MAMMALIAN BIOSTRATIGRAPHY OF THE LATER MIDDLE PLEISTOCENE IN BRITAIN

VOLUME 2

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CHAPTER 6. THE “STAGE 7 INTERGLACIAL”

6.0. Introduction

This chapter will examine the mammals of the “Stage 7 interglacial”. Twenty-six sites are reviewed in this section: Aveley (Essex), Uphall Pit, Ilford (Essex), Itteringham (Norfolk), West Thurrock (Essex), Northfleet (Kent), Brundon (Suffolk), Stoke Tunnel (Suffolk), Stutton (Suffolk), Harkstead (Suffolk), the Lower Channel at Marsworth (Buckinghamshire), the Stanton Harcourt Channel Deposits (Oxfordshire), Lexden (Essex), Selsey and West Wittering (West Sussex), Stone Point (Hampshire), Bielsbeck (East Yorkshire), Stoke Goldington (Buckinghamshire), Upper Strensham (Worcestershire), the Crayford brickearths (including Erith and Slade Green) (Kent), Great Yeldham (Essex), Sible Hedingham (Essex), the Otter Stratum in Tornewton Cave (Devon), Bleadon Cave (Somerset), Hutton Cave (Somerset), Oreston (Devon), Pontnewydd Cave (Clwyd) and Hindlow Cave (Derbyshire). The location of these sites is shown in Figure 6.1.

Many of the localities discussed in this chapter were formerly attributed to the Ipswichian Interglacial, on the basis of palynological correlation. However, as outlined in Chapter 2, strong evidence from mammalian biostratigraphy, in conjunction with terrace stratigraphy, molluscan and coleopteran biostratigraphy, sea level evidence and amino acid geochronology, indicates that an earlier unnamed interglacial episode can be recognised within the ‘Ipswichian’ group of sites, correlated with Stage 7 and seemingly indistinguishable in the pollen record from the Ipswichian. This has been corroborated by the discovery in recent years of new sites that cannot be incorporated into the traditional stratigraphic framework, where stratigraphic superposition can be demonstrated of two interglacial episodes, the lower one relating to a post-Hoxnian, pre-Ipswichian temperate stage and the upper one relating to the Ipswichian sensu stricto.

The recognition of deposits of Stage 7 age within the long terrace sequence of the Thames valley has provided a sound stratigraphic basis for correlation with other sites believed to be of the same age, including other fluvial sites, raised beach deposits and cave sites.
The following section will begin by examining the evidence from Aveley, in order to first establish the differences between the mammal faunas of the “Stage 7 interglacial” and the Ipswichian, and second to identify species of biostratigraphic significance. This information will then be compared with mammalian evidence from the other above-named localities.

Figure 6.1 Location of sites assigned to the “Stage 7 interglacial”.
6.1. SANDY LANE QUARRY (TQ 553807) and A13 SITES, PURFLEET ROAD, AVELEY, ESSEX

6.1.1. Location of the sites

The village of Aveley is situated on the north bank of the Thames, immediately to the north of Purfleet. The former Sandy Lane Quarry is a large gravel and clay pit that occupies almost a square kilometre of land to the north-west of the village. The A13 London to Southend road, which is in the process of being upgraded by the construction of a dual carriageway between the M25 at Purfleet and Wennington, passes in a cutting close to Sandy Lane Quarry and crosses the Purfleet Road at Aveley in a NW-SE direction (Figure 6.2).

6.1.2. History of research

On 27th July 1964, John Hesketh, a local amateur geologist, discovered bones protruding from a claypit face at Sandy Lane Quarry (see Figure 6.2) being worked by the Tunnel Portland Cement Company. Subsequent excavations by the Natural History Museum uncovered the slightly-disarticulated skeleton of a woolly mammoth (the 'Upper Elephant'), lying in a black detrital mud formed of plant remains and with one tusk projecting into a grey-brown silty clay ('brickearth') above. Directly beneath the mammoth, and separated from it by only 0.3m of sediment, lay the incomplete skeleton of a juvenile straight tusked elephant (the 'Lower Elephant') (Anon. 1966; Blezard 1966). Part of a second skeleton of *M. primigenius* was recovered in October 1964 by Keith Redgewell from the brickearth overlying the detrital mud but the remains of a third mammoth, also preserved in the Natural History Museum, unfortunately bear no stratigraphic data. Later commercial extraction at nearby Moor Hall Farm brought to light a second specimen of *P. antiquus* at the same level as the original Lower Elephant, which was collected by John Carreck in 1965 (Carreck 1966). The pit remained open for at least a further decade, during which time investigations were carried out on the stratigraphy, pollen (West 1969; Hollin 1977), Mollusca (Cooper 1972; Holyoak 1983) and mammalian remains (Stuart 1974, 1976, 1982; Sutcliffe and Kowalski 1976). Sandy Lane Quarry has since been completely infilled and landscaped, with a surface higher than the original hillside (Sutcliffe 1995b).
More recently, the A13 road improvement scheme has provided the opportunity to examine fresh exposures of sediments that are stratigraphically equivalent to the deposits at Sandy Lane. The road project included an evaluation of the Quaternary sediments by Essex County Council’s Field Archaeology Group. The evaluation process began in 1992 with an assessment of existing geological borehole data by D.R. Bridgland, allowing an initial impression to be formed of the extent of the geological interest. The contractor’s borehole logs recorded traces of shells and other organic remains at various locations in the vicinity of Purfleet Road, in deposits identified as part of the Mucking Gravel Formation. This formation includes interglacial sediments at a number of sites which have recently been given the name ‘Aveley sands and silts’, with Sandy Lane Quarry as the type locality (Gibbard 1994). In order to identify the edge of the Mucking Formation where it abuts the Palaeogene Woolwich Beds (thus defining the maximum southern limit of the Pleistocene fossiliferous deposits within that part of the road corridor), a series of six test pits was excavated by machine in a line along the central axis of the road between September 1994 and March 1995. One of these pits, located near the former Pond’s Farm on the north side of the Purfleet Road (marked as ‘Pit 1’ in Figure 6.2) (TQ 55328007)
Figure 6.2 Location map of Aveley, showing the site of Sandy Lane Quarry, Essex County Council’s Pit 1 and the approximate positions of Areas I - V (modified from Bridgland and Foreman 1996).
yielded fossiliferous sediments, including pollen, molluscs and vertebrate remains (Bridgland and Foreman 1996).

A watching brief was then carried out in November 1996 during initial groundworks for the road cutting, during which well-preserved bone fragments (including an antler tine of giant deer *Megaloceros giganteus*, a new record for the site) were noted over an area c. 35m² in extent, in a silty clay deposit on the north edge of the road cutting, south of Purfleet Road (centred on TQ 55493 79887) at approximately 7.5m O.D. In the light of this, further investigation into the deposits and a major rescue excavation of fossil material was carried out by the author and Dr P. Allen in conjunction with Essex County Council between November 1996 and June 1997. Five area excavations (marked Areas I - V on Figure 6.2) were opened up along the course of the road, all of which yielded mammalian remains. Of particular importance was the discovery of remains of jungle cat *Felis chaus*, a new record for the British Isles and the addition of five new taxa to the Aveley species list.

6.1.3. Geological background and provenance of mammalian remains

In the area of the former Sandy Lane Quarry, the modern Thames floodplain runs approximately NNW-SSE, by-passing the loop through South Ockendon and Stifford that is followed by the two highest terraces, formed by the Orsett Heath and Corbets Tey Formations (see 5.1). The Mucking Formation however, follows the same route as the modern river. Two terrace spreads formerly covered the areas of the Sandy Lane pit: a higher eastern outlier of Boyn Hill/Orsett Heath Gravel, first recorded by Whittaker (1889), and a lower, western part, containing the fossiliferous sediments and mapped as ‘Taplow Gravel’. It is these latter deposits that are of interest to the present study. At the spot where the elephants were discovered, the ‘Taplow’ deposits were found to occupy a channel cut into the London Clay to a base level of 1.8m O.D (West 1969). The later description by Hollin (1977) indicates that the deposits thicken westwards (as revealed by later quarrying), reaching -4.3m O.D. The sequence at Aveley is as follows (from West (1969), Ward (in Cooper 1972), Hollin (1977) and Sutcliffe (1995b)) (Figure 6.3):
6. Silt, pale yellow with sand and gravel at the base, approximately 1m thick, interpreted as an aeolian or colluvial deposit of Devensian age by Hollin (1977).

5. Yellow sand with scattered gravel, becoming grey and silty in its lower metre, up to 5m. This deposit (mostly removed as overburden prior to the commencement of the elephant dig) originally covered the entire western end of the pit up to a height of about 15m O.D., resting variously on the deposits of the ‘Elephant Channel’ and on London Clay. In one place, the sand filled a second, westerly-sloping gully, known as the ‘Sand Channel’.

4. ‘Brickearth’, 2-2.5m, (orange-brown silty clay, massive, blue cracks, up to c. 11.6m O.D.). This deposit is of uncertain origin but may be derived from oxidised London Clay, a source for which might be found higher up the slope (Sutcliffe 1995b). Mollusca and mammalian remains are present in its basal (calcareous) part only. The brackish water ostracod *Cyprideis torosa* and a wide range of freshwater ostracods are recorded from the lowermost 25cm (Robinson in Sutcliffe *ibid*).

3. Detritus mud (‘Mammoth peat’), up to 60cm, containing abundant plant remains. The mammoth skeleton was located on its surface at the transition to Bed 4.

2. Shelly grey clays and silts (yellow-brown near base), up to 7m thick. This is a water-lain deposit with abundant freshwater mollusca, including *Corbicula*. A brackish influence is also indicated by the presence of the molluscs *Hydrobia* cf. *ventrosa* (Allen in Sutcliffe *ibid*) and *Pseudamnicola confusa* (Holyoak 1983). Robinson (in Sutcliffe 1995b) also records the occurrence of *C. torosa* in the uppermost part of Bed 1, thereby suggesting that Aveley was at the inland edge of the Thames estuary at the time of deposition. Both straight-tusked elephant skeletons were embedded in the upper part of Bed 2. Although most of 1964 skeleton had become scattered, the position of the articulated bones of the right hind foot of the animal, lying ‘sole’ downwards, is in keeping with the elephant becoming mired while crossing the channel. Extensive disturbance of the deposits immediately below is thought to indicate trampling by large herbivores (Sutcliffe *ibid*). Remains of wood, pollen and small vertebrates, including fish, are also recorded from this horizon.
1. Basal gravel below dominant sand, the latter with brown clay layers.

Base: London Clay

Figure 6.3 Section through the deposits of the Mucking Formation at Sandy Lane Quarry, Aveley (modified from Hollin 1977).
The Mucking Formation has a basal sandy and gravelly periglacial element, the Mucking Lower Gravel (Bed 1). Borehole plots show the upper surface of the gravel to reach 6.24m O.D. to the north of Areas I and II, but generally to be 2-3m O.D. in the vicinity of these two excavated areas. This gravel represents the pre-interglacial aggradational phase of the Mucking Formation and is considered to be the equivalent of the lower gravel in the Lion Pit tramway cutting, West Thurrock (6.4), from which Levallois flakes and cores have been obtained (Bridgland 1994; Bridgland and Harding 1995). The basal gravel is overlain by basal sands (the first bed in the Aveley Silts and Sands Member). Borehole plots show the top of the sand to reach 10.8m O.D. in the east but immediately to the south, the surface drops to 1.38-1.7m O.D. to form a north-south trending depression through Ponds Farm, before rising to 2.35-3.91m O.D. where the A13 corridor crossed Purfleet Road. A second depression has also been noted to the north of this higher area. The variations in height might suggest a period of erosion, with incision into the Lower Gravel, leaving a bluff or bank of gravel to the east (P. Allen pers. comm.). Deposition by flowing water in channels is inferred from the presence of sands and occasional gravels, rather than fine-grained material.

