Kirtlington Old Cement Works, Kirtlington, Oxfordshire

[SP 494 199]

Introduction

Kirtlington Old Cement Works quarry is one of the richest Middle Jurassic (late Bathonian) vertebrate sites in the world (Evans and Milner, 1994). The fauna is especially diverse and includes frogs, salamanders, lizards, turtles, crocodiles, pterosaurs, dinosaurs, mammal-like reptiles and mammals. The mammalian fauna is particularly important as it contains relict taxa of Rhaeto-Liassic faunas and early members of Late Jurassic faunas (Freeman, 1979; Sigogneau-Russell, 2001, 2003a,b).

Despite being disused since 1929, Kirtlington Old Cement Works (Figure 2.11) still has good exposures of the White Limestone, Forest Marble and Cornbrash formations. Most of the mammal fossils come from a bed of unconsolidated clay (Bed 3 of McKerrow *et al.,* 1969), within the Forest Marble Formation that crops out in the north-eastern corner of the quarry (Freeman, 1979; Evans, 1990). The absence of ammonite fossils makes precise stratigraphical correlation difficult. However, the presence of an ostracod in the underlying unit suggests placement of the Mammal Bed in the *Clydoniceras discus* Zone; an alternative interpretation is that it belongs to the slightly older *Oxycerites aspidoides* Zone (Freeman, 1979).

Description

The sedimentary succession at Kirtlington Old Cement Works has been described by many authors, including Odling (1913), Arkell (1931), Douglas and Arkell (1932) and Richardson *et al.* (1946). The following section (Table 2.2) is taken from Benton and Spencer (1995, p. 157).

The section described here is a composite based on exposures from around the quarry and therefore does not accurately represent the large amount of lateral variation (Benton and Spencer, 1995).

The Mammal Bed at Kirtlington Old Cement Works consists of an unconsolidated brown marl. It occurs as an impersistent lens in the north-eastern corner of the quarry. The lens is of variable thickness, ranging from 40 to 250 mm, thinning at the edges. The sediments beneath the Mammal Bed are composed of a deep yellow, friable oolitic limestone that grades down into a massive coralline limestone. The sediments above the Mammal Bed are yellow limestones. The Mammal Bed is younger than the mammal-bearing horizons at the Stonesfield Slate Mines (Freeman, 1979).

The Mammal Bed contains indigenous and reworked fossils. The indigenous taxa are characteristic of a non-marine environment and include vertebrates and ostracods. Plant fossils also are common, although they are highly fragmented and poorly preserved. The reworked fossils generally are abraded and include oysters, corals, brachiopods, echinoids and crinoids (Freeman, 1979).

(Table 2.2) Composite section of the Kirtlington Old Cement Works GCR site, Oxfordshire (after Benton and Spencer, 1995)

	Thickness (m)
Lower Cornbrash Formation	
1. Limestone, rubbly and marly	1.07
2. Limestone, tough	0.76
3. Marl and nubby limestone, in places nodular	0.23
4. Astarte–Trigonia Bed. Limestone, very hard, grey	0.61
5. Clay, brown marly	0.30
Forest Marble Formation	

1. Clay, grey and bluff, 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 *et al.,* 1969; Freeman, 1979)	0.61–0.92
4. Clay, grey-blue, with three pale mudstone layers, one at the bottom (= 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
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	1.23–2.21
6. fimbriatu–-waltoni Beds (= Bed 10 of Arkell, 1931; Beds 3k, 1 of McKerrow *et al.,* 1969). Clay, grey-green to greenish black, with some pellets at top; bed largely made up of bivalves; when bed 7 is absent, there is 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
White Limestone Formation	
1. Limestone, hard, blue-hearted (?= Beds 3i, j of McKerrow *et al.,* 1969)	0.92
2. Marl (?= Bed 3h of McKerrow *et al.,* 1969)	0.23
3. Limestone, similar to 8 (?= Bed 3g of McKerrow *et al.,* 1969)	0.84–0.92
4. Epithyris Limestone (= Lower *Epithyris* Bed of Arkell, 1931; = Beds 3a-f, Bed le of McKerrow *et al.,* 1969). Limestones, white at west end of pit a mass of *Epithyris.* Thins out eastwards and replaced from beneath by lenticular limestones	2.44
5. Aphanoptyxis ardleyensis Bed. Limestones, well bedded	0.46–0.61
6. Nerinea eudesii Beds. Limestones in three courses	1.68

The sediments of the Mammal Bed, in addition to the brown marl, contain fragments of oolitic limestone, with individual ooliths, fragments of shells and rare clastic grains. The sediments are well sorted and show no evidence of sedimentary structures. The palaeoenvironment of the Mammal Bed has been interpreted as a shallow pool formed during a temporary marine regression. Sediments from the surrounding oolitic limestone outcrop collected in the pool, along with invertebrate and vertebrate debris (Freeman, 1979).

