KIRTLINGTON OLD CEMENT WORKS QUARRY

OS Grid Reference: SP494199

Highlights

The Forest Marble Formation (Upper Bathonian) at Kirtlington Old Cement Works in Oxfordshire has yielded a rich and diverse fauna of fishes based on teeth, including a microshark assemblage. This unique freshwater assemblage within an otherwise marine succession also includes an important amphibian component.

Introduction

Kirtlington Old Cement Works Quarry in the village of Kirtlington, Oxfordshire, has produced good faunas of fossil fishes and amphibians from the Forest Marble (Late Bathonian). The quarry was formerly worked for the manufacture of cement, and it closed about 1930 (Figure 12.18). 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 fishes, 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, 1989, 1990, 1991, 1992; Evans *et al*., 1988, 1990; Evans and Milner, 1991, 1994).

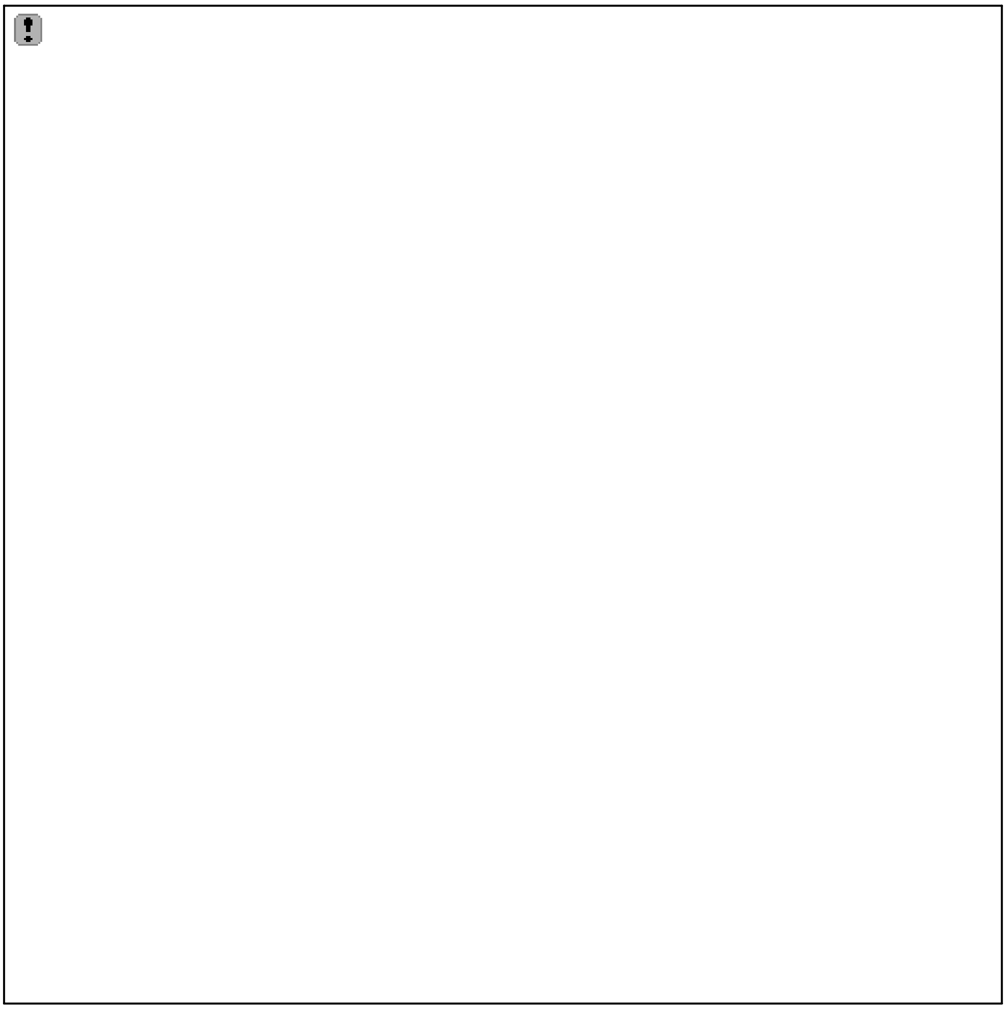

Figure 12.18: Photograph of the Kirtlington section, north face (photo: R Cottle).

