

The Geology of the Site of the Bodleian Extension in Broad Street

By. W. J. ARKELL

THE preliminary excavation for the Bodleian extension involved the removal of the greatest quantity of subsoil ('rock' in the geologist's sense) ever taken out of one hole within the City of Oxford.

The material was of two kinds, classified by geologists as 'Superficial,' of Quaternary age, consisting of gravel laid down by the River Thames in Lower-Middle Palaeolithic times (a few tens of thousands of years ago), and 'Solid,' of Jurassic age, forming the foundation or country-rock, consisting of marine sediments deposited something like 130 million years ago.

Both deposits contained fossil remains of animals which were alive at the time the rocks were formed and are of sufficient interest to put on record.

The excavation as a whole was about 23 ft. deep. The highest 20 ft., approximately, was dug in Thames gravel, and the last two or three feet in the solid Oxford Clay underneath. The line of separation between the two was sharply defined and undulated only slightly, the surface of the Oxford Clay varying in elevation by only 1-1½ ft. The lowest 1-2 ft. of the gravel was saturated with water, which rose to about 3-4 ft. above the surface of the clay in the trial holes.

In the bottom of the huge tank so formed, several pits were dug for foundations. These exposed on an average 5 ft. and a maximum of 6 ft. 6 ins. of Oxford Clay (measured from the base of the gravel). The clay excavated was dumped on the low-lying meadows south of the Botley Road, between Osney and Botley, where the rain washed out the delicate fossils. The greater number of those received at the University Museum were collected by Mr. C. W. Wright of Christ Church, assisted sometimes by his brother, Mr. E. V. Wright of Christ Church, and sometimes by the writer. Altogether about 240 small ammonites were collected, and also many belemnites, numerous oysters and other bivalve shells, some crushed sea-urchins, and well preserved small crabs' claws (PLATE I A, figs. 5, 6).

The fossils indicate on exactly what part of the Oxford Clay the Thames gravels were deposited at this point. They belong to a zone rather above the

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middle of the formation, which has been estimated to have a total thickness, when complete, of nearly 400 ft. They are of particular interest because they all belong to one zone, and they give the first reliable picture of the contemporary assemblage of invertebrate animals proper to that zone yet obtained at Oxford, the type locality. The same clays were formerly dug with several other zones in the Summertown brick-pit (now occupied by the Radiator Works, west of the Woodstock Road), but careful collecting from the 40 ft. face of the pit was never undertaken before it was closed down many years ago, and the collections that survive in the University Museum represent a mixture from several zones.

The collection from the Bodleian site cannot be contaminated from either above or below. The special part of the Oxford Clay to which the assemblage of ammonites is peculiar is called the Lamberti Zone. It crops out at Tidmoor Point, on the shore of the East Fleet near Weymouth, and again on the coast near Villers in Normandy, and in a brick pit at Le West near Boulogne. Since 1936 our knowledge of the zone has been greatly increased by its being penetrated in a new brick pit (Woodham Pit) near Akeman Street Station in Buckinghamshire. There it is only 1 ft. thick and is developed as a marly limestone, crowded with ammonites, more like its known development as a shelly stone on the Yorkshire coast near Scarborough. At the Bodleian site the Lamberti Zone is in clay facies and bears the closest resemblance to the occurrences in Dorset and Normandy. The clay was laid down on a muddy sea bottom in fairly shallow water. A catalogue of the fossils obtained is given below.

The Thames gravel in which the greater part of the excavation was made belongs to the Second or Summertown-Radley Terrace, on which most of the city is built. It is part of a patch $2\frac{1}{4}$ miles in length and $\frac{3}{4}$ mile wide, which stretches from Summertown to St. Aldate's, with a nearly dead level surface for most of the way.¹ The same terrace forms broad stretches of flat dry land at Stanton Harcourt, Eynsham, Cassington, Yarnton, and between Radley and Abingdon, and is exposed in numerous gravel-pits. The Bodleian site therefore adds little to our knowledge of this terrace. The thickness, 20 ft., however, is greater than is known at any other place in Oxford except the City Brewery (perhaps 30 ft.)² Excavations at the Dyson Perrins laboratory showed 18 ft., and at the University Museum (boiler-house) 16 ft., but 21 ft. was recorded at Eynsham Station. At other places in Oxford the thickness of this terrace is only 9-15 ft. (Summertown), 4-6 ft. (Blackhall Farm), and 9 ft. (Bardwell Road). The clay platform below, therefore, must have an uneven surface.

