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A new record of Pleistocene hippopotamus from River Severn terrace deposits, Gloucester, UK—palaeoenvironmental setting and stratigraphical significance

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ABSTRACT

A new Pleistocene vertebrate assemblage from fluvial deposits of the River Severn in Gloucester, England, has yielded the remains of hippopotamus (*Hippopotamus amphibius*), a new record for this terrace system, with additional material from probable bison (cf. *Bison priscus*) and elephant (Elephantidae sp.). The presence of these taxa indicates fully temperate climatic conditions and the occurrence of hippopotamus, a significant biostratigraphical indicator for the British Late Pleistocene, suggests an age for the assemblage within MIS 5e (the Last Interglacial). This would contradict the older MIS 7–6 age for the gravel body that is currently accepted on the basis of deposit mapping and imply a more complex mode of deposition than presently envisaged in the valley.

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1. Introduction

In 2004–2006, a new Pleistocene vertebrate assemblage was obtained from deposits of the River Severn in Gloucester, England, comprising the very fragmentary partial remains of a single adult hippopotamus (*Hippopotamus amphibius*), with additional material from probable bison (cf. *Bison priscus*) and elephant (Elephantidae sp.). The remains have come from deposits mapped as Terrace 4 (Kidderminster Terrace) by the British Geological Survey (=Kidderminster Station Member of Maddy, 1999) of the River Severn sequence, presently correlated with a period spanning the penultimate interglacial (Marine Oxygen Isotope Stage [MIS] 7, c. 245–186,000 years ago) and the succeeding cold stage (MIS 6, c. 186–128,000 years ago). However, the presence of *H. amphibius*, an important biostratigraphical indicator species that is reliably identified only from the Last Interglacial (MIS 5e, c. 125,000 years ago) in Britain, strongly suggests a younger age for the deposits. The finds are therefore particularly interesting, since they either challenge the currently accepted mapping (and inferred age) of the deposits in the Gloucester area, or call into question the validity of the established mammalian biostratigraphy for the British Late Pleistocene. Moreover, since no sediments of Last Interglacial age have previously been identified in the Severn terrace system (excepting the Warwickshire–Worcestershire Avon), these finds may provide the first evidence of deposits from this period.

2. Location and sampling methodology

Gloucester lies on the eastern bank of the River Severn, approximately 4 km from the foot of the Cotswolds escarpment and 74 km south-south-west of Birmingham (Fig. 1A). The site of 118–120 London Road (National Grid Reference SO 8432 1893, formerly a disused service station) follows the line of Roman Ermine Street and lies within the area of one of the city's main Roman cemeteries, in the suburb of Wotton 1.2 km east of the city centre (Fig. 1B and C). Accordingly, the site was the focus of archaeological investigations by Oxford Archaeology from 2004 to 2006, prior to the construction of a new housing development (Simmonds et al., 2008). An area 37 m × 32 m encompassing 0.1 ha was excavated, during the course of which a number of poorly preserved megafaunal remains were discovered in the north-central part of the site. The overlying sediments were stripped off by machine using a toothless bucket, followed by hand excavation, with specimens lifted in blocks and wrapped for subsequent careful excavation in the laboratory. During the assessment stage, some conjoining bone fragments were observed and it was therefore decided to undertake as much refitting and stabilisation work as possible, in order to maximise the amount of identifiable material. Although time-consuming, this approach proved extremely worthwhile by facilitating the identification of both dental and postcranial remains that would otherwise have been impossible to recognise. In addition, it became apparent that many of the blocks of silty clay preserved only 'smears' of fragmented bone on their upper surface that could not assist in the analysis of the assemblage. It was therefore decided to remove these bone 'smears' and to wash the clay blocks through a 500 μm sieve in order to check for additional large bone or tooth material