Description

The succession in the quarry has been described by Odling (1913, pp. 493–4), 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), McKerrow and Kennedy (1973) 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 (1980, p. 36; numbering of individual beds is from the top down):

		Thickness (m)
Lower Cornbrash		
5	Limestone, rubbly and marly	1.07
4	Limestone, tough	0.76
3	Marl and rubbly limestone, in places nodular	0.23
2	*Astarte–Trigonia* Bed. Limestone, very hard, grey	0.61
1	Clay, brown, marly	0.30
Forest Marble Formation		
13	Clay, grey and buff, with some thin, irregular hard bands	1.53
12	Clay, dark grey (= Beds 3w–z of Freeman, 1979)	0.69
11	Limestone, yellowish, flaggy, locally marly and ‘shaly', oolitic, with some inclusions of white lithographic limestone; ripple marks, rain pits (? = Bed 3v of McKerrow *et al*.,1969; Freeman, 1979)	0.61–0.92
(White Limestone Formation)		
10	Clay, grey-blue, with three pale mudstone layers, one at the bottom (= Beds 3p–u of McKerrow *et al*., 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)	2.00
(White Limestone Formation)		
9	Coral–*Epithyris* Limestone (Upper *Epithyris* Bed or ‘Fossiliferous Cream Cheese Bed' of Odling, 1913, and Arkell, 1931; ? Beds 3n–o of McKerrow, 1969). Limestone; at northern end an extremely hard, white, blue-hearted lithographic rock. Passes locally into unfossiliferous oolite	1.22–2.21
8	*fimbriatus–waltoni* Beds (= Bed 10 of Arkell, 1931; Beds 3k, l 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. Locally, a thin layer of corals occurs below	0–0.75
6	Limestone, hard, blue-hearted (? = Beds 3i, j of McKerrow *et al*. 1969)	0.92
5	Marl (? = Bed 3h of McKerrow *et al*., 1969)	0.23
4	Limestone, similar to 8 (? = Bed 3g of McKerrow *et al*., 1969)	0.84–0.92
3	*Epithyris* Limestone (= Lower *Epithyris* Bed of Arkell, 1931; ? = Beds 3a–f, Bed 1e of McKerrow *et al*., 1969). Limestones, white, at west end of pit a mass of the brachiopod *Epithyris*. Thins out eastwards and replaced from beneath by lenticular limestones	2.44

2	*Aphanoptyxis ardleyensis* Bed. Limestones, well bedded	0.46–0.61
1	*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 problems in correlating the litho-stratigraphy of the units in this quarry with those elsewhere in the northern Cotswolds, particularly the boundary between the White Limestone and the Forest Marble (e.g. Odling, 1913; Arkell, 1931, 1947a; Richardson *et al*., 1946).

McKerrow *et al*. (1969) attempted a definition based largely on the oysters, and took the base of the Forest Marble to be at the base of the Oyster–*Epithyris* Marl (Bed 7), as had Arkell (1931) initially. Palmer (1973, p. 61) pointed out that at Kirtlington the Coral–*Epithyris* Limestone (Bed 5) has a typical White Limestone fauna and lithology, and lowered the Forest Marble–White Limestone boundary to between Beds 4 and 5. 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) made 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. Torrens (1980, p. 36) recommended 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).

Vertebrates 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. The *fimbriatus–waltoni* Beds are greenish grey or black clay, which is often lignitic toward the base. Phillips (1871) recorded fish remains in association with the large bones of the sauropod dinosaur *Cetiosaurus oxoniensis*, within lignite resting upon the eroded surface of the underlying limestone. Since then other authors have reported large reptilian bones from the same beds (Richardson *et al*., 1946; Arkell, 1931) and these are outlined in the GCR volume on fossil reptiles (Benton and Spencer, 1995).