In places, the overlying Aveley Silt (Bed 2 and Bed 4) cuts across bedding structures in the sand; elsewhere the junction is marked by gravels or concentrations of winnowed shells (P. Allen pers. comm.). This unconformity indicates erosion between the two phases of deposition. The major part of the Aveley Silt is very clayey and similar in colour and texture to the London Clay from which it is derived. The basal 2-3m of this silty clay are frequently laminated, being interbedded with silt or fine sand. Above this, the clay becomes massive and the top 2-3m are channelled with infills of sand and gravel. The fine-grained nature of these sediments indicates deposition in a quiet-water environment. The basal laminated deposits were created by variations in flow velocities, the silty clay being deposited in slow or stagnant water and the silt and fine sand from slightly faster flows, possibly associated with flooding. The range of sedimentary structures would be in keeping with overbank deposits of a meandering stream, although the uniform and extensive nature of the silty clay suggests that the main channel was stable, rather than tending to migrate across the floodplain (P. Allen pers. comm.).
The sequence of events appears to be that after the period of main channel flow, during which the lower sands of the Aveley Member were deposited, a period of erosion followed, then quiet water deposition of the silty clay. This resulted in a local landscape of small channels (sands) with marginal deposition of silts, separated by floodplain deposits (silty clay, often laminated) and areas of organic peaty deposits (Bed 3), possibly collecting in old depressions or channels. The organic horizons are therefore not uniformly present over the entire area and, according to borehole records, vary considerably in height when present. Organic material was recorded between 1.3 and 4.7m O.D. and between 5.59 and 7.09m O.D. This latter horizon compares well with the heights of c. 7m O.D. from which mammalian remains were recovered during the author’s recent excavations. The majority of the mammalian remains from these investigations came from the massive upper part of the silty clay (see below). At Sandy Lane, the peaty clay detrital mud horizon within the silty clay declines in height from east to west, from approximately 9m to 5.5m O.D over a distance of 100m (Bridgland and Foreman 1996). At Purfleet Road, the organics also lose height from east to west over a distance of 100m, from c. 7m to c. 4m O.D.

The silty clay has been affected by tectonic activity and shows signs of deformation and shearing towards the south. Whether local diapiring could account for these phenomena or a more serious form of disturbance is involved is not clear. Tectonic deformation may also be responsible for the varying height of the peaty clay/detrital mud.

The Mucking Upper Gravel (Bed 5) occupies channels cut into the Aveley silty clay, with infills of medium to coarse sand with occasional zones of gravel. Slumping of the channel sides and deformation structures were observed, possibly indicating a periglacial phase (P. Allen pers. comm.). Above the channelled horizon, sand or gravel forms a continuous cover (Bed 6). The sands are affected by frost-cracking, reinforcing evidence for a periglacial phase.

Finds from Essex County Council’s excavations at Ponds Farm in 1994-5 came from shelly sands at approximately 3m O.D. These sands underlie blue-grey clays with organic seams at c. 5.25m O.D. (Bridgland and Foreman 1996) and are therefore tentatively correlated with the lower silty clay (Bed 2) at Sandy Lane Quarry, from
which the *P. antiquus* skeleton was recovered. Remains of fish and herpetiles are also reported (Bridgland *et al.* 1995b).

During the course of the new excavations along the A13 road corridor, the following observations were made by the author:

Initially, an area to the south of Purfleet Road of approximately 220m$^2$ was excavated by machine to a depth of 9m O.D. (ground level at 10.1m O.D.) (marked Area I in Figure 6.2 and centred on TQ 55493 79887). The depth was guided by the presence of bone in an initial exposure on the side of the road cutting at a slightly lower level. However, extensive hand excavation between 8.9m and 8.5m O.D. produced only two poorly-preserved bone fragments. Area I was then expanded by machine to the north, opening up a further 48m$^2$. The new trench (centred on TQ 55489 79894) was excavated to a maximum depth of 6.1m O.D. with two 2m x 5m steps cut at 7.2m and 8m O.D. respectively. The bottom level did not produce any bone but as it was only briefly examined, this was not considered to be a reliable indicator of the lower limit of the fossiliferous deposits in this area. However, all 47 bones and bone fragments from this area came from a limited altitudinal range from within a massive brown silty clay with blue cracks (believed to be the lateral equivalent of Sandy Lane Bed 4), falling between 6.95m and 8.12m O.D. All finds were recorded in three dimensions. No trace of organic deposits was observed in this Area.

A large area immediately to the south and west of Area I was excavated by the road contractors to a depth of 7m O.D. to make a working platform for piling operations. A new area (marked as ‘Area II’ in Figure 6.2 and centred on TQ 53480 94851), approximately 900m$^2$ in extent, was temporarily exposed, allowing bones on the surface of the brown silty clay to be collected. Thirty-four widely scattered specimens from a wide range of species were collected.

Between January and February 1997, two new areas were opened up to the north of Purfleet Road, with the aim of establishing the stratigraphic relationship between the Area I and II fossiliferous deposits and those in Sandy Lane Quarry by excavating at two intermediate points along the road corridor. The first (Area III in Figure 6.2 and centred on TQ 55397 80012) was located 55m north-west of Purfleet Road and comprised a
total area of 336m², extending from 9m to 4m O.D. The sides of the excavation were stepped for safety and hand excavation was undertaken on two platforms, on the north-west and north-east sides (2.5m x 4.5m and 5m x 3.5m respectively). The excavation revealed deposits of brown silty clay, at the top of which was a thin (<20cm) but distinct humic horizon at 6.4m O.D. Mammalian remains were embedded in the upper part of this humic band. Signs of soil development are also present within this horizon (R. Kemp pers. comm.). The north-west platform yielded only one bone fragment in spite of extensive hand excavation of the humic layer. In contrast, the north-east platform produced a dense concentration of bones, including 122 recorded pieces, almost all deriving from a single adult large bovid (probably *Bos primigenius*) (Figure 6.4). The completeness of the skeleton suggests that this individual may have become mired in marshy areas at the water’s edge and was quickly buried following death. Molluscan remains were also present.

Figure 6.4 Left metacarpal of a large bovid (cf. *Bos primigenius*), part of an associated skeleton from the author’s excavations (February 1997), brown silty clay above the organic horizon, Purfleet Road, Aveley (anterior view).
Area IV (see Figure 6.2) was located 255m north-west of Purfleet Road and centred on TQ 55279 80119. This area was 340m² in extent and was excavated to a depth of 4.3m (from 9.1m to 4.8m O.D.). A concentration of 67 poorly-preserved bones, mostly from a single juvenile large bovid, was recovered from a very thin humic horizon at 5.8m O.D. on the south-east side of the excavation.

Between June and July 1997, excavations on the south side of Purfleet Road were resumed, following the discovery of more bones in the brown silty clay. Area V (see Figure 6.2) was opened up, centred on TQ 79885551. The section revealed the presence of two separate organic clay horizons at approximately 5m O.D. and 3m O.D. (Figure 6.5), the upper one being the most likely equivalent of the peaty clay detritus mud horizon (Bed 3) at Sandy Lane. Both organic clay horizons contained abundant plant macrofossil remains, including large chunks of wood and spectacular leaf impressions, beetles and molluscs.

Mammalian remains recovered from the upper organic clay horizon include the partial skeletons of a narrow-nosed rhinoceros (Stephanorhinus hemitoechus) (Figure 6.6) and a jungle cat (Felis chaus). The presence of articulated remains suggests that these specimens had not moved very far from their original place of deposition. A further 115 specimens, representing a wide variety of species, were recovered from the overlying brown silty clay, between 5 and 7.5m O.D.
Figure 6.5 Section in Area V, Purfleet Road, Aveley (February 1997), showing the presence of two dark organic clay horizons in the brown silty clay (immediately above and below the measuring rod).
Figure 6.6 Partial skeleton of *Stephanorhinus hemitoechus* from the author’s excavations, Purfleet Road, Aveley (June 1997) (photo: R.M. Fyfe).

Arrow indicates North.

During the course of road construction, a single canine of *Panthera leo* was recovered from a borehole in Mucking Lower Gravel deposits, below the main interglacial horizon.

6.1.4. *Palaeontology*

The following species lists have been compiled from material in the Natural History Museum, London, collected by J. Hesketh, G.R. Ward, K. Redgewell, J. Carreck and the Natural History Museum; from material collected by Essex County Council from Ponds Farm (Bridgland *et al*. 1995c; Bridgland and Foreman 1996); and from material collected by the author on behalf of Essex County Council during excavations at Purfleet Road. The total number of specimens seen in the older collections (J. Hesketh, G.R. Ward, K. Redgewell, J. Carreck and the Natural History Museum) was 459. The number of specimens collected by Essex County Council from Ponds Farm is unknown. A total of 389 specimens were collected during the author’s excavations at Purfleet Road.
The condition of the mammalian remains from the *P. antiquus* horizon is good, the bones being a medium brown in colour. Material from the 'mammoth peat' is stained black, while specimens from the overlying brown silty clay is medium brown and well-preserved. The condition of the remains from Purfleet Road sites is extremely variable. Specimens from Area I are rather poorly preserved and often fragmentary, with many bones encrusted in a ?manganese concretion. In some cases, this concretion is all that remains of the specimen, often forming a 'shell' around the degraded bone. The best-preserved specimens from Area I are, as one would expect, the more compact and robust remains, such as horse teeth and cervid antler bases. Preservation of material from Area 2 is far superior, although breakage and crushing resulting from mechanical extraction during the levelling of this area has damaged most specimens. Material from both areas however, displays an unusual glossy polish which is seemingly unrelated to the freshness of the bone. This polish may be the result of aeolian action, although the precise cause is as yet unconfirmed.

Material from Areas III and V is much better preserved, with complete and partial skeletons recovered. Specimens from the organic horizon in Area V are stained black and extremely fresh, whereas those from the brickearth are brown in colour and generally well-preserved, although most specimens have suffered some post-depositional crushing. The juvenile bovid remains in Area IV are poorly preserved and completely crushed, although the recovery of a partial skeleton suggests that there had been little post-depositional movement.

Species List (Mammalia) from the Lower Elephant (*P. antiquus*) horizon, Aveley, Essex

**Insectivora**

*Crocidura* sp., white-toothed shrew

Soricidae sp.

**Chiroptera**

*Barbastella barbastellus* (Schreber), barbastelle bat

**Rodentia**

*Clethrionomys glareolus* (Schreber), bank vole

*Arvicantha terrestris cantiana* (Hinton), water vole (intermediate form)
* Microtus agrestis (L.) or Microtus arvalis (Pallas), field or common vole
* Microtus sp., indet. vole
* Apodemus sylvaticus (L.), wood mouse

**Proboscidea**
* Palaeoloxodon antiquus (Falconer and Cautley), straight-tusked elephant

**Perissodactyla**
* Equus ferus Boddaert, horse
* Stephanorhinus sp., indet. rhinoceros

**Artiodactyla**
* ? C. elaphus L., red deer
* Bos primigenius Bojanus, aurochs
* Bison priscus Bojanus, bison
* Bovidae sp., indet. large bovid (Bos or Bison)

Species List (Mammalia) from the Upper Elephant (M. primigenius) horizon and from the overlying brickearth, Aveley, Essex

**Rodentia**
* Arvicola terrestris cantiana (Hinton), water vole (intermediate form)*

**Carnivora**
* Canis lupus L., wolf*
* Ursus cf. arctos L., brown bear*
* Felis chaus Güldenstaedt, jungle cat*
* Panthera leo (L.), lion*

**Proboscidea**
* Mammuthus primigenius (Blumenbach), woolly mammoth

**Perissodactyla**
* Equus ferus Boddaert, horse
* Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros*

Rhinoceros indet. sp.