Bulk sampling of the unconsolidated brown marls produced batches of mammal teeth with similar taphonomic characteristics. The teeth appear to have been hollowed out from within, removing the root. Freeman (1979) considered this to be caused by stomach acids during digestion. However, Fisher (1981) considered loss of enamel to be characteristic of digestion; a feature not shown by the mammal fossils at Kirtlington Old Cement Works. The crowns are generally incomplete and show unabraded fractures. The lack of matching pieces of the teeth would suggest that the breakage occurred before fossilization (Freeman, 1979).

Fauna

The fauna from various horizons at Kirtlington Old Cement Works consists of frogs, salamanders, turtles, lizards, crocodilians, pterosaurs, dinosaurs and plesiosaurs (Freeman, 1979; Evans and Milner, 1994; Benton and Spencer, 1995). The mammalian fauna from Kirtlington Old Cement Works is represented by about 700 specimens, mainly isolated teeth, which were recovered from 10 tonnes of sediment (Kermack *et al.,* 1987). There is much uncertainty about the identification of some specimens. The list below represents the most securely recognized taxa. In addition, Freeman (1976a, 1979) has tentatively recognized the genus *Amphitherium* and a dryolestid whereas Sigogneau-Russell (2003b) has recorded several additional 'symmetrodonts' and cladotheres. Four more allotherian taxa have also been described, including the oldest multituberculates (Butler and Hooker, 2005).

REPTILIA

'Therapsida'

Tritylodontidae

Stereognathus ooliticus Charlesworth, 1855

MAMMALIA

Morganucodontidae

Wareolestes rex Freeman, 1979

Docodonta

Docodontidae

Borealestes serendipitus Waldman and Savage, 1972

Borealestes mussetti Sigogneau-Russell, 2003a

Cyrtlatherium canei Freeman, 1979

Krusatodon kirtlingonensis Sigogneau-Russell, 2003a

Peraiocynodon major Sigogneau-Russell, 2003a

Simpsonodon oxfordensis Kermack, Lees and Mussett, 1987

Allotheria

'Haramiyida'

Millsodon superstes Butler and Hooker, 2005

Kirtlingtonia catenata Butler and Hooker, 2005

Eleutherodontidae

Eleutherodon oxfordensis Kermack, Kermack, Lees and Mills, 1998

Multituberculata

Kermackodontidae

Kermackodon multicuspis Butler and Hooker, 2005

Hahnotheriidae

Hahnotherium antiquum Butler and Hooker, 2005

Shuotheridia

Shuotheriidae

Shuotherium dongi Chow and Rich, 1982

Shuotherium kermacki Sigogneau-Russell, 1998

Cladotheria

Amphitheriidae

Palaeoxonodon ooliticus Freeman, 1976a

Palaeoxonodon freemani Sigogneau-Russell, 2003b

Palaeoxonodon sp. (Sigogneau-Russell, 2003b)

?Peramuridae

genus indet. (Sigogneau-Russell, 2003b)

Family indet.

Kennetheredium leesi Sigogneau-Russell, 2003b

The tritylodont *Stereognathus* and the mammals from Kirtlington Old Cement Works are all represented mainly by teeth (Freeman, 1979; Evans and Milner, 1994). The morganucodontid *Wareolestes* ((Figure 2.12)a) is one of the last surviving members of the group, known otherwise from Rhaeto-Lias rocks.

The most diverse and well-studied mammalian group from Kirtlington is now the Docodonta (Sigogneau-Russell, 2001, 2003a). At first, the sole docodont was *Simpsonodon* (originally recorded as *?Borealestes* by Freeman, 1979), an early record of a group that was otherwise best known from Late Jurassic deposits (Kermack *et al.,* 1987). Then *Cyrtlatherium* ((Figure 2.12)b) was added (Sigogneau-Russell, 2001), having been described initially (Freeman, 1979) as a kuehneotheriid, which would have been an unusual late record of the group, known otherwise from the Rhaeto-Liassic fissure deposits of southern Wales. Sigogneau-Russell (2003a) added a further four species, reporting the first teeth of *Borealestes serendipitus* from Kirtlington, a species named from the Bathonian of Skye (see below). She added three new species, *B. mussetti,* with larger lower molars than *B. serendipitus, Krusatodon kirtlingtonensis,* a new genus and species, and *Peraiocynodon major,* a new species of a genus reported before from the Purbeck strata of Durlston Bay (see below). All these docodont fossils are based on upper and lower molar teeth, and the generic and specific distinctions are based on variations in size and arrangement of the cusps.