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 north-eastern corner of the quarry (Figure12.18; Freeman 1979, p. 136). The fish fauna within this unit occurs as dissociated remains of a variety of bony fishes and sharks. Associated fossils include microscopic freshwater charophytes, indeterminate plant fragments, and ostracods (Evans and Milner, 1994). The tetrapod remains include amphibians, reptiles and mammals (Evans and Milner, 1991, 1994). Most of the vertebrate material occurs as isolated elements, and some specimens show signs of abrasion and transport. However, delicate bones are also preserved in the accumulation. Some remains of marine fish in this horizon are regarded as being derived from the underlying White Limestone, along with marine invertebrates such as corals, brachiopods and echinoderm material (E. Freeman, pers. comm. to Evans and Milner, 1994). By contrast, a few genera (including much of the amphibian material) have most of their skeletal elements preserved, these are possibly those which have been transported least.

Fauna

It is assumed that older fish specimens labelled 'Kirtlington' in collections came from the *fimbriatus–waltoni* Beds, where there were extensive excavations for large reptilian remains (e.g. Phillips, 1871), since the microvertebrate remains of the Mammal Bed were not exploited before bulk preparation by Freeman (1976, 1979) and the University College, London, team (Kermack *et al*., 1987).

(1) *fimbriatus–waltoni* Beds (data from

Phillips, 1871)

Chondrichthyes: Elasmobranchii: Euselachii: Hybodontoidea

Asteracanthus sp.

Hybodus sp.

Osteichthyes: Actinopterygii: Neopterygii: Halecostomi

Pycnodonts *indet*. *Eomesodon bucklandi* Woodward, 1918 *Proscinates (Microdon)* sp.

Lepidotes sp.

(2) Kirtlington Mammal Bed (data from

Freeman, 1979; Evans and Milner, 1991,

1994; Evans *et al*., 1988, 1990).

Chondrichthyes: Elasmobranchii: Euselachii: Hybodontoidea

Asteracanthus sp.

Hybodus polyprion Agassiz, 1843

Hybodus sp. *Lissodus pattersoni*Duffin, 1985

L. *wardi*Duffin, 1985

Chondrichthyes: Elasmobranchii: Neoselachii: Batomorphii

Spathobatis sp.

‘batoid'

Osteichthyes: Actinopterygii: Neopterygii: Halecostomi

Eomesodon sp.

Lepidotes sp.

pycnodont indet. Osteichthyes: Actinopterygii: Neopterygii: Holostei: Halecomorphi

?amioid

TETRAPODA Amphibia: Lissamphibia: Anura

Eodiscoglossus oxoniensis Evans, Milner and Mussett, 1990

Amphibia: Lissamphibia: Caudata

Marmorerpeton freemani Evans, Milner and Mussett, 1988

M. *kermacki* Evans, Milner and Mussett, 1988

Salamander A

Salamander B

Amphibia: Lissamphibia: Albanerpetontidae

Celtedens sp.

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, 1980). 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* and *morrisi* Zones, Ardley Member, ?lower *hodsoni* Zone, and Bladon Member, ?upper *hodsoni*–lower *aspidoides* Zones (Palmer 1979; Torrens, 1980). However, the evidence for zonation of these members is 'not compelling' (Torrens, 1980, p. 37), and 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 vertebrate-bearing *fimbriatus–waltoni* Beds (base of the Bladon Member) are thus dated as upper *hodsoni* Zone (basal Late Bathonian; Torrens, 1980, p. 36). 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) interpreted the abundance of lignite and occasional caliche-like nodules as indicating shallow water with occasional subaerial exposure. Palmer (1979, pp. 210–11) noted the complex channelled interdigitations of this unit at Shipton (SP 4717), and suggested that deposition of some of the clays was local and catastrophic, and that the nodules were derived from elsewhere. He also (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 and tetrapods presumably lived nearby.