**Artiodactyla**
* Megaloceros giganteus (Blumenbach), giant deer*
* Cervus elaphus L., red deer
* Bos primigenius Bojanus, aurochs
*new records for Aveley, collected by the author

Finds from the most recent excavations on the A13 are still being processed at the time of writing. Final counts of numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals from these excavations are consequently not yet available. Tables 6.1 and 6.2 therefore provide a breakdown of the species list using only material collected by J. Hesketh, G.R. Ward, K. Redgewell, J. Carreck and the Natural History Museum. Although these tables do not include the most recently-excavated specimens, it was nevertheless felt useful to provide some indications of specimen numbers, based upon previously excavated material. Preliminary examination of the new A13 collections reveals that the 389 specimens confirm the relative species abundances noted here. Table 6.1 refers to material from the Bed 2 ('Lower Elephant') *P. antiquus* horizon (192 specimens). Table 6.2 refers to material from the Bed 3 ('Upper Elephant') *M. primigenius* horizon and Bed 4, the overlying silty clay (267 specimens). The richly-organic Bed 3 was extremely localised and it is therefore not thought likely that it is widely separated in time from Bed 4. The mammalian assemblages from Beds 3 and 4 have therefore been combined. The tables show numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site and minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M N.I)</th>
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<td><em>Insectivora</em></td>
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<td>1</td>
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<td></td>
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<tr>
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<td>0.52</td>
<td>1</td>
</tr>
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<td>1.04</td>
<td>1</td>
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<td>0.52</td>
<td>1</td>
</tr>
<tr>
<td><em>Microtus</em> sp.</td>
<td>1</td>
<td>0.52</td>
<td>1</td>
</tr>
<tr>
<td><em>Apodemus</em> sp.</td>
<td>5</td>
<td></td>
<td>1</td>
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<tr>
<td><em>Proboscidea</em></td>
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384
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<th>Species</th>
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<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
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<td><em>C. elaphus</em></td>
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<td>0.52</td>
<td>1</td>
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<tr>
<td><em>B. primigenius</em></td>
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<td>1.04</td>
<td>1</td>
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<td><em>B. priscus</em></td>
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<td>4.68</td>
<td>1</td>
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<tr>
<td>Bovidae sp.</td>
<td>8</td>
<td>4.16</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
</tbody>
</table>

Table 6.1 Breakdown of the mammalian species list from Bed 2 (the ‘Lower Elephant’) *Palaeoloxodon antiquus* horizon, Aveley, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
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<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>136</td>
<td>50.93</td>
<td>4</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>43</td>
<td>16.1</td>
<td>1</td>
</tr>
<tr>
<td><em>S. hemitoechus</em></td>
<td>1</td>
<td>0.37</td>
<td>1</td>
</tr>
<tr>
<td>Rhinocerotidae sp.</td>
<td>2</td>
<td>0.74</td>
<td>1</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. elaphus</em></td>
<td>2</td>
<td>0.74</td>
<td>1</td>
</tr>
<tr>
<td><em>B. primigenius</em></td>
<td>19</td>
<td>7.11</td>
<td>1</td>
</tr>
<tr>
<td><em>B. priscus</em></td>
<td>43</td>
<td>16.1</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>21</td>
<td>7.86</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
</tbody>
</table>

Table 6.2 Breakdown of the mammalian species list from Bed 3 (the ‘Upper Elephant’) *Mammuthus primigenius* horizon, and Bed 4, Aveley, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.1.5. Palaeoenvironmental and palaeoclimatic interpretation

Pollen analysis recorded a high proportion of arboreal pollen, in particular *Pinus*, *Quercus* and *Corylus*, from Bed 2 (the *P. antiquus* horizon) (West 1969). This is interpreted as reflecting heavily-wooded conditions during zone IIb of an interglacial (West *ibid*). The predominance of deciduous woodland conditions is also reflected in the mammalian assemblage by *P. antiquus* (Figure 6.7) (almost 69% of the assemblage from this horizon), with smaller numbers of *B. barbastellus* (Figure 3.7), *C. glareolus*.
and *A. sylvaticus*, although the presence of large herbivores (*E. ferus*, rhinoceros and large bovids) and *Microtus* sp. suggests the availability of more open areas. A source of slow-flowing or still freshwater, fringed by vegetation, is suggested by the presence of *A. t. cantiana* and a fish assemblage including *Anguilla anguilla* (eel), *Gasterosteus aculeatus* (three-spined stickleback), *Scardinius erythrophthalmus* (rudd), *Rutilus rutilus* (roach) and *Esox lucius* (pike) (Bridgland et al. 1995c). The presence of *Triturus cristatus* (warty newt), *Rana* sp. (frog) and *Natrix natrix* (grass snake) also reflects the proximity of aquatic habitats (Bridgland et al. *ibid*). Mollusca from this horizon are considered indicative of a slowly-moving river, probably of moderate size, with *Valvata piscinalis* and *Bithynia tentaculata* being most abundantly represented. *Corbicula fluminalis* was also recorded. The extinct hydrobiid *Paludilhia radigueli*, which was present in low numbers, suggests the possibility of a tidal influence in the area (D.H. Keen pers. comm.), a supposition which is supported by the presence of migratory fish, such as eel. The vertebrate and molluscan assemblages attest to fully interglacial conditions. In particular, the presence of a white-toothed shrew (*Crocidura* sp.), which today has a predominantly southern European distribution, may indicate a climate slightly warmer than at present.
A period of decrease in *Tilia* and increase in *Picea, Betula* and *Alnus* marks the transition to Bed 3, which is characterised by a much higher proportion of non-arboreal pollen (West 1969). Pollen from grasses, sedges, herbs and aquatic plants dominates the assemblage but substantial amounts of *Pinus, Carpinus* and *Salix* are also recorded. *Quercus* and particularly *Corylus* is less common and the proportion of AP:NAP continues to fall throughout this zone. The pollen spectra from these levels are considered to reflect open conditions on an alluvial plain with fen and marsh vegetation during zone III of an interglacial (West *ibid*). No pollen has been recorded from the overlying brickearths. The transition from woodland-dominated to grassland-dominated
conditions is also reflected in the mammalian assemblage from the organic clay and the overlying brown silty clay. Preliminary analysis reveals that it is dominated by large herbivores, in particular *E. ferus*, which display a marked preference for open environments with abundant grazing, such as a river floodplain. The presence of *M. primigenius, S. hemitoechus, M. giganteus* and large bovids also reflects the immediate proximity to the site of open ground. *F. chaus* is today indicative of both grassland and marshy areas, where it preys on small mammals and waterbirds. Aquatic habitats are indicated by *A. t. cantiana*. The molluscan remains from the upper brickearth are dominated by species characteristic of flowing freshwater, including *Corbicula fluminalis, V. piscinalis, B. tentaculata, P. moitessierianum* and *P. amnicum*. ‘*Paladilhia radiguelli*’ is also abundant, although the brackish ostracod *Cyprideis torosa* is relatively poorly-represented (D.H. Keen pers. comm.).

### 6.1.6. Biostratigraphy and correlation

The dating of the Aveley sediments continues to be a matter of controversy, since the deposits were originally attributed to the Ipswichian Interglacial (West 1969; Hollin 1977; Stuart 1976, 1982; Gibbard 1994, 1995b) on the basis of palynological biostratigraphy. Conversely, the evidence from terrace stratigraphy, mammalian biostratigraphy and amino acid geochronology strongly suggests that the temperate sediments at Aveley relate to an unnamed temperate episode between the Hoxnian and Ipswichian Stages (Sutcliffe and Bowen 1973; Sutcliffe 1975, 1976, 1995b; Sutcliffe and Kowalski 1976; Shotton 1983; Wymer 1985; Bowen *et al.* 1989; Bridgland 1994; Bridgland *et al.* 1995c). The arguments for both correlations are outlined in Chapter 2.

The stratigraphical scheme for the Thames terrace sequence proposed by Bridgland (1994) advocates correlation of the interglacial deposits contained within the Mucking Formation with Stage 7, the third post-Anglian interglacial (see Figure 2.8). The underlying Mucking Lower Gravel is consequently attributed to Stage 8 and the overlying Mucking Upper Gravel to Stage 6, during which downcutting between the Taplow and Kempton Park terrace levels occurred. Any Thames sediments of Ipswichian age in this area would therefore be expected to be close to, or below ordnance datum and to be represented within the gravel sequence beneath the modern floodplain. Gibbard (1994, 1995b) on the other hand, viewed the Aveley Silts and
Sands Member as part of a single, complex Ipswichian Stage, deposited as a consequence of rising water levels following a marine transgression.

The Aveley mammalian assemblage will be examined in detail below and conclusions drawn as to whether it is indeed justifiable to regard it as relating to a pre-Ipswichian Stage 7 interglacial (as proposed by Sutcliffe 1976, 1995a, b), or whether it should be considered as part of a single Ipswichian Stage, following Stuart (1976, 1982).

Mammalian studies

The mammalian assemblage from the lower part of the sequence at Aveley is similar to that of the immediately preceding Stage 9 interglacial, as represented by Purfleet (5.1), Grays (5.2) and Cudmore Grove (5.3), since both are faunas with a pronounced woodland character. *Crocidura* is present in both, although it was not possible to determine in the present study (on the basis of a single specimen) whether the species represented at Aveley is the same as that in the Stage 9 interglacial (attributed to *C. cf. leucodon*). However, differences are apparent in the Aveley *Arvicola* remains, which show a more advanced dental morphology than those from Stage 9, with enamel in equal thickness on both sides of the salient angles. The absence at Aveley from of *Macaca sylvanus*, which has never been recorded from any post-Stage 9 deposit, is also highly significant. The presence of *Crocidura* in association with *P. antiquus* in the lower part of the sequence at Aveley is therefore considered to reflect an early woodland period during this interglacial, as opposed to any age-equivalence with Stage 9 sites and indeed, this is paralleled at other sites, such as Itteringham (6.3). *Hippopotamus* is apparently absent from this part of the sequence, even though the deposits have been assigned to zone IIb on palynological grounds (West 1969). *Mammuthus primigenius* is also absent (the elephant remains from this horizon consisting exclusively of *P. antiquus*) but *Equus ferus* (which is supposedly absent from this zone according to Stuart (1976, 1982)) is present (see Figure 3.42).

The upper part of the Aveley sequence is distinguished by a rather different mammalian assemblage, reflecting the development of much more open conditions. *Mammuthus primigenius* replaces *P. antiquus* as the dominant elephant species (over 50% of the assemblage from this horizon). The mammoth in question is of ‘Ilford type’, meaning
that it is a form characterised by a combination of small size and teeth with a relatively low plate (Lister pers. comm.). This combination has been noted as a consistent feature of the mammoths from contemporary sites, including the Uphall Pit at Ilford (6.2), Northfleet (6.5) Brundon (6.6), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Crayford (6.18), thereby leading to the conclusion that the presence of the ‘Ilford type’ mammoth may be of biostratigraphic importance. To date, the ‘Ilford type’ mammoth has only been found in association with interglacial episodes. *P. antiquus* has not been recorded from Aveley in this part of the sequence, although evidence from contemporary sites, such as Ilford (Uphall Pit) and Brundon, suggest that it continued to be present in Britain at this time but always in much smaller numbers than *M. primigenius*. The upper part of the Aveley sequence is also characterised by an abundance of *Equus ferus*, together with large forms of *Cervus elaphus, Bos primigenius* and *Bison priscus*.

The Carnivora from the upper part of the Aveley sequence are comparatively well-represented, with lion, *Panthera leo*, being the most common predator. The Aveley lion specimens have all come from the recent A13 excavations and include a right mandible with the dentition *in situ* and two metapodials (Figure 6.8). Preliminary examination suggests that these remains are of significantly large size, visually surpassing both modern comparative and other Middle and Late Pleistocene specimens. A single individual each of brown bear, *Ursus arctos*, and wolf, *Canis lupus*, is also represented, the latter being a small individual. The jungle cat, *Felis chaus*, makes its first appearance in the British fossil record during the Aveley interglacial, although the biostratigraphic significance of this (if any) is unclear, since this is the sole record of this species. At the present day, *F. chaus* inhabits open grassland and marshy areas and it seems likely that its presence in Britain coincided with the arrival of a suite of animals from continental Europe that are characteristic of open, steppic conditions. This is attested to by the presence of species such as *Coelodonta antiquitatis* and *Citellus citellus* at contemporary sites, including Ilford (Uphall Pit) (6.2), Crayford (6.18), and Oreston (6.24).
Figure 6.8 Left third metatarsal of Panthera leo from the author’s excavations, Purfleet Road, Aveley (anterior view).

The rhinoceros in the upper part of the sequence at Aveley is represented by a single species, Stephanorhinus hemitoechus. The presence of S. kirchbergensis has been verified during the present study at the contemporary site of Ilford (6.2) (contra Stuart 1976), although in comparatively smaller numbers. The predominance of the grassland-favouring S. hemitoechus over the forest-dwelling S. kirchbergensis corresponds well with other lines of evidence that suggest the development of more open conditions during this part of the Aveley interglacial and is paralleled by other changes in the fauna, for example the dominance of the grassland elephant M. primigenius over the forest elephant P. antiquus.