The materials swept together by the Thames to form this terrace consist, at the Bodleian site as elsewhere, mainly of pebbles and more or less worn small

¹ T. I. Pocock, *Geology of the Country around Oxford*, (Mem. Geol. Survey, 1908), p. 87.

² K. S. Sandford, *op. cit.* (2nd ed., 1926), p. 132.

FOSSILS FROM THE BODLEIAN SITE

pieces of limestone from the stony uplands north and north-west of Oxford, mixed with pebbles of flint and quartzite, probably derived second-hand from glacial drift. At the Bodleian site there were also fairly numerous thick oyster shells (*Gryphaea dilatata* and *G. lituola*) and belemnites ('*Belemnites oweni*') derived from the Oxford Clay, and some massive lumps of fossil coral (*Isastraea explanata*, 9 $\frac{3}{4}$ ins., and *Thamnastraea concinna*) representing lost Corallian strata eroded in Pleistocene times from the edges of Wytham Hills. These blocks were at the bottom of the gravel, 20 ft. below the surface. With them was a large bun-shaped piece of worn Sarsen stone, 14 $\frac{1}{2}$ ins. in diameter. Although these quartzitic stones are chiefly found on the surface of the Chalk Downs, huge isolated masses are scattered throughout the Thames Valley, at Swindon, Highworth, Faringdon, Coxwell, and elsewhere, apparently the last relics of the long-since retreated escarpment of the Chalk with their mother-rock, the Tertiary sands, above.

As was to be expected, the variety of rocks in the base of the gravel was not nearly so great as in the pits at present being worked near Cassington.

The only contemporaneous fossils found in the gravel at the Bodleian site were parts of several teeth of mammoth (*Elephas primigenius*) and one of horse (*Equus caballus*). Many others have been found in and around Oxford, associated with Woolly Rhinoceros and other animals.

No human implements were found. Only seven seem to be recorded from this terrace. All were found many years ago in various excavations. All were of Upper Chellean or Lower Acheulian types.¹

The Department of Geology and the present writer are much indebted to Mr. Walker, of Messrs. Benfield & Loxley, and to Mr. Luxton, Clerk of the Works, for watching the progress of the excavation and bringing specimens from the gravels, and to Messrs. C. W. and E. V. Wright for laboriously collecting fossils from the dumped clay at Botley Road.

CATALOGUE OF FOSSILS FROM THE OXFORD CLAY ON THE SITE OF THE BODLEIAN EXTENSION

VERTEBRATA

Vertebra of fish, indet.

INVERTEBRATA

Phylum ARTHROPODA

¹ Sandford, *op. cit.*, pp. 130-1.

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Class CRUSTACEA

Goniocheirus cristatus Carter. Two complete chelae (claws) and various other fragments
(PLATE I A, 5, 6).

Phylum MOLLUSCA

Class CEPHALOPODA

Order AMMONOIDEA

Family OPPELIDAE

Oppelia cf. *jurensis* Maire (1 crushed specimen).

Horioceras baugieri (d'Orbigny) (1 damaged specimen).

Hecticoceras cf. *punctatum* (Stahl) (10 fragments and nuclei). (PLATE I A, 13, 14).

Hecticoceras (2 small smooth specimens).

Aptychi (2).

Family CADOCERATIDAE

<i>Quenstedtoceras lamberti</i> (J. Sowerby)	}	(100 specimens and fragments). (PLATE I A, 7-9).
„ <i>henrici</i> Douvillé		
„ <i>praelamberti</i> Douvillé		
„ sp. nov.		
„ sp. (1 nucleus, PLATE I A, 10).		