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 fishes, amphibians and aquatic reptiles (choristoderes, crocodilians and turtles), agrees well with such a palaeoenvironmental scenario. Terrestrial elements, including the albanerpetonid amphibian, lizards, archosaurs and mammals, are much rarer (Evans and Milner, 1994); they may have been transported into the lagoon from inland.

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

The only early reference to the fish fauna of Kirtlington is a brief mention of 'teeth of *Hybodus*, *Pycnodus* and *Strophodus*, and scales of *Lepidotus*' (Phillips, 1871, p. 244). *Hybodus* is a ubiqitous element in the classic Great Oolite sequences and the presence of this genus in the *fimbriatus–waltoni* Beds is not remarkable. The reference to both pycnodont teeth and semionotid scales (Phillips, 1871) is also consistent with a shallow-marine fauna similar composition to other Great Oolite fish-bearing localities (cf.Rayner, 1958). The tetrapod fauna is dominated by long-snouted piscivorous crocodilians.

The fish, amphibians, reptiles and mammals from the Kirtlington Mammal Bed have been summarized by Freeman (1979), Duffin (1985) 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 reptiles have been described in the GCR fossil reptile sites volume (Benton and Spencer, 1995) and the mammals will be detailed in the GCR fossil mammal sites volume.

The fish fauna from the Mammal Bed is unremarkable; it contains the typical hybodont shark and halecostome bony fish components found in most Great Oolite Group assemblages. The microvertebrate fauna includes neoselachian teeth (Evans and Milner, 1994), and several may be attributable to the primitive ray *Spathobatis*, a genus present throughout the British marine Bathonian (D. Ward, pers. comm., 1993; S. Metcalf and C. Underwood, pers. comm.).

The bony fish component consists of disassociated teeth, and scales of various holosteans are the most abundant fossils within both meso- and microfossil fractions. The commonest is the pycnodont *Eomesodon bucklandi*, although *Proscinates* (*Microdon)* and at least one semionotid are also present. Microvertebrate samples contain gular plate and mandible fragments of far smaller fish; some of these, with closely spaced crushing teeth, may be a pycnodont. The vast majority of material is generically indeterminate. In many old collections it has been assigned to ‘bucket genera' (e.g. Phillips, 1871; Woodward, 1890, 1892, Savage, 1963), especially *Eomesodon*, *Lepidotes* (ornamented bones and heavy scales) and *Pholidophorus* (light bones). Evans and Milner (1994) also record the presence of possible amioid teeth and jaws in the acid residues, which Freeman (1976) referred to *Caturus*. As with other Bathonian fish assemblages, there is some indication of durophagy (e.g. the hybodonts *Asteracanthus* and *Lissodus*, the ‘batoid' neoselachian and the semionotid and pycnodont osteichthyans).

The amphibians include the dissociated and fragmentary remains of a frog referrable to the family Discoglossidae (*Eodiscoglossus oxoniensis*), four species of salamander (*Mar-morerpeton kermacki*, *M. freemani* and two unnamed forms) and the small salamander-like *Celtedens* (Figure 12.19). *Eodiscoglossus oxon-iensis* is the earliest identifiable discoglossid frog known, and one of the oldest frogs of modern aspect (Evans *et al*., 1990). The specimens of *E. oxoniensis* from Kirtlington are comparable with *E. santonjae* from the Early Cretaceous of Montsech, Lérida Province, Spain, but they may be clearly distinguished by characters of the ilium and premaxilla. The only older frogs are the primitive *Triadobatrachus* from the Early Triassic of Madagascar, *Vieraella* from the Early Jurassic of Argentina and *Prosalirus bitis* from the Kayenta Formation (Pliensbachian, Early Jurassic) of Arizona (Shubin and Jenkins, 1995).

Figure 12.19: Amphibian remains from Kirtlington; the albanerpetonid Celtedens, restoration (after McGowan and Evans, 1995).

The record of the albanerpetontid is one of the oldest of this enigmatic tetrapod family, the oldest being from the Bajocian of Aveyron, France (Evans and Milner 1994). The ?amphibious albanerpetontids are also known from a range of localities including those in the Jurassic of Portugal, the Cretaceous of North America and Spain and the Miocene of France (McGowan, 1994; McGowan and Evans, 1995). Albanerpetonids were slender little animals, superficially not unlike newts.