Having considered the Aveley mammalian assemblage as a whole, certain conclusions may be drawn as to the age of the site. Several points make the assemblage difficult to reconcile with an Ipswichian age, namely the absence of Hippopotamus and especially the presence of Equus ferus and Crocidura in deposits attributed to zone Ip IIb. The presence of Hippopotamus in Ip IIb deposits is considered to be diagnostic of that part of the Ipswichian Interglacial, as is the absence of Equus, according to Stuart (1976). To find these roles reversed is incompatible with an Ipswichian age. The presence of Crocidura is also suggestive of a pre-Ipswichian age, since this species has never been recovered from any site in association with Hippopotamus. Its occurrence at Aveley in deposits attributed to zone Ip IIb but lacking Hippopotamus is an indication that the
Aveley deposits are not necessarily of Ipswichian age. Further evidence, in the form of woolly mammoth with primitive dental features, also suggests that the Aveley deposits may be older, rather than younger. It is therefore concluded that the mammalian assemblage from Aveley should be correlated with the earlier Stage 7 interglacial, rather than the Ipswichian. This determination supports the findings of Sutcliffe (1975, 1976) and evidently raises the issue that the palaeobotanical evidence is unable to distinguish between these two separate interglacials. However, taken in conjunction with supporting evidence from the Thames terrace model of Bridgland (1994), with molluscan and coleopteran biostratigraphy (see below) and amino acid geochronology (see below), the mammalian biostratigraphic argument becomes all the more persuasive.

The fact that an assemblage of Aveley type has never been found to overlie a *Hippopotamus* assemblage becomes immediately understandable if it is accepted that the assemblage at Aveley is actually older than that at Trafalgar Square, and indeed, the relative positions of the two sites in the Thames sequence bears testimony to this. The need to invoke complicated tectonic movements, massive rises in sea level or the action of tributary rivers to explain the differences in height between these sites also becomes unnecessary if Aveley is attributed to an earlier interglacial. The dangers of continued reliance on correlations based upon palynological evidence are particularly well illustrated here, since the Aveley Silts and Sands Member of Gibbard (1994, 1995b) includes deposits which occur at a variety of altitudes and in three separate terraces, but which the pollen biostratigraphy places in a single Ipswichian stage. Thus, Aveley is correlated with sites as widely separated in time as Purfleet (5.1) and Trafalgar Square, an interpretation which is inconsistent with every other line of evidence, including the mammalian biostratigraphic model established in the present study. Correlation of the Aveley temperate deposits with Stage 7 is therefore affirmed, but further refining of the age of the different parts of the sequence is also possible.

Examination of the oxygen isotope curve reveals that Stage 7 contains three major climatic oscillations, consisting of two temperate peaks (Substages 7c and 7a), separated by a short period of colder conditions (Substage 7b). A considerable time gap between the deposition of the lower and upper sequences at Aveley was proposed by Blezard (1966) and supported by the palynological evidence, which assigned them to separate zones in the interglacial (West 1969). This has been supported by preliminary results
from the author’s excavations on the A13 road corridor, which suggest the development of a soil within the thin humic band seen in Areas III and IV. This implies a hiatus of unknown duration at the top of Bed 2, prior to the penecontemporaneous deposition of localised beds of organic clay (Bed 3) and brown silty clay (Bed 4). The mammalian evidence is consistent with such a hiatus within the sequence. A transition from the woodland-dominated fauna of Bed 2 to the open grassland fauna of Bed 3+4 seems difficult to reconcile within the single climatically-unidirectional interglacial proposed by the pollen record because both assemblages (although different in their ecology) are apparently equally temperate in character. It is also not apparent where species such as *Mammuthus primigenius* appeared from, if the British Isles had already been cut off from the continent. Only a period of cooler conditions, permitting a lowering of sea level, could allow the immigration of this species. It is therefore suggested here that the lower part of the Aveley interglacial sequence (Bed 2) reflects the early temperate peak of Stage 7 (Substage 7c). Mammalian remains from the upper part of the sequence (Beds 3 and 4) reflect the later temperate peak (Substage 7a). The period of soil development is consequently attributed to cooler conditions during the intervening Substage 7b. This is the first time that the mammalian remains from Aveley have been interpreted in a way other than as part of a single temperate episode.

On the basis of the above conclusions, it is now possible to determine certain key features which may be regarded as diagnostic of the mammalian fauna from the third post-Anglian interglacial in Britain, here correlated with OIS 7. The lower part of the sequence (correlated with Substage 7c) is characterised by:

- Presence of *Crocidura* sp., white-toothed shrew
- Presence of a morphotype of the water vole *Arvicola terrestris cantiana* with a more advanced enamel morphology than the Stage 9 morphotype.
- Presence of *Palaeoloxodon antiquus*, straight-tusked elephant
- Presence of *Equus ferus*
- Absence of *Macaca sylvanus*, Barbary macaque
- Absence of *Mammuthus primigenius*, woolly mammoth
- Absence of *Hippopotamus amphibius*, hippopotamus
The upper part of the Aveley sequence (correlated with Substage 7a) is characterised by:

- Presence of *Mammuthus primigenius*, woolly mammoth, as the most abundant elephant species. *M. primigenius* remains from this time are frequently (but not exclusively) of ‘Ilford type’, with small molars bearing a low plate count. Although *P. antiquus* has not been recorded from this part of the sequence at Aveley, it is known to have co-existed with *M. primigenius* at this time but always in much smaller numbers (see Ilford, 6.2, Brundon 6.6).

- Presence of the horse *Equus ferus* in abundance

- Presence of a very large form of lion *Panthera leo*, brown bear *Ursus arctos* and wolf *Canis lupus*

- Presence of large forms of *Cervus elaphus* and *Bos primigenius*

- Absence of *Hippopotamus amphibius*, hippopotamus

None of the species listed should be taken in isolation as OIS 7 indicators, but in combination, these species form two consistent, coherent groups that can be repeatedly observed at other British localities.

**Malacological studies**

The presence at Aveley of *Corbicula fluminalis* is considered to be a strong indication that the deposits are of pre-Ipswichian age, since this species is not known from Stage 5 (Keen 1990). *Corbicula* is an invasive coloniser and its occurrence at Aveley but not upstream at Trafalgar Square is incompatible with any suggestion of contemporaneity of the two localities (Preece 1988; Meijer and Preece 1995). The absence of *Corbicula* at Trafalgar Square cannot be attributed to collection failure or to the effects of facies, since the sandy sediments there would seem an ideal habitat for it (Preece 1995).

**Coleopteran studies**

Differences in the dung beetle faunas from Aveley and Trafalgar Square are considered to reflect a difference in age. The Aveley assemblage is dominated by *Aphodius*, whereas Trafalgar Square has yielded an exotic *Onthophagus*-dominated assemblage.
(Coope, in Sutcliffe 1995b). The presence of Anotylus gibbulus at Aveley (Coope, in Shotton 1983c) is also considered to indicate a pre-Ipswichian age for the deposits.

Palynological studies

The lower part of the sequence at Aveley (Bed 2) has been correlated with subzone IIb of the Ipswichian Interglacial, while the upper part (Bed 3) has been correlated with zone Ip III (West 1969; Blackford, in Bridgland et al. 1995c).

6.1.7. Discussion and conclusions

On the basis of mammalian biostratigraphy, the Aveley temperate stage deposits are correlated in the present study with Stage 7 of the oxygen isotope record. Critical factors which argue against an Ipswichian age include the absence of Hippopotamus and the presence of Equus ferus and Crocidura in deposits assigned on palynological grounds to zone Ip IIb. The presence of a primitive form of Mammutthus primigenius in overlying deposits also supports the views of Sutcliffe (1976) that the deposits are of greater antiquity than the Ipswichian, contra Stuart (1976). A pre-Last Interglacial age for the deposits is supported by other lines of evidence, including terrace stratigraphy (Bridgland 1994) and molluscan and coleopteran biostratigraphy. Aminostratigraphic analyses have produced ratios of 0.19 ± 0.023 on Corbicula fluminalis (Bowen et al. 1989), which are also consistent with a Stage 7 age.

The Aveley mammalian assemblage is of considerable biostratigraphic significance, since it contains two distinctive faunal groupings that are tentatively correlated with the early and late Stage 7 temperate peaks respectively. Important features of the putative Substage 7c assemblage include the co-existence of Crocidura with P. antiquus, in association with a range of woodland indicators, but differentiated from the preceding Stage 9 interglacial by the absence of Macaca sylvanus and by the presence of a more advanced morphotype of A. t. cantiana. Hippopotamus is absent from this period but E. ferus is present.

Assemblages of putative Substage 7a age are defined by the combined presence of M. primigenius (frequently of ‘Ilford type’) and E. ferus, with large forms of C. elaphus, B.
primigenius and Bison priscus also present. S. hemitoechus and M. giganteus are also encountered. The carnivores of Substage 7a are represented by a particularly large form of lion (most common), with smaller numbers of C. lupus and U. arctos. Hippotamus amphibius is also apparently absent.

The single specimen of P. leo from the Mucking Lower Gravel is not part of the interglacial assemblage but relates to the cold period (attributed to OIS 8 by Bridgland 1994) immediately preceding the temperate episode.

A range of sites (many of which have also been traditionally correlated with the Ipswichian) will now be examined and comparisons made with the Stage 7 'type assemblage' from Aveley.
6.2 UPHALL PIT, ILFORD, ESSEX (centred on TQ 436857)

6.2.1. Location of the site

During the last century, the Ilford area was extensively exploited for commercial brickmaking and numerous pits to the north and south of what is now Ilford High Road were referred to by early authors. The main locality of interest in the present study is the Uphall brickfield, which was located on the Barking Road, Ilford, 6.4 km north of the River Thames and on the eastern slope of the tributary River Roding. Specimens were also collected from brickearth deposits at Richmond Road and the Harrison Gibson Store, approximately 500m north-east of Uphall (Figure 6.9). A further site, the Cauliflower Pit (also known as Curtis’ Pit, Sam’s Green or Page’s Pit), is part of the higher (and older) Lynch Hill/Corbets Tey terrace (Bridgland 1994) and will only be briefly mentioned here.

Figure 6.9 Map of the Ilford area, showing the location of the Uphall Pit and other sites mentioned in the text (modified from Redknap and Currant 1985).

6.2.2. History of research

The Ilford brickfields are justifiably famous and an extensive body of literature about them extends back to the early nineteenth century, when fossil mammals began to be
recovered by workmen during clay extraction. As early as May 1824, a substantial part of an elephant skeleton was obtained by a Mr Gibson from a brickfield on the London road (Morris 1838). The earliest detailed account of the site was given by Cotton (1847), based upon his observations of two cuttings in the brickfields at Ilford, one in Mr Curtis’ field, the other in Mr Kilverton’s. Cotton reported the presence of extensive deposits of clay (brickearth), resting on top of sands and gravels and commented on the spectacular discovery of numerous bones of mammoth, aurochs, rhino, horse and red deer, which he described as coming from both the brickearth and the sands (although their most common position was on the point of contact between the two, or in the upper part of the sands). He also remarked upon the presence of enormous quantities of freshwater shells, including *Corbicula fluminalis*, in the sands. The bones from the brickearth were said to be in an excellent state of preservation, whereas those from the sands (although equally fresh), were fragile and difficult to remove entire. Of particular note was the horizontal position of the bones within the deposits and the unusual completeness of most of the skeletons (Cotton 1847). Other early references to the site and its mammalian fossils were provided by Owen (1848), Wood jun. (1866a), Walker (1880), Johnson and White (1899), Johnson (1900) and Hinton (1900a, b, 1902).

By the 1860s, the Uphall brickfield had become a celebrated locality for fossil mammal remains, particularly after the discovery in 1863 of a virtually complete skull of a mammoth, with 8’ 8” (2.6m) tusks (Walker 1880). A comprehensive study of the material was carried out by Davies (1865, 1874), who produced a catalogue of the bones of 14 species in the collection of the proprietor of the brickfield, Sir Antonio Brady of Stratford. Since the early part of the 20th century, most of the area has lain under housing, but occasional temporary exposures during trenching or other developments have provided opportunities for the collection of further fossil material between Green Lane and Ilford High Road (Rolfe 1957), at the Harrison Gibson Stores on Ilford High Road, and in Richmond Road (Redknap and Currant 1985). Palaeobotanical analyses, undertaken by West *et al.* (1964) at Seven Kings (TQ 453872), are probably unrelated to the Uphall Pit (see below).
6.2.3. **Geological background and provenance of mammalian remains**

Cotton (1847) recorded the following sequence in the two cuttings in the Ilford brickfields:

7. Vegetable soil with gravel, 2ft (0.6m)
6. Coarse gravel and yellow sand, stratified, 3-6ft (0.9-1.8m)
5. Brickearth ‘of various shades of brown’, regularly stratified, with calcareous nodules (race) and a few bones, 5-6ft (1.5-1.8m)
4. Light brown brickearth, interstratified with wavy layers of sand and numerous bones, 2-3ft (0.6-0.9m)
3. Irregularly wavy layers of yellow and brown sand, containing abundant bones in the upper part, 2-4ft (0.6-1.2m)
2. Fine yellow and white sand with freshwater shells (Kilverton’s pit only), 2ft (0.6m)
1. Coarse gravel

Wood (1866a) recorded the section shown in Figure 6.10.

d. Humus

c. Newer Gravel, laying unconformably on top of Bed b.

b. Bright yellow sand with *Corbicula fluminalis* and elephant remains. The potholes marked by asterisks on the right of the section indicate patches or erosion, prior to the deposition of Bed c.

a. Clayey brickearth with *Corbicula fluminalis* and other freshwater molluscs.