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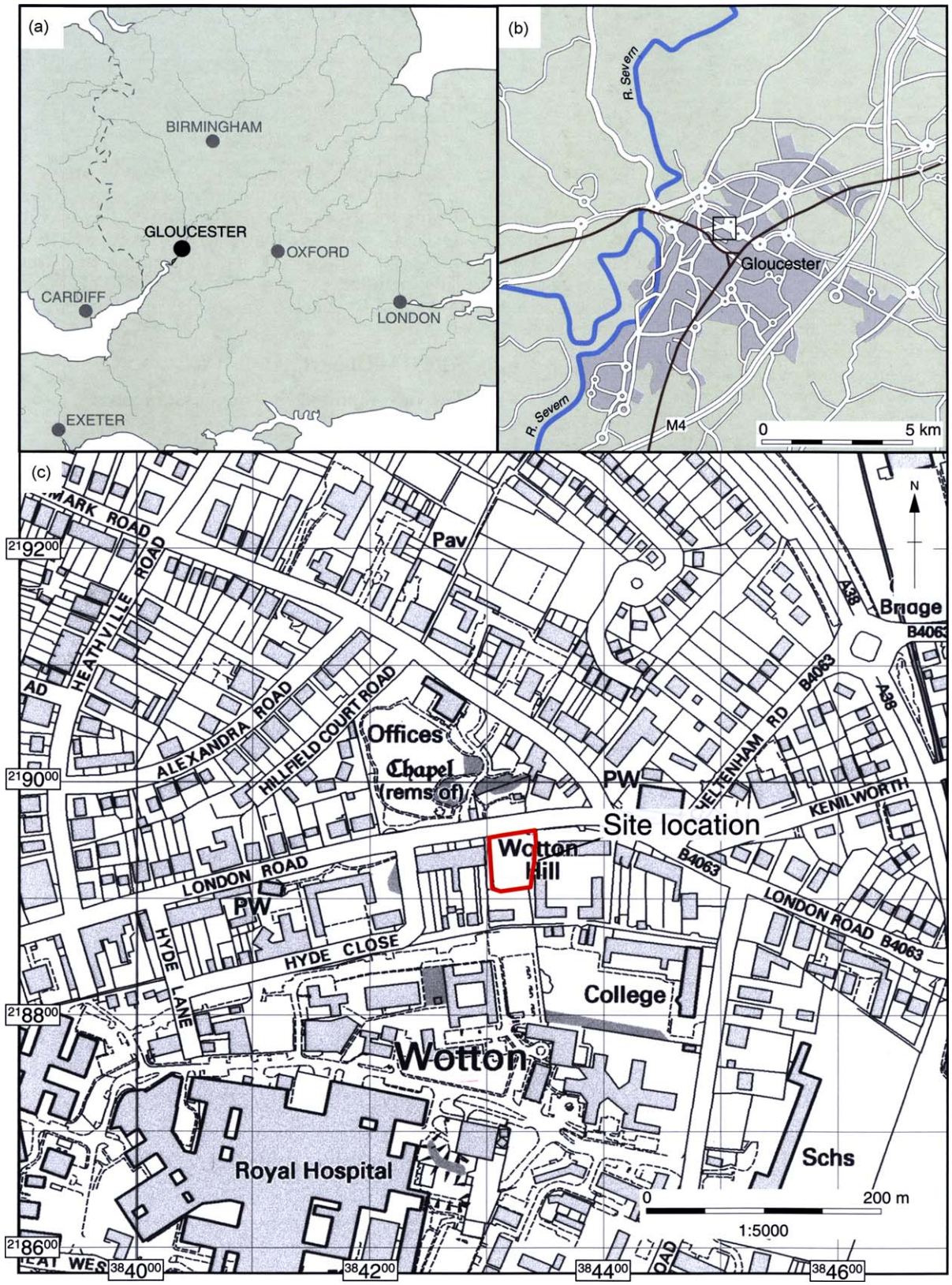

Fig. 1. (A) Location of Gloucester. (B) Location of Wotton within Gloucester (inset shows (C)). (C) Detail of site location (after Simmonds et al., 2008).

preserved within. Again, the approach proved justified when a virtually complete molar of hippopotamus (GLLR 04/1335/186, Fig. 2) was recovered from inside one of the blocks (refitting on to a small fragment of tooth originally on the surface of the block), together with long bone fragments of probable hippopotamus tibia, an element of the body previously not identified in the assemblage. All clay blocks were subsequently washed through and any contained material removed and conserved.

