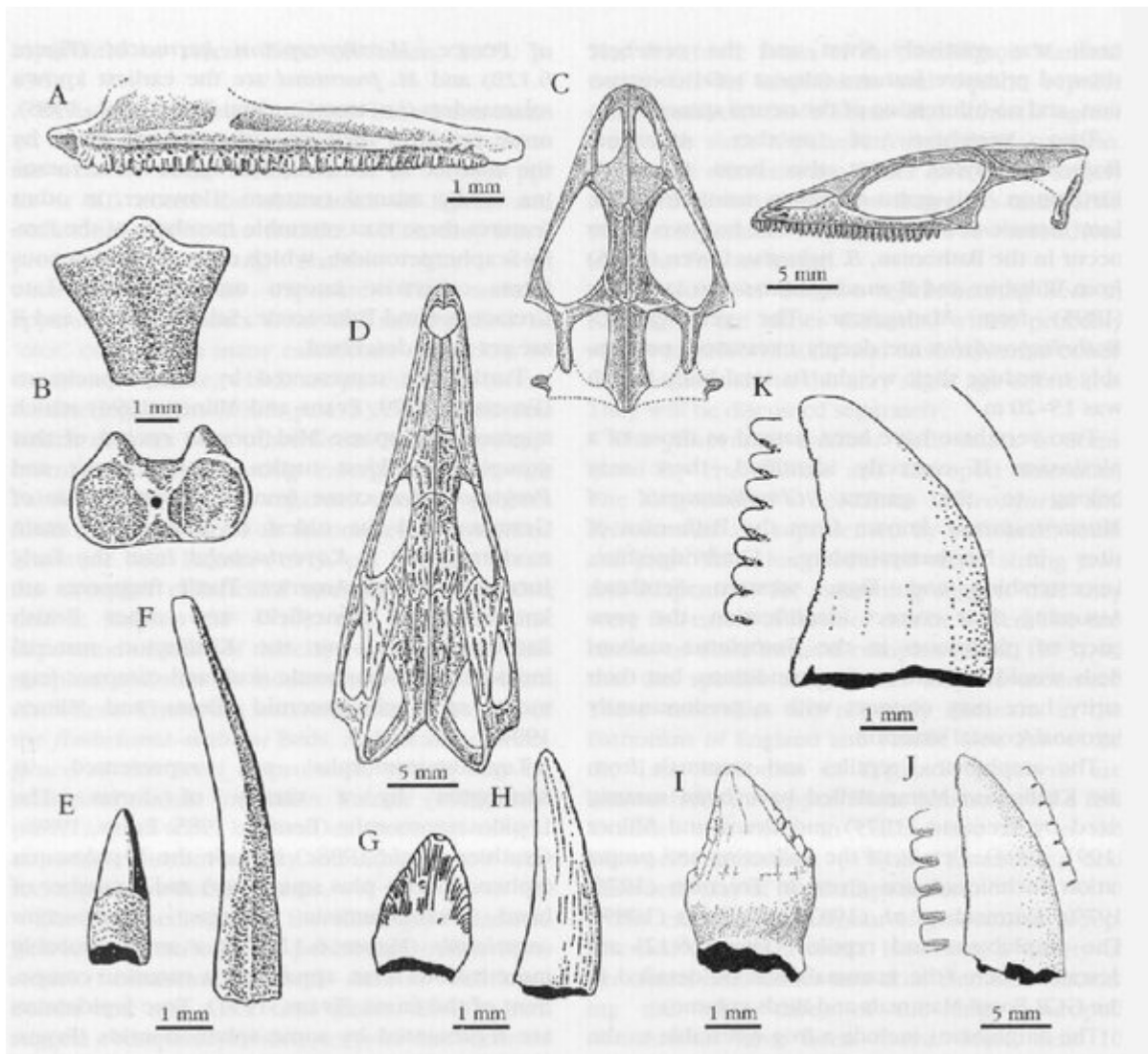
The Kirtlington Mammal Bed fauna bears a significant resemblance to later Mesozoic freshwater assemblages, rather than earlier ones (Evans *et al.*, 1988; Evans and Milner, 1994). The salamanders cannot with certainty be referred to later families, but elements of the salamander–discoglossid–albanerpetontid–turtle–crocodile–choristodere association are found in later assemblages, such as those of Late Jurassic age at Guimarota (Oxfordian) and Solnhofen (Portlandian), the Late Jurassic/Early Cretaceous Purbeck in Dorset (q.v.), the Early Cretaceous at Una, Spain, and the Late Cretaceous of the Judith River (=Lance Formation) of North America.

## Conclusions

Kirtlington Quarry represents the best Late Bathonian site for a variety of amphibian and reptile groups, and it is the source of numerous new forms. The *fimbriatus*–*waltoni* Beds reptiles are comparable with those from the same unit at several other sites in Oxfordshire, but the variety of material is greater than elsewhere, and the site is still readily accessible for further excavation. The fauna of the Kirtlington Mammal Bed is without rival for its age; the selection of large and small reptiles has still to be studied fully, but they could rival the older Stonesfield fauna in their importance. The Mammal Bed fauna includes a unique freshwater assemblage of small reptiles and amphibians, several of which are the earliest known occurrences of their respective groups (the first discoglossid frog, salamanders, pleurosternid turtle, true lizards of several groups, goniopholidid and atoposaurid crocodylians, pterodactyloid pterosaur and ?maniraptoran dinosaur). The amphibian and reptile fauna is extensive, including frogs, salamanders, turtles, lepidosauromorphs, sphenodontids, lizards, choristoderes, crocodylians, pterosaurs and small dinosaurs.

The diversity and importance of the fossil vertebrates and potential for future finds give the site its high conservation value.

## [References](#)



(Figure 6.12) Bathonian amphibians and reptiles from Kirtlington Old Cement Works Quarry. (A) The frog *Eodiscoglossus oxoniensis* Evans, Milner and Mussett, 1990, right maxilla in medial view; (B) the salamander *Marmorerpeton kermacki* Evans et al., 1988, atlantal centrum in ventral and anterior views; (C) the lepidosauromorph *Marmoretta oxoniensis* Evans, 1991, reconstructed skull in lateral and dorsal views; (D) the choristodere *Cteniogenys oxoniensis* Evans, 1990, reconstructed skull in dorsal view; teeth of: (E) rhamphorhynchoid pterosaur; (F) pterodactyloid pterosaur; (G) goniopholidid crocodile; (H) atoposaurid crocodile; (I) fabrosaurid dinosaur; (J) megalosaurid dinosaur; (K) maniraptoran dinosaur. All after Evans and Milner (1994).