![Figure 6.10 Section through Uphall Pit, Ilford (modified from Wood 1866a, in Davies 1874). No scale given, vertical scale exaggerated from original x 50%.

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Similar sequences were noted by Dawkins (1867a), Phillips (1871), Walker (1880), Hinton (1900a, b) and Rolfe (1957).

Records of the exposures by Rolfe (1957) suggest the presence at Ilford of two separate terrace formations, the higher one relating to the Lynch Hill Corbets Tey Formation and the lower one to the Taplow/Mucking Formation, with the junction (indicated by a distinct rise in the gravel surface, beneath overlying brick earth) at about TQ 446867. All deposits to the south of this (including Uphall Pit) are therefore considered to be part of the Mucking Formation, whereas the Cauliflower Pit is in the higher Corbets Tey Formation (Bridgland 1994). The difference in elevation between the two pits is less than that separating the two formations as a whole, since the Uphall sediments occupy the back edge of the lower (Mucking Formation) terrace and the Cauliflower deposits the leading edge of the higher terrace. This also explains why sediments at Aveley (6.1), on the extreme feather-edge of the Mucking Formation, occur at approximately the same height as those in the Corbets Tey terrace. Since the Aveley deposits are possibly of estuarine origin and thus influenced by high sea level, they therefore reached considerably higher elevations than the general level of the Mucking Formation (Bridgland ibid).

The sections described above demonstrate that molluscan remains from the Uphall Pit were obtained from a sand interbedded with the gravel of the Mucking Formation, but that most of the mammalian assemblage was obtained from brick earth overlying the shelly gravel. Wood (1866a) showed a further gravel overlying the fossiliferous beds in Uphall Pit, presumably the deposit later mapped by the Geological Survey as 'Floodplain Gravel', which would appear to confirm the sequence in the Uphall Pit as part of the Mucking Formation. According to West et al. (1964), Wood (in Davies 1874) later retracted this observation, although examination of Wood's statement shows that he was not denying the presence of the upper gravel at Ilford but merely (and correctly) stating that it was not the same as the deposit that underlay the fossiliferous beds at Grays (5.2) and Crayford (6.18). Wood clearly continued to recognise an upper gravel deposit, since the reproduction of his section by Davies (1874) (Figure 6.10) shows the presence of a 'Newer Gravel'. An upper gravel unit was also described by Phillips (1871) and by Dines and Edmunds (1925).
The Ilford deposits have previously been regarded as Ipswichian, on the basis of palynological analyses undertaken by West et al. (1964) on a series of silts, sands and 'detritus muds' at Seven Kings, only 300m to the east of the Cauliflower Pit. These sediments overlie the Corbets Tey gravel and would, if a Thames deposit, be regarded as pre-dating the Mucking Formation, sensu Bridgland (1994). However, in order to explain the seemingly anomalous elevation of the Seven Kings 'Ipswichian' deposits, West et al. (1964) attributed them to a later tributary stream. The relationship of the Seven Kings to the Corbets Tey Formation is uncertain, since the fossiliferous deposits are not overlain by a further aggradation of Thames gravel. Most importantly, however, there is nothing to suggest that the Seven Kings deposits (and their palaeobotanical information) are in any way related to the Mucking Formation and the Uphall Pit sequence.

As with the sequence at Aveley (6.1), with which it has been correlated on altitudinal and biostratigraphic grounds, the Uphall Pit deposits can thus be confidently assigned to the Mucking Formation, the third post-Anglian formation (Bridgland 1994) (see Figure 2.8). In accordance with the model of terrace aggradation of Bridgland (1994 and Bridgland and Allen 1996), the basal gravel at the site is considered to represent the pre-interglacial aggradational phase, whereas the interglacial deposits represent the mid-sequence temperate episode. The main Mucking Gravel aggradation ('Floodplain Gravel') post-dates the main interglacial. These three elements are attributed to oxygen isotope Stages 8, 7 and 6 respectively (Bridgland 1994, 1995).

6.2.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London, the British Geological Survey Museum at Keyworth, Manchester Museum, the Lapworth Museum at Birmingham University, Oxford University Museum and the Yorkshire Museum. The collections are mostly those of Sir Antonio Brady but other specimens were presented by J. Morris, W. Boyd Dawkins, J. Flower, J. Brown, C. Lyell, Lady Prestwich, W. Ball, W. Reed, H. Falconer, W.J.L. Abbott, F. Corner, Mason, J.P. Johnson, M.A.C. Hinton, G. White, J.E. Lee, W. Thompson, W. Hill, Mann, Charlesworth, C. Westendarp, R.D. Darbishire, Dixon, Warburton, A.J. Sutcliffe and W.D.I. Rolfe. 1669 specimens were examined and the presence of 16 mammalian
species confirmed during the present study. No new records were identified but some important re-identifications were made of material in the Brady Collection, Natural History Museum, London, in particular the dismissal of the record of *Hippopotamus* (see below):

1. a right scaphoid (45111 C 165) identified by Davies (1874) as *Mammuthus primigenius* was re-identified as *Palaoloxodon antiquus*
2. a left femoral head (45157 C 207) identified by Davies (1874) as *M. primigenius* was re-identified as *P. antiquus*
3. a distal right humerus (45352 K/23) identified by Davies (1874) as *Cervus elaphus* was re-identified as *Equus ferus*
4. four teeth of *Equus ferus* (45291 H/2, 45294 H/5, 45298 H/9 and 45302 H/13) all appear to be from Recent animals
5. a complete pelvis and sacrum (45314 H/33,) identified by Davies (1874) as *Equus ferus* was re-identified as *Stephanorhinus hemitoechus*
6. a fragment of right innominate (44925 B/3) identified by Davies (1874) as *Ursus* sp. was re-identified as *Stephanorhinus hemitoechus*
7. a fragment of left upper second molar (45236 E/23) identified by Davies (1874) as *Stephanorhinus hemitoechus* was re-identified as *Stephanorhinus kirchbergensis*
8. three thoracic vertebrae (45733 O/3, 45734 O/4, 45735 O/5) identified by Davies (1874) as *Bos primigenius* were re-identified as *Stephanorhinus sp.*
9. two thoracic vertebrae (45531 N/105, 45536 N/110) identified by Davies (1874) as *Bos primigenius* were re-identified as *Stephanorhinus sp.*
10. part of a right innominate (44925 B/3) identified by Davies (1874) as *Ursus* sp. was re-identified as *Stephanorhinus sp.*
11. a right upper third molar (45333 K/3) identified by Davies (1874) as *C. elaphus* was re-identified as *Megaloceros giganteus*
12. a left astragalus (45689 N/249) identified by Davies (1874) as *Bos primigenius* was re-identified as *M. giganteus*
13. two right astragali (45410 M/19, 45412 M/21) identified by Davies (1874) as *Bison* were re-identified as *M. giganteus*
14. an unshed frontal and antler pricket (45379 L/1) identified in Davies as *Cervus* sp. was identified as *C. elaphus*
15. a centrum of a cervical vertebra (45380 L/2) identified in Davies as *Cervus* sp. was identified as *C. elaphus*
16. two thoracic vertebrae (45381 L 3, 45382 L 4) identified in Davies as *Cervus* sp. were identified as *C. elaphus*
17. a series of 3 thoracic vertebrae and 5 lumbar vertebrae of very young animal (45383 L/5) identified in Davies as *Cervus* sp. were identified as *C. elaphus*
18. a small centrum of lumbar vertebra (45384 L/6) identified in Davies as *Cervus* sp. was identified as *C. elaphus*
19. part of sacrum (45385 L/7) identified in Davies as *Cervus* sp. was identified as *C. elaphus*
20. an incomplete right humerus (45386 L/8) identified in Davies as *Cervus* sp. was identified as *C. elaphus*
21. two right metacarpals (45387 L/9, 45388 L/10) identified in Davies as *Cervus* sp. were identified as *C. elaphus*
22. a fragment of left innominate (45389 L/11) identified in Davies as *Cervus* sp. was identified as *C. elaphus*
23. a thoracic vertebra (45743 O/3) identified by Davies (1874) as a 'miscellaneous ruminant' was re-identified as *Bos primigenius*
24. 45344 K/16, identified by Davies (1874) as an antler base of *C. elaphus* was re-identified as a fragment of the centrum of a thoracic vertebra of *B. primigenius*
25. a last lumbar vertebra (45791 P/1) identified by Davies (1874) as *Hippopotamus major* was re-identified as *B. primigenius*
26. a left humerus (45394 M/3) identified by Davies (1874) as *Bison* was re-identified as *B. primigenius*
27. a left humerus midshaft fragment (45780 O/59) identified by Davies as a 'miscellaneous ruminant' was identified as *B. primigenius*
28. two distal left humeri (45327 1/4, 45329 1/7) and a right humerus (45326 1/3) identified by Davies (1874) as *M. giganteus* were re-identified as *B. primigenius*
29. a small right radius (45395 M/4) and a small proximal right radius (45396 M/5) identified by Davies (1874) as *Bison* were tentatively re-identified as female *B. primigenius*
30. a right scaphoid (45402 M/11) and a left lunar (45398 M/7) identified by Davies (1874) as *Bison* were re-identified as *B. primigenius*
31. three right metacarpals (45403 M/12, 45404 M/13, 45405 M/14) identified by Davies (1874) as *Bison* were re-identified as *B. primigenius*
32. a proximal right metacarpal (45761 O/31) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as *B. primigenius*

33. three first phalanges (45769 O/39, 45770 O/40, 45771 O 41) identified by Davies (1874) as a ‘miscellaneous ruminant’ were identified as *B. primigenius*

34. six second phalanges (45772 O/42, 45773 O/43, 45774 O 44, 45775 O/45, 45776 O/46, 45777 O 47) identified by Davies (1874) as a ‘miscellaneous ruminant’ were identified as *B. primigenius*

35. three third phalanges (45781 O/51, 45782 O/52, 45783 O 53) identified by Davies (1874) as a ‘miscellaneous ruminant’ were identified as *B. primigenius*

36. a right tibia (45409 M/18) identified by Davies (1874) as *Bison* was re-identified as *B. primigenius*

37. a left astragalus (45414 M/23) identified by Davies (1874) as *Bison* was re-identified as (?female) *B. primigenius*

38. a left cubo-navicular (45416 M/25) and a right cubo-navicular (45415 M/24) identified by Davies (1874) as *Bison* was re-identified as *B. primigenius*

39. a left metatarsal (5422 M/31), a proximal left metatarsal (45721 N/281) and a right metatarsal (45417 M/26) identified by Davies (1874) as *Bison* was re-identified as (?female) *B. primigenius*

40. a distal right humerus (45788 O/58) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as *B. priscus*

41. a proximal right ulna (45758 O/28) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as *B. priscus*

42. a midshaft of a left femur (45765 O/35) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as *B. priscus*

43. a distal right metatarsal (45762 O/32) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as *B. priscus*

44. a thoracic vertebra (45349 K/50) identified by Davies (1874) as *C. elaphus* was re-identified as a large bovid