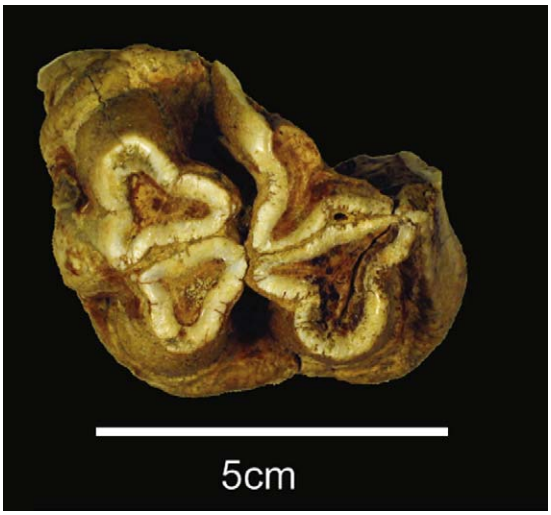

Fig. 2. Virtually complete ?LM3 of *Hippopotamus amphibius*.

3. Geological context

The site lies at approximately 23 m OD on the north-western edge of a gravel spread, known as locally the 'Wotton hillock gravel cap' (Simmonds et al., 2008). The spread is aligned NW-SE and is sharply truncated on the north-eastern side by a small valley containing the Wotton Brook, a minor tributary of the River Severn. To the south-west, the ground slopes away more gently towards a second tributary, the Twyver. Maddy et al. (1995) proposed two Formations for the Pleistocene River Severn succession: the Wolston Formation (represented by the Woolridge Member and consisting of Anglian glaciogenic sediments) and the post-Anglian Severn Valley Formation, subdivided into six Members that are separated altitudinally and lithologically. The Wotton gravel cap has been mapped as the fourth oldest of these members, represented by the Kidderminster Station Member (formerly the Kidderminster Terrace, e.g. Wills, 1938; Worssam et al., 1989) (Fig. 3), which lies between 20 and 28 m above the modern River Severn. At the type section near Kidderminster railway station (Yates Pit), Wills (1938) recorded 5.2 m of gravel, which contained some Welsh erratics, Uriconian Clent Breccia and broken and wind-etched Bunter pebbles. The small remnant at Wotton was considered to be created by erosion of the terrace and the underlying Jurassic Lower Lias clay bedrock by snow meltwaters flowing westward into the Severn from the Cotswolds (Simmonds et al., 2008). The faunal material reported here was recorded as lying at the interface between the Lias clay bedrock and overlying fluvial gravels at an approximate depth of 2 m below ground surface and within a restricted area of a few metres. The gravels thickened westward to a maximum depth of 0.5 m. Occasional cobbles were reported underlying some of the bones in the south of the area but the main constituent material of the excavated blocks was a medium brown silty clay with occasional sub-rounded gravel clasts (<10 cm), apparently reflecting periods of quieter water deposition than those represented by the sands and gravels.

4. Description of the finds

The most diagnostic elements within the assemblage are dental remains of hippopotamus (attributed to *H. amphibius*, the extant African species). The anterior-projecting lower incisor tusks are large with a smooth surface and blunted points, whereas the upper incisors are much smaller. Refitting of specimen GLLR 04/1052, the very crushed ivory fragments of a left lower 1st incisor, allowed the blunted wear facet to be clearly discerned. The upper and lower canines consist of large, curving tusks, with fine grooves running lengthwise along their surface; in the largest modern adults, these may reach up to 700 mm overall (300 mm above the gum) (Skinner and Smithers, 1990). The canines, like the incisors, grow continuously. They are triangular in section and are sharpened against each other, thereby creating a pronounced flat wear facet. The cheek teeth (premolars and molars) are also highly characteristic and readily identifiable. They are relatively low-crowned when compared to other herbivores (a reflection of the soft diet of the animals). Premolars have a single large cusp that rises to a rounded point, with a pronounced cingulum and smaller accessory cusps near the base. The molars have four cusps, which rise to high peaks. Once in use, these form a highly recognisable, almost 'flower-like' pattern of wear. Three partial molars have been identified within the assemblage (GLLR 04/1335/185, 186 and 194).