The enigmatic *Eleutherodon* (Kermack *et al.,* 1998) is recognized as an unusual late member of the order Haramiyida (Butler, 2000). The presence here of *Shuotherium,* with its pseudo-tribosphenic molars, is remarkable in that *Shuotherium* is known otherwise only from China (Sigogneau-Russell, 1998).

An unexpected diversity of allotherians has only just been recognized (Butler and Hooker, 2005). These include two more 'haramiyidans' of uncertain affinities plus the earliest known multituberculates. The latter, *Kermackodon* and *Hahnotherium,* are placed in their own families, considered to branch successively from the base of the multituberculate tree.

Palaeoxonodon ((Figure 2.12)d,e), once thought to be a peramurid (Freeman, 1976a) is now recognized to be an amphitheriid close to *Amphitherium* (Sigogneau-Russell, 2003b); the classic type of Bathonian mammal ((Figure 2.12)e) being known already from Stonesfield Slate Mines. A possible peramurid, a family typical of late Jurassic and early Cretaceous times, has nevertheless now been recognized (Sigogneau-Russell, 2003b).

In some respects, the faunal composition of this site is one that might be expected from a locality intermediate between Early Jurassic and Early Cretaceous age. The fauna at Kirtlington Old Cement Works is characterized by relict examples of 'Rhaeto-Liassic' families, as illustrated by the Morganucodontidae and Tritylodontidae. Representatives of Late Jurassic and Early Cretaceous taxa include Docodontidae, Multituberculata and ?Peramuridae (Evans and Milner, 1994; Sigogneau-Russell, 2003a; Butler and Hooker, 2005). The occurrence of *Shuotherium,* is quite unexpected, as well as anachronistic.

Interpretation

During the Bathonian Stage, Kirtlington Old Cement Works lay on or close to the south-western shore of a small barrier island that was located approximately 30 km from the coast of the Anglo-Brabant landmass in subtropical latitudes. The presence of fragments of lignite, charophytes and freshwater ostracods and gastropods indicates that the local environment was dominated by swamps with shallow pools, creeks and lagoons, similar to the Florida Everglades (Palmer, 1979). This environment supported a range of aquatic taxa, including crocodiles, turtles and choristoderes. The rarer terrestrial taxa may have been washed into the area (Evans, 1990; Evans and Milner, 1994).

Comparison with other localities

The vertebrate fauna from the Kirtlington Old Cement Works GCR site is comparable in age to the fauna preserved at Watton Cliff, Dorset (see GCR site report in the present chapter). Although the amphibians from these sites are very similar, other elements of the fauna show greater differences. The slightly older vertebrate assemblage from Stonesfield Slate Mines (Middle Bathonian in age) shows some similarities with the fauna at Kirtlington Old Cement Works, but the mammal species represented are different and the fauna at Stonesfield Slate Mines is smaller. Some of the taxa are unusual in their temporal distribution at Kirtlington Old Cement Works. If correctly identified, the morganucodontid tooth is comparable with material from Early Jurassic localities, and some of the other mammals are comparable with Late Jurassic materials from North America and Portugal. *Shuotherium* occurs otherwise in Late Jurassic deposits in China (Chow and Rich, 1982; Wang *et al.,* 1998).

Conclusions

Kirtlington Old Cement works preserves one of the most diverse Middle Jurassic mammal faunas in the world, with at least 19 published species, six of them docodonts. This number will increase when work on the other faunal elements appears. The site is one of the five globally important Middle Jurassic mammal localities in Britain (Clemens *et al.,* 1979). The fauna is intermediate in character between Early Jurassic and Late Jurassic–Early Cretaceous age. Good exposure at the site means that continued excavation and sampling will further our knowledge of the taxa and increase our understanding of mammalian relationships and lineages.

References

(Figure 2.11) General view of the disused Kirtlington Old Cement Works quarry, Oxfordshire. Exposures of White Limestone, Forest Marble and Cornbrash formations. (Photo: Dave Evans.)