45. a cervical vertebra fragment (45732 O/2), five thoracic vertebrae (45736 O/6, 45737 O/7, 45739 O 8, 45740 O/10, 45739 O/9), five lumbar vertebrae (45744 O 14, 45745 O/15, 45746 O/16, 45747 O/17, 45748 O/18) identified by Davies (1874) as ‘miscellaneous ruminants’ were identified as large bovids
46. a rib (45750 O 20) and five proximal rib fragments (45751 O/21, 45752 O 22, 45753 O/23, 45754 O 24, 45755 O 25) identified by Davies (1874) as ‘miscellaneous ruminants’ were identified as large bovids
47. two rib fragment (45794 R/3, 45795 R/4) described by Davies (1874) as indeterminate was identified as a large bovid
48. a scapula fragment (45756 O 26) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as a large bovid
49. a distal left humerus fragment (45757 O 27) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as a large bovid
50. a proximal right radius (45759 O/29) and a distal right radius identified by Davies (1874) as ‘miscellaneous ruminants’ were identified as large bovids
51. a damaged left metacarpal (45764 O/34) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as a large bovid
52. a second phalanx (45778 O/48) and two third phalanges (45784 O 54, 45785 O/55) identified by Davies (1874) as ‘miscellaneous ruminants’ were identified as large bovids
53. a left cubo-navicular (45767 O/37) identified by Davies (1874) as a ‘miscellaneous ruminant’ was identified as a large bovid
54. a left metatarsal midshaft (45768 O/38) and a distal metatarsal (45763 O/33) identified by Davies (1874) as ‘miscellaneous ruminants’ were identified as large bovids

Species List (Mammalia) from the Uphall brickpits, Ilford, Essex

**Rodentia**
*Castor fiber* L., beaver
*Arvicola terrestris cantiana* (Hinton), water vole (intermediate morphology)

**Carnivora**
*Canis lupus* L., wolf
*Ursus arctos* L., brown bear
*Panthera leo* (L.), lion

**Proboscidea**
*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant
*Mammuthus primigenius* (Blumenbach), woolly mammoth
Elephantidae sp., indet. elephant

**Perissodactyla**
Equus ferus Boddaert, horse
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros
Stephanorhinus kirchbergensis (Jäger), Merck's rhinoceros
Coelodonta antiquitatis (Blumenbach), woolly rhinoceros
Stephanorhinus indet. sp., rhinoceros

Artiodactyla

Megaloceros giganteus (Blumenbach), giant deer
Cervus elaphus L., red deer
Capreolus capreolus (L.), roe deer
Bos primigenius Bojanus, aurochs
Bison priscus Bojanus, bison
Bovidae sp., indet. large bovid (Bos or Bison)

Table 6.3 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. fiber</td>
<td>22</td>
<td>1.31</td>
<td>4</td>
</tr>
<tr>
<td>A. t. cantiana</td>
<td>1</td>
<td>0.05</td>
<td>1</td>
</tr>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. lupus</td>
<td>3</td>
<td>0.17</td>
<td>1</td>
</tr>
<tr>
<td>U. arctos</td>
<td>20</td>
<td>1.19</td>
<td>2</td>
</tr>
<tr>
<td>P. leo</td>
<td>16</td>
<td>0.95</td>
<td>2</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>41</td>
<td>2.45</td>
<td>4 (1 juv., 3 adults)</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>441</td>
<td>26.42</td>
<td>50 (20 juv., 30 adults)</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>2</td>
<td>0.11</td>
<td>1</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>75</td>
<td>4.49</td>
<td>6 (2 juv., 4 adults)</td>
</tr>
<tr>
<td>S. hemitoechus</td>
<td>161</td>
<td>9.64</td>
<td>9 (1 juv., 8 adults)</td>
</tr>
<tr>
<td>S. kirchbergensis</td>
<td>23</td>
<td>1.37</td>
<td>3</td>
</tr>
<tr>
<td>C. antiquitatis</td>
<td>3</td>
<td>0.17</td>
<td>2</td>
</tr>
<tr>
<td>Stephanorhinus sp.</td>
<td>16</td>
<td>0.95</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. giganteus</td>
<td>25</td>
<td>1.49</td>
<td>3</td>
</tr>
<tr>
<td>C. elaphus</td>
<td>106</td>
<td>6.35</td>
<td>14 (1 juv., 14 adults)</td>
</tr>
<tr>
<td>C. capreolus</td>
<td>1</td>
<td>0.05</td>
<td>1</td>
</tr>
</tbody>
</table>

cont'd.../...
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. primigenius</td>
<td>548</td>
<td>32.83</td>
<td>19 (1 juv., 18 adults)</td>
</tr>
<tr>
<td>B. priscus</td>
<td>42</td>
<td>2.51</td>
<td>5</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>123</td>
<td>7.36</td>
<td>6 (2 juv., 4 adults)</td>
</tr>
</tbody>
</table>

Table 6.3 Breakdown of the mammalian species list from the Uphall brickfields, Ilford, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.2.5. Palaeoenvironmental and palaeoclimatic interpretation

The Ilford mammalian assemblage is characterised by a predominance of species favouring open grazing conditions, such as *Bos primigenius* (32.83% of the assemblage), *M. primigenius* (26.42%), *S. hemitoechus* (9.64%), *Equus ferus* (4.49%), and *Bison priscus* (2.51%), with smaller numbers of *C. antiquitatis* and *M. giganteus*. Woodland habitats are also indicated by the presence of *C. fiber*, *P. antiquus*, *U. arctos* (Figure 3.30), *S. kirchbergensis* (Figure 6.11) and *C. capreolus*, although these 5 species make up only 6% of the total assemblage. The presence of a slowly-flowing body of water is suggested by *C. fiber* (Figure 3.11) and *A. t. cantiana*. Fully temperate climatic conditions are indicated by the presence of large numbers of *Bos primigenius*, together with *P. antiquus*, *S. kirchbergensis* and *C. capreolus*, since these species are known only from warm episodes in the Pleistocene (Stuart 1982). The molluscan remains from the upper brickearth are dominated by freshwater species, including *Helicella crayfordensis*, *Lymnaea palustris*, *Belgrandia marginata*, *Planorbis planorbis*, *Valvata piscinalis* and *Corbicula fluminalis* (collections seen in the B.G.S. Museum, Keyworth).

6.2.6. Biostratigraphy and correlation

As at Aveley (6.1), the dating of the Uphall Pit mammalian assemblage has been the subject of much controversy. Contrary to the conclusions drawn on the basis of palynological biostratigraphy from the Seven Kings site by West et al. (1964), which assigned the Ilford deposits to the Ipswichian Interglacial, Sutcliffe (1975, 1976) and Sutcliffe and Kowalski (1976) proposed that the mammalian assemblage from Uphall Pit should be regarded as pertaining to a pre-Ipswichian temperate episode, correlated
with Stage 7 of the oxygen isotope record. In addition to the evidence from mammalian biostratigraphy, Sutcliffe (ibid) cited terrace stratigraphy in support of his argument (see Chapter 2). This was countered by Stuart (1976, 1982) who, in accordance with the palynological correlation, assigned the Ilford fauna to the terminal phases of the Ipswichian Interglacial. Stuart (1976) disputed the records at Ilford of a primitive type of *Mammuthus primigenius* and of *Stephanorhinus kirchbergensis*, which Sutcliffe (1976) considered to be important indicators of a pre-Ipswichian age. Stuart (ibid) further cited deposition of the Uphall sediments by a tributary stream and tectonic uplift as possible explanations for the difference in height between the Ilford deposits and those at Trafalgar Square.

Most recently, the Uphall Pit deposits have been attributed to the Mucking Gravel Formation in the terrace model of Bridgland (1994, 1995) (see Figure 2.8) and their position in Stage 7 reaffirmed. In contrast, the terrace model of Gibbard (1994, 1995b) accommodates the height differential problem by assigning the Ilford deposits to the Aveley Silts and Sands Member, as part of a single, complex Ipswichian aggradational unit. The Ilford (Uphall Pit) mammalian assemblage will therefore be examined in detail in the light of both terrace models and conclusions drawn, on the basis of the mammalian biostratigraphic evidence, as to the probable age of the deposits.

**Mammalian studies**

An important element of the Uphall assemblage is *Mammuthus primigenius*, remains of which dominate the Ilford Elephantidae (91% of the elephant specimens). Of critical importance to the discussion is the confirmation that 100% of the mammoth M3s (which can be used to differentiate primitive or advanced types) are of a primitive type (Lister pers. comm., contra Stuart 1976), first commented upon by Adams (1877-81). These mammoths are characterised by a combination of small size and relatively low plate count in their teeth. This combination (henceforth referred to as the 'Ilford type') is reminiscent of the earlier Pleistocene *Mammuthus trogontherii* and has been noted as a feature of the mammoths from a wide range of contemporary interglacial sites, including Northfleet (6.5), Brundon (6.6), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Crayford (6.18). The majority of the above sites were formerly considered to be of Ipswichian age (Stuart 1976, 1982) but are now all widely
regarded as being of Stage 7 age (Sutcliffe 1995a). It is therefore concluded that the ‘Ilford type’ mammoth is of biostratigraphic importance in demonstrating a Stage 7 age. The presence at Ilford (Uphall Pit) of *P. antiquus* is also critical to the discussion, since the co-existence of this species with *M. primigenius* is also a diagnostic character of the Stage 7 interglacial. *P. antiquus* is present during the Ilford interglacial in much smaller numbers than *M. primigenius* (41 and 441 specimens respectively), thereby reflecting the predominance of open conditions.

Three species of rhinoceros are also present in the Uphall Pit assemblage. Remains of *Stephanorhinus hemitoechus* are the most commonly encountered, comprising almost 80% of the rhinoceros specimens, again reflecting the prevalence of grassland habitats. The presence of *S. kirchbergensis* in the Uphall Pit assemblage has also been unequivocally verified during the present study (*contra* Stuart 1976). Stuart’s dismissal of *S. kirchbergensis* at Ilford was based upon the absence of upper third molars of this species in the assemblage and indeed, analysis of the rhinoceros remains in the course of the present study has failed to identify at Ilford a single example of this particular tooth that can be reliably attributed to *S. kirchbergensis*. However, there exist in the collections 23 other perfectly good specimens of *S. kirchbergensis*, comprising 2 mandibular rami with teeth *in situ* (Figure 6.11), 2 lower cheek teeth, 10 upper cheek teeth, showing the characteristic inflated lingual lophs and smooth enamel, and 9 postcranial elements, including the highly characteristic long metapodials. All specimens display the orange staining that typifies the Uphall Pit assemblage. The presence of *S. kirchbergensis* as a genuine inclusion in the Ilford fauna is therefore beyond question and is of considerable biostratigraphic significance. *S. kirchbergensis* has never been recorded from any Ipswichian site and its presence in the Ilford assemblage may therefore be considered as indicating a pre-Ipswichian age for the deposits.
The presence of *Coelodonta antiquitatis* at Ilford (Uphall Pit) is also important as an indicator of the steppe-grassland character and inferred continental climate during this part of the interglacial. The first appearance of this species in Britain is tentatively attributed to Stage 8 (see Chapter 3 and 6.5), although it becomes moderately common at the end of the ensuing Stage 7 interglacial, in response to changing climatic conditions and is recorded at other sites also attributed to Stage 7 in the present study (see 6.5, 6.7, 6.18 and 6.24) but is not known from either the Hoxnian, Stage 9 or Ipswichian Interglacials.

The Carnivora from Uphall Pit are very similar to those described from the upper part of the sequence at Aveley (6.1), with *Panthera leo*, *Ursus arctos* and *Canis lupus* all represented. The lion is particularly notable for its large size, a feature that has consistently been observed at sites now widely regarded as belonging to the Stage 7 interglacial, such as Aveley (6.1). No enamel differentiation was apparent in the single specimen of *Arvicola terrestris cantiana*. An equal thickness of enamel on both sides of the salient angles suggests that the specimen is younger than the Stage 9 interglacial.

The remaining large herbivores at Ilford are also distinguished because of their large size. Remains of *Bos primigenius* are the most numerous in the Uphall Pit assemblage (548 specimens out of 1669) (Figure 3.55), followed by *Cervus elaphus* (106 specimens) (Figure 3.51), *Equus ferus* (75 specimens), *Bison priscus* (42 specimens) (Figure 3.56) and *Megaloceros giganteus* (25 specimens).
An important re-identification carried out in the present study is the dismissal of the single record of *Hippopotamus* from the site. This record was based upon a last lumbar vertebra (45791, N.H.M.L.), erroneously identified by Davies (1874) as *Hippopotamus major* but now demonstrated to be a last lumbar vertebra of *Bos primigenius*.