The postcranial remains of hippopotamus from London Road consist of a partial atlas vertebra, one cervical vertebra (Fig. 4), two

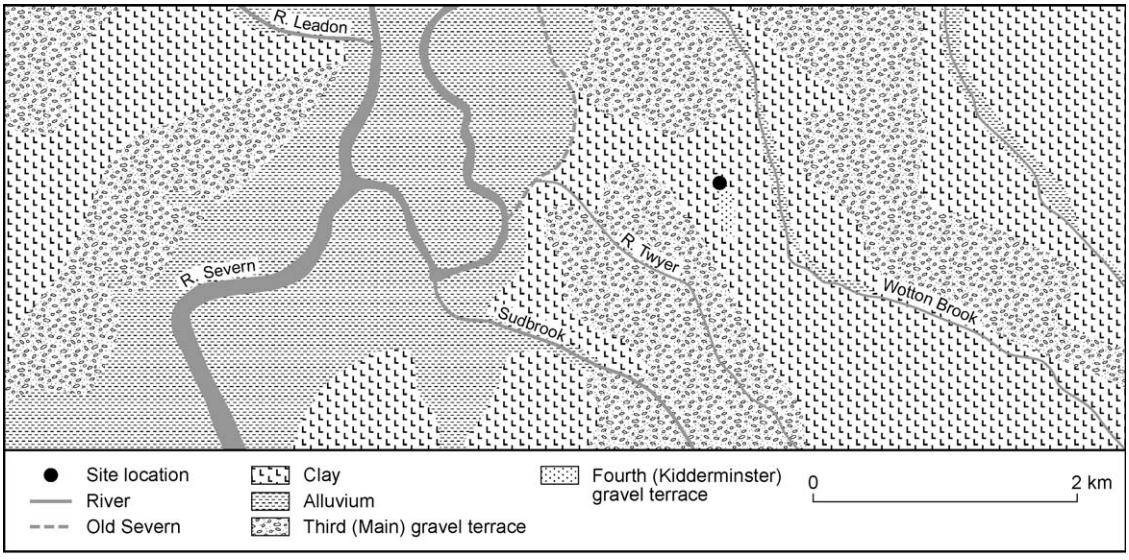

Fig. 3. The location of the site in relation to the gravel terraces of the River Severn (after Simmonds et al., 2008).

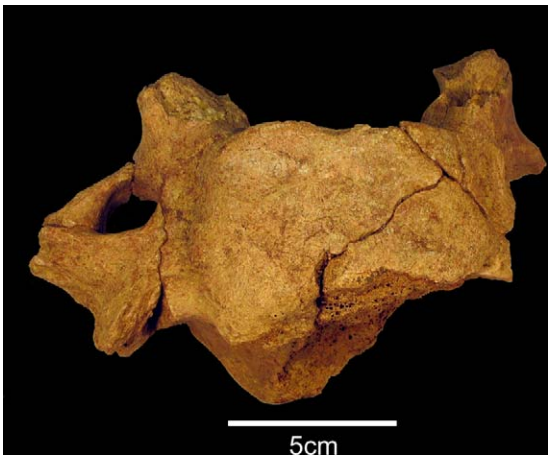

Fig. 4. Reconstructed cervical vertebra of *Hippopotamus amphibius*.

partial thoracic vertebrae and other vertebral fragments. Major anterior elements such as the humeri and scapulae are apparently missing, although distal parts of the limbs are present in the form of a proximal right radius, a proximal left 2nd metacarpal and a first phalanx.

The only other animal identified to species level is a large bovid, on the basis of four postcranial elements: a distal humerus condylar fragment, an incomplete calcaneum, a femoral diaphysis fragment and a fragmentary proximal left tibia. Separation of the postcranial remains of aurochs (*Bos primigenius*) and Pleistocene bison (*B. priscus*) is notoriously difficult (Gee, 1993) but evaluation of the morphology of the specimens against modern and fossil comparative material suggested closer resemblance to the latter. Large long bone fragments (GLLR04/1107/151) have been tentatively attributed to an indeterminate elephant (Elephantidae sp.) on account of the compact and massive aspect of the material.

Preservation of the material is extremely poor, both in terms of the overall surface condition and the high degree of fragmentation. This is particularly noticeable with elements of the dentition (especially canines and incisors), which are exceptionally comminuted (Fig. 5) and are represented by many hundreds of small fragments. None of the material extracted is complete and in some cases, the original surface of the bone has been completely destroyed, exposing the cancellous bone below. Virtually all is heavily crushed, although it is not possible to establish whether this is the result of past activities such as trampling by large mammals, sediment pressure or more recent factors such as damage by heavy machinery at the ground surface. A combination of old breaks and recent excavation damage is also apparent on most of the material.

Fig. 5. Heavily comminuted upper canine of *Hippopotamus amphibius*.

The list of identified species is given below, with Number of Identified Specimens (NISP) and Minimum Numbers of Individuals (MNI) in brackets.