Family KOSMOCERATIDAE

<i>Kosmoceras spinosum</i> (J. de C. Sowerby)	}	(82 specimens, nuclei, and fragments). (PLATE I A, 12).
„ aff. <i>spinosum</i> (J. de C. Sowerby)		
„ <i>annulatum</i> (Quenstedt) (1 and 3 fragments).		
„ cf. <i>compressum</i> (Quenstedt) (3 fragments).		

Family REINECKEIDAE

Reineckeia sp., 1 nucleus of the subgenera *Collotia* or *Kellawaysites* (PLATE I A, 11).

Family PERISPHINCTIDAE

Perisphinctes latilinguatus Noetling (27 specimens, fragments and nuclei).

? *Grossouvria thiebauti* (Gérard and Contaut) (one large fragment agreeing closely with the type figure).

Family PELTOCERATIDAE

Peltoceras sp., 2 fragments of nuclei, indet.

Order BELEMNOIDEA

Hibolites hastatus (Blainville) (abundant).

Class LAMELLIBRANCHIA

Nucula calliope d'Orbigny (abundant).

„ *pollux* d'Orbigny (abundant).

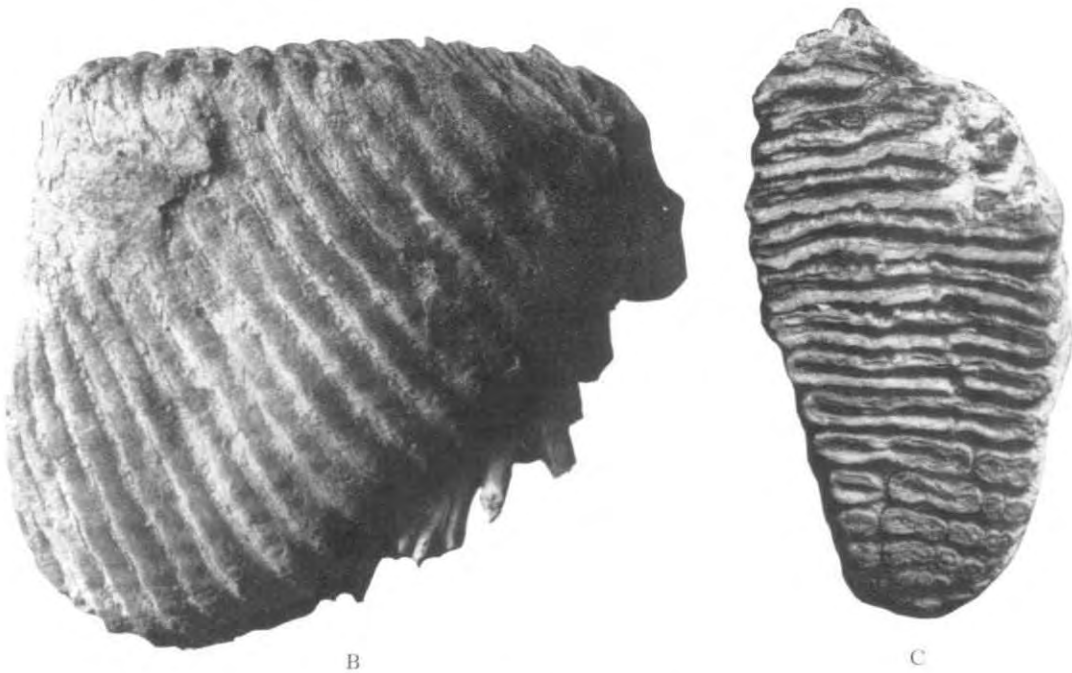
„ *caecilia* d'Orbigny.

Grammatodon gnoma (d'Orbigny).

PLATE I



A



B

C

A. Fossils from the Oxford Clay. *Ph. W. J. Arkell.*

B, C. Tooth of *Elephas* from the Gravel. *Ph. H. J. Hambridge.*

PALAEONTOLOGICAL FINDS FROM THE SITE OF THE BODLEIAN EXTENSION,
OXFORD, 1937.