Having examined the Ilford (Uphall Pit) mammalian assemblage in some detail, it may be seen that the results of the present study are consistent with the conclusions of Sutcliffe (1975, 1976, 1995a) and Bridgland (1994, 1995), who assign the Uphall Pit deposits to a pre-Last Interglacial temperate stage, correlated with Stage 7. These findings are based upon the extremely close similarity of the mammalian assemblage from Uphall Pit to that from the upper part of the sequence at Aveley, designated for the purposes of the present work as the ‘type locality’ for Stage 7 (6.1) and upon various significant ‘presences’ and ‘absences’, which argue against an Ipswichian correlation. The case for this conclusion is presented below.

An Ipswichian age for the Uphall Pit deposits seems unlikely on several counts. With the record of *Hippopotamus* disproved, any argument for an Ipswichian age based on mammalian biostratigraphy can no longer be entertained. The Uphall Pit assemblage contains a distinctive suite of mammals, commonly referred to as a *Mammuthus-Equus* fauna, that is considered diagnostic of the Stage 7 interglacial. Important features of this assemblage include the presence of the primitive ‘Ilford type’ mammoth and *S. kirchbergensis*, together with *P. antiquus, E. ferus* and *S. hemitoechus* and large forms of *C. elaphus, B. primigenius* and *B. priscus*. The occurrence of *C. antiquitatis* is also significant, since this species is unknown from any interglacial other than Stage 7.

**Malacological studies**

The presence of *C. fluminalis* presents a strong case against correlation of the Uphall Pit deposits with the Last (Ipswichian) Interglacial (Keen 1990). The absence of this species at the Ipswichian site of Trafalgar Square is considered a reliable indication that the Ilford deposits are not of Last Interglacial age.
Palynological studies

Pollen spectra from the Seven Kings site at Ilford have been assigned to the Ipswichian Interglacial, probably zone Ip IV, by West et al. (1964). The similarity in height of the Seven Kings deposits to those at Aveley (which was also regarded as Ipswichian by West 1969) was cited as corroborative evidence for their contemporaneity (West et al. 1964). However, doubt must now be cast upon these conclusions following the demonstration that the Seven Kings site is actually part of the older Corbets Tey terrace (Rolfe 1957; Bridgland 1994). The Seven Kings deposits are therefore unlikely to be of Ipswichian age, but are in any case completely unrelated to the Uphall deposits of the younger Mucking terrace. As outlined above, the difference in height between the Seven Kings and Uphall Pit sites is not very noticeable in this area because the former locality occupies the leading edge of the older terrace, while the latter is situated on the back edge of the younger terrace. Furthermore, even if the Seven Kings and Uphall Pit sites were part of the same terrace formation and thus comparable, in the light of the growing evidence that the pollen evidence is unable to differentiate between two successive interglacials indicated in the oxygen isotope record (Stage 7 and Substage 5e) (see 6.1), the attribution of any Ilford deposits to the Ipswichian must be considered open to question.

6.2.7. Discussion and conclusions

On the basis of mammalian biostratigraphy, the Ilford temperate stage deposits are correlated in the present study with Stage 7 of the oxygen isotope record, based upon the very close similarity of the assemblage to that from Aveley (6.1), the established ‘type-locality’ for Stage 7. Critical factors in opposition to an Ipswichian age include the dismissal of the single record of Hippopotamus and the presence of a diagnostic and biostratigraphically significant fauna, including the ‘Ilford type’ mammoth and S. kirchbergensis, in association with P. antiquus, E. ferus and S. hemitoechus, with large forms of C. elaphus, B. primigenius and Bison priscus also present. C. antiquitatis, which is unknown from any other interglacial, is also present. As at Aveley, the carnivores are represented by a large form of P. leo, U. arctos and C. lupus. A pre-Last Interglacial age for the Uphall Pit is supported by other lines of evidence, including terrace stratigraphy (Bridgland 1994) and the presence of Corbicula fluminalis (Keen
Correlation with the upper part of the sequence at Aveley and thus the later part of the Stage 7 interglacial (possibly Substage 7a), is proposed on the basis of the presence of the temperate grassland fauna, dominated by *M. primigenius*.

Aminostratigraphic analyses have produced mixed results. Two separate groupings of ratios were produced by Miller *et al.* (1979) the first consistent with a Stage 7 and the second consistent with a Stage 9 age, while ratios produced by Bowen *et al.* (1989) are also indicative of a Stage 9 age. The reason for this discrepancy may, however, be the provenance of the shells themselves, since it seems likely that the specimens of *Bithynia tentaculata* tested by Bowen *et al.* (ibid) came from the Cauliflower Pit (and would therefore be expected to be of Stage 9 age according to Bridgland 1994), whereas Miller *et al.* (1979) may have used a mixture of shells from the Uphall and Cauliflower Pits.

In conclusion, the mammalian biostratigraphic evidence, in conjunction with that from terrace stratigraphy and molluscan biostratigraphy, is strongly supportive of a Stage 7 age for the Ilford (Uphall Pit) temperate sediments. This correlation obviates the need to invoke tectonic movement, sea level rises or the action of tributary rivers to support the palynostratigraphic model of West *et al.* (1964) and Gibbard (1994, 1995a), which cannot accommodate the Uphall Pit deposits other than in a single Ipswichian Interglacial. The terrace model of Bridgland (1994, 1995) is therefore favoured here, with the basal gravel at the site considered to represent Stage 8, the interglacial deposits considered to represent Stage 7 and the main Mucking Gravel aggradation ('Floodplain Gravel') attributed to Stage 6.
6.3. ITTERINGHAM, NORFOLK (TG 139305)

I am extremely grateful to Martin Warren of the Cromer Museum for his generosity in allowing me access to his unpublished personal notes and observations on the site. The following summary of the history of research at the pit, the geological descriptions and supplementary information on the palaeobotany, malacology (by T. Allen), avian remains (C.J.O. Harrison) and coleoptera (by A. Beesley) were all made available to me.

6.3.1. Location of the site

The Itteringham Gravel Pit lies in the parish of Oulton, approximately 6 km to the west of Aylsham, Norfolk. The site itself is located in the bottom of the narrow, incised valley of the upper Bure river. The floodplain of the river is 200m wide and lies at an elevation of 20m O.D, surrounded by hills which rise to 50m O.D. (Figure 6.12).

Figure 6.12 Location of the Itteringham Gravel Pit
(modified from Ordnance Survey Map).
6.3.2. **History of research**

In January 1984, fossiliferous deposits were reported by a local collector, Mr J. Lightwing, in a gravel pit operated by the Longwater Gravel Company. A watching brief by M.R. Warren of the Cromer Museum was kept on operations for three years, giving the opportunity to see and record sections as they were freshly exposed. The gravel of interest to the extractors was covered by a thick layer of Holocene valley peats, which passed laterally into silts, sands and soils towards the valley sides. Once the peat was removed, the gravels were then excavated to a depth of 4.5-5m below the level of the river. The lower boundary of the gravel was determined by a sharp contact with very dark, rich organic deposits, from which the fossils were obtained. Open sections (particularly those in trenches cut to drain the working areas of the pit) provided opportunities for the collection of bulk samples. Two deep trial holes were also dug. Large bones (sometimes *in situ*) were occasionally reported by the excavator and extensive sieving for microfauna was carried out. The gravel pit remained in more or less continuous production until December 1985 and has since been flooded for the provision of a trout hatchery.

6.3.3. **Geological background and provenance of mammalian remains**

A composite three-dimensional picture of the stratigraphy in the Itteringham pit was built up by M.R. Warren over three years of observation. In the western end of the pit, five major lithostratigraphic units have been recorded overlying chalky Lowestoft Till: (from the base upwards) cold climate gravels, interglacial organic deposits, early Devensian ‘Arctic Beds’, Devensian cold climate gravels and Holocene peats. The Pleistocene interglacial beds are thickest towards the centre of the basin but clearly thin towards the east. The two cold stage gravel deposits however, have similar lithologies and even similar floras but through the intervention of the feather-edge of the interglacial deposits, it is possible to demonstrate the unequivocal separation of the Upper and Lower Gravels, even where they rest directly on top of one another. A schematic sketch section of the deposits is shown in Figure 6.13.
Figure 6.13 Schematic cross-section through the Itteringham deposits (courtesy of M.R. Warren, Cromer Museum).
1. Lower Gravels

In the eastern half of the pit, gravels were seen to underlie the main interglacial beds. During cold climate conditions (immediately?) prior to the interglacial, deep valley excavation caused reworking of the Anglian till and led to the formation of a hollow. At the base of this hollow and in contact with the underlying till, are steeply-dipping sands and gravels, interpreted as glaciofluvial outwash. Overlying these are a sequence of channel fills of finer-bedded deposits, indicating backwater conditions with quieter or negligible flow. These deposits are thought to represent the onset of sedimentation within a lake. The channel fills comprise alternating sands, clay-silts (with freshwater gastropods, beetles and remains of mosses) and gravels. A high water table is suggested by the prevalence of moss in the silts. No vertebrate remains were recovered from this horizon.

2. Interglacial Beds

In the western half of the pit, a series of organic, highly fossiliferous interglacial deposits up to 4.3m thick was observed. The deposits were seen to thin out away from the centre, thus clearly delimiting the margins of the basin in which they were laid down. The following sequence was recorded, representing the gradual infilling of the basin:

Bed:

a (top) Fine, dark brown detritus mud up to 30 cm thick, containing wood fragments.

b Olive-grey laminated silts with shells and abundant seeds, especially Ceratophyllum demersum (hornwort), Potamogeton spp (pondweed) and Betula (birch). A maximum thickness of 70cm was observed.

c Grey shelly silt lacking apparent stratification, containing seeds of C. demersum and freshwater bivalves.

dm A stony, sandy brown detritus mud containing light brown, soft marl pellets and autochthonous wood peat (visible in section MH). This horizon contained an in situ partial skeleton of M. primigenius and remains of M. giganteus.
310 cm of brown detritus mud, becoming darkest and sandiest towards the top. Abundant wood, beetles and vertebrate remains throughout, shelly only in the lowest part. Discrete patches of grey sand, varying from a few centimetres to over a metre in thickness occur apparently sporadically. Ochreous patches and limonite nodules (bog iron) visible in the upper parts of the sections in the western end of the pit. These are thought to indicate lowering of the water level as the basin infilled. Contact with bed c appears to be erosional but not sharp, whilst the upper surface contact with bed e is uneven and clearly erosional, often with a layer of drift mud separating the two beds.

Grey-black varying to orange-black organic fluviatile sands, containing drift mud and irregular streaks of detritus mud. Wood fragments and larger pieces frequent. This unit rests on the uneven, eroded surface of bed d and is thought to represent a return to fluvial conditions, as the top of the sequence was eroded by flowing water.

Above this are sands and gravels assigned to the Upper Gravels. Unfortunately however, the relationship between the Interglacial Beds and the overlying gravels was obscured because of commercial extraction.

3. Arctic Beds

In the eastern part of the pit, the Upper Gravels were underlain in part by beds of clay, organic muds, stony clays, sands and gravels which filled former channel systems and are known as the Upper Arctic Beds. These have been interpreted as Devensian in age. A mammalian assemblage containing abundant *D. torquatus* and *L. lemmus*, with *A. terrestris* and *M. gregalis*, together with a beetle fauna and arctic flora, was collected from these beds. *Salix herbacea* (least willow) was common. Evidence of cryoturbation was visible in section BJX.

4. Upper Gravels

Gravels were 2-3 m thick, occurring in spreads and channels.
5. **Holocene valley deposits**

A coarse, fibrous peat in the floor of the valley, attaining a thickness of 2m, was underlain by fine organic sands from which remains of *C. capreolus* and *C. elaphus* were recovered. The peat was observed to pass laterally into weathered silts and soils at the valley edges.

6.3.4. **Palaeontology**

The following species list has been compiled from material in the Harrison Zoological Museum, Sevenoaks, Cromer Museum and the Castle Museum, Norwich. The collections are the work of excavations coordinated by M.R. Warren of the Cromer Museum and of extensive sieving by J.D. Clayden. The present study examined 610 specimens and confirmed the identity of 20 species from the interglacial beds at the site, all of which are previously unpublished records, with the exception of *Crocidura* (Currant 1989b).