Proboscidea

Elephantidae

Elephant undet., indeterminate elephant (NISP = 1; MNI = 1)

Artiodactyla

Hippopotamidae

Hippopotamus cf. *amphibius* Linné, 1758, hippopotamus (NISP = 21; MNI = 1)

Bovidae

Bovini sp., large bovid, cf. *Bison priscus* Bojanus, 1827, bison (NISP = 4; MNI = 1)

5. Taphonomy

From the remains recovered, it appears that a major part of the skull and dentition, with some vertebrae and postcranial elements of a single adult hippopotamus was present at the site. Although these are in poor condition and demonstrate evidence of abrasion, the presence of associated remains provides a strong indication that they have not been transported a great distance since death. In particular, the presence of a mandibular process, fragments of mandibular ramus and isolated teeth suggests that a complete lower jaw with *in situ* dentition once occurred at the site. It is possible that more of the skeleton was initially present but only a few, incomplete postcranial elements of hippopotamus have been identified. The majority of the postcranial skeleton may therefore have been destroyed previously or more widely scattered, after disarticulation, beyond the limits of the site under investigation. This is particularly likely since the northern part of the site had been significantly disturbed by the construction of the service station and the digging of a pit for a fuel tank (Simmonds et al., 2008).

In addition to the high degree of fragmentation, most of the material is heavily iron-stained, from the post-depositional uptake of iron oxides, and bears evidence of moderate abrasion from transportation. A small number of specimens also show the fine tracery of acid etching left by roots. This indicates that either the decomposing carcass lay exposed on the landsurface for a considerable period prior to its burial in the fluvial sediments, or that the bones became re-exposed at a later date, thereby allowing them to become root-damaged before being buried a second time. No evidence of carnivore, human or other modification (such as gnawmarks or cutmarks) was noted, although the fragmentary state of the material may have obscured this evidence. The presence of articulated specimens was noted in the context sheets provided and in the accompanying photographic record, although the very fragmented state of the material made previous associations difficult to verify at the analysis stage.

6. Evidence of local environment and climate from the vertebrate remains

Although the condition of the bones is poor, the different elements form a coherent assemblage that may credibly be interpreted as a single entity in terms of its palaeoecology. The extant hippopotamus (*H. amphibius*) is today restricted to sub-Saharan Africa, although in historical times, it extended from the

Nile Valley into the Mediterranean. In Britain, hippos were restricted to interglacial occurrences during the Pleistocene and were extremely widespread when present, extending as far north as Stockton-on-Tees and as far west as south Wales during the Last Interglacial. As amphibious mammals, they are found in close association with lakes or slow-flowing rivers sufficiently deep enough to allow total immersion, spending most of the day in the water and feeding nocturnally. Notable exceptions to immediate proximity to water are the numerous fossil records from Last Interglacial (MIS 5e) age cave sites, particularly those from North Yorkshire, such as Kirkdale Cave and Victoria Cave. At the latter site, the cave is located more than 2 km from and about 290 m above the floodplain of the River Ribble, the nearest source of water today, as it would have been during the Last Interglacial. It is assumed that the animals left the water at night to graze on the rich limestone herb flora (Stuart, 1982a); even today hippos may travel substantial distances at night in search of food.

During the Last Interglacial, a period for which there are abundant palaeoenvironmental records available, hippopotamus apparently occurred during the climatic optimum of the interglacial (pollen zones Ip II-early III), for example at Swanton Morley in Norfolk (Coxon et al., 1980) but not later in the stage (Stuart, 1982b). There are no records of this animal from later parts of MIS 5, the early Devensian (Currant and Jacobi, 2001). During MIS 5e, mean summer temperatures were approximately 4 °C warmer than in southern Britain today (Coope, 2001). Temperate mixed-oak forest with *Quercus*, *Pinus*, *Corylus*, *Alnus* and *Carpinus* was widespread (e.g. Sparks and West, 1970) but in many cases, the floodplain vegetation was locally deforested and dominated by herbaceous vegetation such as plantain (*Plantago* sp.), the likely result of extensive grazing and trampling by large herbivores. At Barrington, Cambridgeshire, where hippopotamus remains were extremely abundant, the sediments had a notably high minerageneic content (implying inwashing of soils from bare trampled ground) and the pollen spectra consisted of 90% herb pollen, implying clear modification of the vegetation by the megaherbivores (Gibbard and Stuart, 1975). Bison are found in cold-climate and temperate episodes alike and inhabit a wide range of environments at the present day, including both closed woodland and more open habitats.