Marmorerpeton kermacki and *M. freemani* are the earliest known salamanders (i.e. true Caudata; Evans *et al*., 1988), more primitive than any other known forms, as shown by the absence of intravertebral spinal nerve foramina in the atlantal centrum. In other features these taxa resemble members of the family Scapherpetonidae, which comprises neotenous forms otherwise known only from the Late Cretaceous and Palaeocene. At present *Marmorerpeton* is under revision and its tentative attribution to the Scapherpetonidae, is unlikely to stand (S. Evans, pers. comms., 1994). Salamanders A and B are yet to be described.

Comparison with other localities

The fish and amphibian remains from Kirtlington Cement Works compare best with Mid- and Late Bathonian faunas nearby. The *fimbriatus–waltoni* Bed at Shipton-on-Cherwell quarry (SP 477175) has yielded abundant fish remains (Evans and Milner, 1994) and a diverse fauna with *Lissodus* has been recovered from the 'Monster Bed' (Palmer, 1979) at Woodeaton Quarry, Oxfordshire (SP 534122; Freeman, 1979, F. Mussett, pers. comm. to Evans and Milner, 1994). The Forest Marble at Tarlton Clay Pit, near Cirencester (SO 970001), has yielded a similar but fragmentary fauna to that from the Mammal Bed at Kirtlington, including albanerpetontids and the enigmatic caudates *Mar- morerpeton*, and Kirtlington salamanders A and B (Evans and Milner, 1994). The palaeoenvironment of the Tarlton site is similar to that of the Mammal Bed (Ware and Windle, 1980; Ware and Whatley, 1983). Sections of Forest Marble at both Swyre (SY 525868) and Watton Cliff, Dorset (q.v.), yield a similar microvertebrate assemblage (Freeman, 1976; Evans and Milner,1994). Marine elements, such as selachian teeth, are much better preserved there, whilst the tetrapod material is generally abraded and water-worn, indicating transport (Evans and Milner, 1994) into a more high-energy offshore environment (Holloway, 1983). Finally, the small section of offshore Forest Marble at the Leigh Delamere service station, Wiltshire (ST 890790), has also produced fragmentary and rolled microvertebrates including marine selachians and Sala-mander A (Evans and Milner, 1994; pers. obs., 1993).

Some older localities in the British Bathonian have yielded rich freshwater faunas; for example, Hornsleasow Quarry (SP 132323; earliest Bathonian) has yielded a similar, but less diverse, fish fauna and comparable amphibian remains (Metcalf *et al*., 1992). At Stonesfield (q.v.; early Mid-Bathonian), and Huntsmans Quarry (SP 125254; early Mid-Bathonian) elements of the Kirtlington fauna, (although no amphibian material) have been recovered. *Marmorerpeton* also occurs in the Kilmalaug Formation on Skye (Waldman and Evans, 1994).

The Kirtlington Mammal Bed fauna resembles later rather than earlier Mesozoic freshwater assemblages (Evans *et al*., 1988; Evans and Milner, 1994; pers. comm., 1993). Elements of the tetrapods are found in later assemblages, such as those at Guimarota (Oxfordian) and Solnhöfen (Portlandian), the Late Jurassic–Early Cretaceous Purbeck in Dorset (q.v.), the Early Cretaceous at Uña and Las Hoyas, Spain, and the Late Cretaceous of the Lance Formation of North America.

Conclusions

Kirtlington Quarry represents the best late Bathonian site for a variety of amphibian groups, and it is the source of numerous new forms. Marine fishes from the *fimbriatus–waltoni* Beds 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 Mammal Bed fauna includes a unique freshwater assemblage of small fishes and amphibians, several of which are the earliest known occurrences of their respective groups (the first discoglossid frog and salamanders). Altogether the diversity of these faunas from different depositional environments gives the site its conservation value.

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