	Thickness (m)
Lower Cornbrash Formation	
1. Limestone, rubbly and marly	1.07
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4. Clay, grey-blue, with three pale mudstone layers, one at the bottom (= 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
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	1.23–2.21
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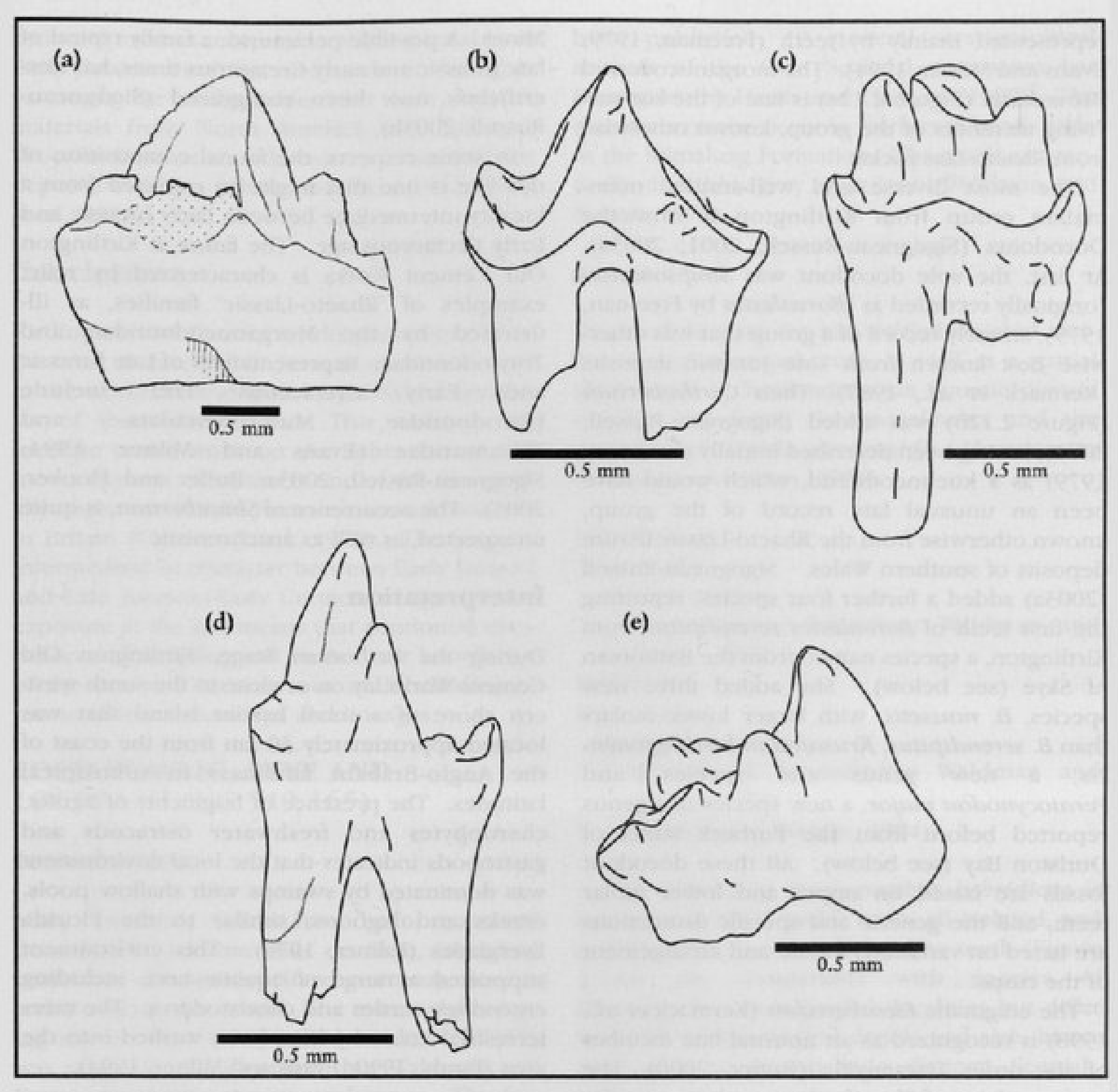

(Figure 2.12) Mammal specimens from the Middle Jurassic sediments of Kirtlington Old Cement Works, Oxfordshire. (a) Lower molar of the morganucodontid Wareolestes rex, outer view. (b) Lower molar of the docodont Cyrtlatherium canei, outer view. (c) Lower molar of the amphilestid Amphilestes from Watton Cliff, Dorset, inner view. (d) Lower molar of the amphitheriid Palaeoxonodon ooliticus, inner view (e) Upper molar of Palaeoxonodon, back view. (Based on Freeman, 1979.)