The vertebrate assemblage from London Road, Gloucester, therefore suggests (1) that the sediments were laid down under temperate conditions with mean summer temperatures several degrees warmer than at present and (2) that a substantial water body lay close by. In terms of the surrounding vegetation, a mosaic of environments with some regional temperate forest and locally open grassland is therefore inferred.

7. The age of the vertebrate assemblage

The utility of mammalian assemblages as indicators of relative age for Pleistocene sediments has been repeatedly demonstrated in recent years (e.g. Currant and Jacobi, 2001; Schreve, 2001a; Stuart and Lister, 2001). In particular, vertebrate assemblages from fluvial deposits have proved particularly useful in establishing the relative age of sediment bodies and in permitting correlation over long geographical distances (Schreve and Bridgland, 2002; Schreve et al., 2007). A succession of discrete Mammal Assemblage-Zones has been erected for the British late Middle and Late Pleistocene that has been tested against and corroborated by various stratigraphical schemes, for example that put forward by Bridgland (1994), which recognises a suite of four interglacial deposits in the Lower Thames, correlated with MIS 11, 9, 7 and 5e. The recognition of distinctive mammalian faunas corresponding to individual temperate episodes has been further established at the oxygen isotope substage level (Schreve, 2001b) and has been underpinned by high-precision geochronology (e.g. Candy and Schreve, 2007).

The vertebrate assemblage from London Road, Gloucester, although small, can be considered to be particularly age-diagnostic, on account of the presence there of the extant species of hippopotamus, *H. amphibius*. Rare early Middle Pleistocene ("Cromerian Complex") occurrences of an extinct hippopotamus (*Hippopotamus antiquus* = *H. major*) are known from a number of sites in East Anglia, for example Norton Subcourse (Lewis et al., 2004). However, *H. amphibius* is distinctive in that it apparently makes only a single appearance in the British Pleistocene record, during the Last Interglacial (MIS 5e). It is not reliably known from any other late Middle Pleistocene or Late Pleistocene temperate episode despite tens of thousands of large mammal remains being recovered from appropriate sedimentary and palaeoenvironmental contexts (Schreve, 2001a) and it may thus be considered an excellent biostratigraphical indicator in the British fossil record. Hippopotamus is also present in the German Rhine during the Eemian Interglacial (MIS 5e) (van Kolfschoten, 2000) but there is a marked contrast with the evidence from northern France, where hippopotamus remains attributed to *Hippopotamus incognitus* occur in MIS 11 and 7 deposits in the Somme valley, but are conversely absent during MIS 5e (Schreve et al., 2007). This disparity is surprising, since hippopotami (essentially circum-Mediterranean animals in their European distribution) must have spread extensively across north-west Europe during the course of their dispersal into Britain. However, it is increasingly clear that British Pleistocene mammalian assemblages often have a closer correspondence to German ones (cf. Stuart, 1981; Schreve and Bridgland, 2002) than they do to those from French sites, perhaps highlighting the importance of the Rhine-Thames corridor as a natural highway for dispersal and implying that there may be biogeographical or other barriers separating these faunas from French ones.

In Britain, the mammalian fauna of the Last Interglacial climatic optimum (the Joint Mitnor Cave Mammal Assemblage-Zone of Currant and Jacobi, 2001), of which hippopotamus is the most characteristic component, has been dated on the basis of consistent radiometric dating of deposits clearly associated with this fauna to around 125,000 BP. Uranium-series dating of speleothem sealing deposits containing a *Hippopotamus* assemblage at Victoria Cave has produced age-estimates of 120 ± 6 ka BP (Gascoyne et al., 1981) and these have since been corroborated at other Last Interglacial sites by further U-series age-estimates, for example 129–116 ka BP obtained from stalagmite fragments at Bacon Hole, Gower (Stringer et al., 1986). In the light of this, the presence of hippopotamus would suggest that the Gloucester deposits contain material originally of Last Interglacial age, although this may have been reworked into younger deposits (see below).