FOSSILS FROM THE BODLEIAN SITE

- Oxytoma expansa* (Phillips) (abundant). (PLATE I A, 2, 3).
Chlamys scarburgense (Young & Bird) (abundant).
Ostrea of the shape and size of *O. acuminata*, Sowerby. (PLATE I A, 1a, 1b).
Gryphaea dilatata J. Sowerby.
Plicatula sp. (PLATE I A, 4).
Pinna sp., fragment.
Astarte, small sp. (abundant).

Class GASTROPODA

- Aporrhais* sp. or spp. (fragments abundant).
Procerithium sp. indet.

Phylum BRACHIOPODA

Class ARTICULATA

- Aulacothyrus impressa* (Schlotheim) (= *bernardina* d'Orbigny) (19 specimens).

Phylum ECHINODERMA

Class ECHINOIDEA

Family COLLYRITIDAE

- Crushed tests, indet. (Presented to Prof. H. L. Hawkins, F.R.S., of Reading University who identified them as Collyritidae).

NOTE ON TEETH OF *ELEPHAS* FROM GRAVELS ON THE SITE OF THE BODLEIAN EXTENSION

By K. S. SANDFORD

Three teeth, an adult molar and two milk molars, were presented to the Department of Geology, University of Oxford, by Messrs. Benfield & Loxley: another molar was found among excavated gravel by Mr. J. A. Daniell (Trinity College). The following is a brief description of their more important features.

Upper Milk Molars.—Both are fragmentary and reduced by growth and attrition during life to a few lamellae, and both show pressure-scars. One consists of four more-or-less complete lamellae in 33 mm., fairly compressed, straight, with rather thin enamel: the crimping is entire. The inter-lamellar spaces are rather narrower than the plates themselves, and the width is about 47 mm. This specimen is almost certainly of the species commonly called the Siberian Mammoth (*Elephas primigenius sibericus*). The other exhibits much coarser lamellae, five being complete in 42 mm.: they are wide (5 mm.) and straight, slightly curved at the margins, and the width of the tooth is 50 mm. The inter-lamellar spaces are reduced to vanishing point, a character of most

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proboscidean teeth that have been worn almost to the roots. The enamel is very slightly waved, but not crimped. The tooth, though worn and fragmentary, can hardly be attributed to the common mammoth, but suggests rather the coarse type of tooth that occurs in the local gravels of Summertown, Oxford and Radley (see *Quart. Journ. Geol. Soc. London*, LXXXI (1925), 62).

It is difficult to assign these fragments: they are probably last milk molars, but might be first molars.

Molars.—The molar presented by Messrs. Benfield & Loxley is a well preserved tooth of the lower jaw, probably a third molar, of which nine plates and a last (probably the posterior talon) were uncut at the time of the animal's death. The anterior margin of the tooth is much abraded, the root-zone being involved in the abrasion surface and the anterior talon missing. The specimen may thus have a formula of $-22 \times$ in 200 mm., and on the grinding surface there are ten plates in 100 mm.: figures characteristic of the Siberian Mammoth stock. The worn lamellar surfaces are straight and in the anterior figures crimping is strong and entire, while the cutting of the posterior plates is normal for the species. The maximum breadth is nearly 80 mm., and the abrasion disc is pear-shaped (PLATE I B, C).

The molar found by Mr. Daniell is probably the third of the upper jaw. The tooth is somewhat broken, but includes 18 complete lamellae, perhaps the posterior talon and remains of an anterior plate in an overall length of about 240 mm.: ten plates are in wear. The general condition of the abraded surface is much the same as that described above, but the lamellae are a little coarser, the four anterior slightly sinuous and the remainder straight and narrow. As in the above specimen, the inter-lamellar spaces are rather narrower than the plates themselves. There does not seem to be sufficient reason to remove this tooth from the Siberian Mammoth stock, but clearly in some particulars it recalls the type possessing coarse lamellae to which reference has been made in describing the second of the two small teeth.

An upper molar of *Equus caballus*, probably from the gravels, was also given to the University Museum by Messrs. Benfield & Loxley.