A discrepancy therefore exists with the current age interpretation of the Wotton gravel spread, which has been mapped as the Kidderminster Terrace (No. 4) of the River Severn sequence (Wills, 1938), underlain by sands and gravels of the Kidderminster Station Member (Maddy et al., 1995). Although no direct geochronological information is available, the Kidderminster Station Member has been correlated with the Ailstone Member of the Avon Valley Formation (Maddy et al., 1991) and associated deposits at Strensham in Worcestershire (de Rouffignac et al., 1995), both of which have been attributed to MIS 7-6 (c. 245–128,000 years) on the basis of amino-acid geochronology (Maddy et al., 1995; Bowen, 1999). This would suggest a substantially older age than the Last Interglacial. However, as stated above, *H. amphibius* has not been recognised in any of the abundant MIS 7 interglacial sites in the UK (Schreve, 2001a). That observation would strongly suggest that the current age interpretation for the Wotton gravel as Terrace 4 is incorrect and should be re-examined.

The hippopotamus skeleton from London Road is clearly incomplete and has suffered substantial breakage and some abrasion, attesting to a degree of transportation after death. Nevertheless, the presence of a hippopotamus mandible with teeth still *in situ* mitigates against any long distance reworking from older deposits. A point of note here is the presence of numerous fan gravel deposits to the north of the London Road location (D. Maddy pers. comm. 21/4/06). The Wotton gravel may thus, in fact, represent a later fan gravel deposited on top of the Kidderminster Station gravel, similar to the deposition of the hippopotamus-bearing Eynsham gravel on top of the Summertown-Radley gravel in the Upper Thames (Bridgland, 1994).

Deposits containing other reworked remains of Last Interglacial hippopotamus have been recognized nearby, at the base of the Holt Heath Member in tributary valleys of the Severn, for example at Stourbridge (SO 895855) in the River Stour valley (Boulton, 1917). However, no actual Last Interglacial deposits have yet been identified in the Severn Valley itself, the closest being the New Inn Member at Cropthorne (SO 997443; Strickland, in Jardine, 1858) and Eckington Railway Cutting (SO 919417; Keen and Bridgland, 1986) in the Avon valley. It is therefore plausible that the London Road hippopotamus may have come from now-vanished Last Interglacial deposits, which were locally reworked during the early part of the ensuing Devensian cold stage (MIS 5d/b or MIS 4) when the fans would have been active. Reworking of the hippopotamus and other faunal remains into an early last cold stage context would also fit well with the report of woolly rhinoceros (*Coelodonta antiquitatis*) bones on a plot of land adjacent to the site (Sermon, 1996), as the presence of this animal would otherwise be palaeoecologically incompatible with hippopotamus.

A perhaps more compelling hypothesis is that the Wotton gravel is a hitherto-unrecognized Severn equivalent of Avon Terrace No. 3 (Cropthorne Member). At Cropthorne, the Avon incised a narrow, meandering course through the Terrace No. 4 deposits, prior to the aggradation of Terrace No. 3. The outcrop of Avon Terrace No. 3 therefore represents the sedimentary fill of an abandoned meander system, with the remnants of Terrace No. 4 forming meander cores (Bridgland et al., 1989), with no overlap in vertical extent between the two. The presence of a younger terrace nested within an older one might explain why the presence of Last Interglacial fluvial sediments has not been recognised previously in the Severn and would also fit more comfortably with the context of the bones (since they lay directly on top of bedrock and within fine-grained sediments) than invoking reworking into a fan gravel. The relatively low height (c. 23 m OD) of the Wotton gravel cap would also be commensurate with a position nested within Terrace 3, the height of which varies locally from c. 26 m to c. 38 m OD. Further work would be required in order to test which of these hypotheses is most likely, but it is clear nonetheless that the London Road site is of prime importance in demonstrating the erstwhile presence of Last Interglacial deposits in this area and also in calling into question the published age of the Wotton gravel.

8. Summary

- The new vertebrate evidence from London Road, Gloucester, calls into question the currently correlated age of the Wotton gravel as MIS 7-6 based upon mapping of the deposits as Terrace 4 of the River Severn sequence.
- A younger (MIS 5e, Last Interglacial) age is proposed on account of the presence of *H. amphibius*, a species that is characteristic of the Last Interglacial in Britain.
- The vertebrate assemblage from London Road provides the first evidence of deposits of MIS 5e age from the main valley of the River Severn, thereby contributing to our knowledge of the evolution of this river system.

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