**Species List (Mammalia) from the interglacial beds at Itteringham, Norfolk**

**Insectivora**

*Sorex araneus* L., common shrew  
*Sorex minutus* L., pygmy shrew  
*Neomys fodiens* (Pennant), water shrew  
*Crocidura* sp., white-toothed shrew  
*Soricidae* sp., indet. shrew

**Rodentia**

*Sciurus vulgaris* L., red squirrel  
*Clethrionomys glareolus* (Schreber), bank vole  
*Arvicola terrestris cantiana* (= *Arvicola cantiana* Hinton), water vole (intermediate form)  
*Microtus agrestis* (L.), field vole  
*Microtus arvalis* (Pallas), common vole  
*Microtus* sp., indet. vole  
*Apodemus sylvaticus* (L.), wood mouse
**Carnivora**

*Canis lupus* L., wolf  
*Mustela nivalis* L., weasel  
*Meles meles* (L.), badger  
*? Crocuta crocuta* Erxleben, spotted hyaena

**Proboscidea**

*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant  
*Mammuthus primigenius* (Blumenbach), mammoth  
Elephantidae sp., indet. elephant

**Artiodactyla**

*Megaloceros giganteus* (Blumenbach), giant deer  
*Dama dama* (L.), fallow deer  
*Cervus elaphus* L., red deer  
Cervidae sp., indet. cervid  
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 6.4 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insectivora</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. araneus</em></td>
<td>37</td>
<td>6.06</td>
<td>15</td>
</tr>
<tr>
<td><em>S. minutus</em></td>
<td>13</td>
<td>2.13</td>
<td>6</td>
</tr>
<tr>
<td><em>N. fodiens</em></td>
<td>7</td>
<td>1.14</td>
<td>3</td>
</tr>
<tr>
<td><em>Crocidura</em> sp.</td>
<td>4</td>
<td>0.65</td>
<td>3</td>
</tr>
<tr>
<td><em>Soricidae</em> sp.</td>
<td>2</td>
<td>0.32</td>
<td>2</td>
</tr>
<tr>
<td><strong>Rodentia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. vulgaris</em></td>
<td>1</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td><em>C. glareolus</em></td>
<td>93</td>
<td>15.24</td>
<td>22</td>
</tr>
<tr>
<td><em>A. t. cantiana</em></td>
<td>141</td>
<td>23.11</td>
<td>21</td>
</tr>
<tr>
<td><em>M. agrestis</em></td>
<td>10</td>
<td>1.63</td>
<td>6</td>
</tr>
<tr>
<td><em>M. arvalis</em></td>
<td>4</td>
<td>0.65</td>
<td>3</td>
</tr>
<tr>
<td><em>M. agrestis</em> or <em>M. arvalis</em></td>
<td>38</td>
<td>6.22</td>
<td>22</td>
</tr>
<tr>
<td><em>Microtus sp.</em></td>
<td>97</td>
<td>15.9</td>
<td>14</td>
</tr>
<tr>
<td><em>A. sylvaticus</em></td>
<td>111</td>
<td>18.19</td>
<td>17</td>
</tr>
</tbody>
</table>

cont’d.../...
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lupus</em></td>
<td>1</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td><em>M. nivalis</em></td>
<td>1</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td><em>M. meles</em></td>
<td>1</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td><em>C. crocuta</em></td>
<td>(1)</td>
<td>(0.16)</td>
<td>(1)</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. antiquus</em></td>
<td>4</td>
<td>0.65</td>
<td>1</td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>25</td>
<td>4.09</td>
<td>1</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>1</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. giganteus</em></td>
<td>1</td>
<td>0.16</td>
<td>1</td>
</tr>
<tr>
<td><em>D. dama</em> ssp. indet.</td>
<td>3</td>
<td>0.49</td>
<td>1</td>
</tr>
<tr>
<td><em>C. elaphus</em></td>
<td>6</td>
<td>0.98</td>
<td>1</td>
</tr>
<tr>
<td>Cervidae sp.</td>
<td>3</td>
<td>0.49</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>5</td>
<td>0.81</td>
<td>2</td>
</tr>
</tbody>
</table>

* presence inferred on the basis of a coprolite

Table 6.4 Breakdown of the mammalian species list from the interglacial beds at Itteringham, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.3.5. Palaeoecological and palaeoclimatic interpretation

A severe climate is indicated by the beetle assemblage from the Lower Gravels. Maximum annual temperature ranges are estimated to be between 9°C and 13°C (present day: ca. 16°C in Britain), with minimum annual temperatures between -14°C and -27°C (present day: ca. 4°C in Britain). The palaeoenvironment indicated by the beetles is that of a swampy valley bottom, surrounded by dry heathland, scrub and patches of snow, with some bare sand and gravel in the immediate vicinity (A. Beesley, in M.R. Warren, unpublished notes).

The interglacial beds have yielded a rich herpetofauna, including *Hyla* sp. (tree frog), *Rana esculenta/Rana ridibunda* (edible or marsh frog), and *Emys orbicularis* (pond terrapin) (Hallock et al. 1990). None of these species occurs naturally in Britain at the present day, although they are present on the continent. They may therefore indicate warmer summer conditions in Britain than occur at present. *E. orbicularis*, in particular, requires a mean July temperature approximately 2°C warmer than at present.
breed successfully (Stuart 1979). The Itteringham herpetofauna is generally indicative of the presence of a body of water, either a pond or very slow-moving river, with adjacent damp vegetation (Arnold and Burton 1980). A large molluscan assemblage from the interglacial beds is also indicative of fully interglacial conditions (T. Allen, in M.R. Warren, unpublished notes). The combined presence of Belgrandia marginata and Anisus vorticulus would suggest mean summer temperatures 2°C warmer than the present day. The water body appears to have been a permanent feature of the landscape, since approximately 50% of the assemblage consists of operculate snails, which need a permanent water body in which to survive. The Pisidium species present at Itteringham (P. milium, P. subtruncatum and P. nitidum) are characteristic of lakes or slow moving streams. All the running water combinations of Pisidium are completely absent but although the water may have been static, it was apparently well-oxygenated and aquatic vegetation was abundant. Ditch snails, such as Valvata cristata, B. marginata, Anisus vortex, A. vorticulus and the freshwater limpet Acroluxus lacustris are especially typical of this kind of environment.

Mixed woodland was present in the immediate vicinity of the lake during the interglacial, as attested to by abundant plant macrofossils, such as hazel nuts (Corylus), yew nuts (Taxus), acorns (Quercus) and pine cones (Pinus). Remains of Trapa natans, Nuphar and Nymphaea have also been recovered. As the basin filled during the interglacial, fen-carr developed. Remains of freshwater fish, including Esox lucius, Perca perca, Tinca tinca, Abramis bjoernka, Rutilus rutilus and Alburnus alburnus were recovered from the interglacial lake deposits. These species may all be found in still or slow-flowing water (Wheeler 1969). Of these, E. lucius spawns in winter in water not less than 5°C (Wheeler 1969) and T. tinca requires minimum summer temperatures of 18°C in order to spawn. Birds recorded from the lake deposits include waterbirds, such as Cygnus cygnus (whooper swan), Anas penelope (widgeon), Porzana porzana (spotted crake), Motacilla sp. (wagtail) and Acrocephalus schoenobaenus (sedge warbler) (C.J.O. Harrison, in M.R. Warren, unpublished notes).

The mammalian remains are indicative of fully temperate conditions during the Itteringham interglacial, with temperatures possibly slightly higher than at present. This is on the basis of the presence of Crocidura, which is today absent from the British mainland and has a predominantly southern European distribution (Churchfield 1988).
A co-abundance of *C. glareolus* and *A. sylvaticus* has been cited as a reliable indication of the presence of deciduous woodland (Currant 1986). This is strongly suggested at Itteringham with bank vole and wood mouse representing an unusually large percentage of the assemblage (15.24% and 18.19° respectively). The presence of deciduous woodland is supported by *S. vulgaris, M. meles* and *D. dama*, while areas of grassland and scrubby habitats with plenty of ground cover are also indicated by *S. araneus, S. minutus* and *M. agrestis*. However, the assemblage is dominated by an abundance of *A. t. cantiana*, with almost a quarter of the specimens belonging to this species. This reveals an important aquatic habitat nearby, with slowly-flowing water and well-vegetated margins, an inference supported by the presence of *N. fodiens*.

In the ‘Arctic Beds’, 24 obligate low temperature stenothermic beetle species have been recorded, all of which have distributions well north of Britain at the present day, mostly in the Arctic. In particular, *Boreaphilus nordenskioeldi* can now only be found to the north of the earth’s large landmasses, whilst *Aphodius holderi* occurs only above 10 000 ft in Tibet. The beetle assemblage therefore reflects conditions of severe cold, with maximum annual temperature ranges estimated to be between 9°C and 11°C and minimum annual temperatures between -23°C and -27°C. The palaeoenvironment indicated by the beetles is that of a swampy valley bottom, surrounded by dry heathland, scrub and patches of snow, with some bare sand and gravel in the immediate vicinity (A. Beesley in M.R. Warren, unpublished notes). The combination of *D. torquatus, L. lemmus* and *M. gregalis* in the Arctic Beds is characteristic of cold conditions. Unlocalised remains of *M. giganteus, R. tarandus* and *E. ferus* are thought to have come from the Upper Gravels, on the basis of preservation type. These species broadly reflect a colder, more open environment.

6.3.6. Biostratigraphy and correlation

Mammalian studies

The stratigraphic position of the interglacial deposits, lying below gravels attributed to the Devensian, led to the conclusion that the Itteringham interglacial was Ipswichian in age (Hallock *et al.* 1990). However, on the basis of mammalian biostratigraphic
evidence, it has been suggested that the interglacial represented at Itteringham is, in fact, pre-Last Interglacial in age (Currant 1989b).

Of critical importance to the argument is the absence of *Hippopotamus* and the presence of *Crocidura* at Itteringham. The thermal maximum of the Last Interglacial (pollen zone Ip II) in Britain is characterised by the common occurrence of *Hippopotamus* (Stuart 1982; Currant 1989b; Sutcliffe 1995a). However, despite the attribution of the Itteringham detrital muds to this pollen zone (see below) and the apparent availability of eminently suitable conditions, remains of *Hippopotamus* are absent, although the sample size of large mammals is admittedly small. The presence of *Crocidura* at Itteringham is also very significant, since white-toothed shrews are unknown from deposits of Last Interglacial age in this country.

The Itteringham *Arvicola* sample show an intermediate morphology between Hoxnian *A. t. cantiana* and the modern species *A. t. terrestris*, with the enamel more or less evenly distributed on both sides of the angles. No trace of the *Mimomys* fold was detected in this comparatively large sample (141 specimens), thereby suggesting that the Itteringham *Arvicola* are of more recent age than sites attributed to Stage 9 in the present study, such as Cudmore Grove, where the *Mimomys* fold persists in very small numbers (4.3). This is upheld by measurements of the first lower molar, which show a progressive increase in length through time (Figure 3.20; Tables 3.3 and 3.4). First lower molars in Itteringham *Arvicola* have a mean length of 3.62mm (± 0.035), n = 19, a figure that is significantly larger than that for Cudmore Grove at 3.47mm (± 0.015), n = 67.

The record of badger has been established on the basis of a single, incomplete ulna (length from the coronoid process to the maximum distal point = 79.28 mm, narrowest point of diaphysis 6.40 mm). In both size and morphology, these correspond well with recent *M. meles*.

The upper part of the Itteringham sequence contains a partial skeleton of a single adult individual of *M. primigenius*. Unfortunately, the dentition is not present so no comment can be made as to whether this specimen was of 'Ilford type' or not. However, given the temperate nature of the deposits from which this specimen was recovered (bed dm, see
above) and the fact that they are clearly separated from the Devensian ‘Arctic Beds’ and Upper Gravels, it is evident that the Itteringham mammoth cannot be of Devensian age. Furthermore, the presence of this species at Itteringham M. giganteus is also recorded from this horizon.

Palynological studies

High frequencies of Betula and Pinus from the lowermost deposits of the Interglacial Beds (beds a-c) suggested correlation with pollen zone Ip I. The detritus mud (d), which makes up the bulk of the interglacial deposits, was attributed to Ip II (high Pinus and Quercus with Betula, some Carpinus, Ulmus and Alnus. High Corylus-Myrica). The organic fluvial sands (e), with high levels of Carpinus, were thought to represent Ip III-IV (after West 1980b, M.R. Warren, unpublished notes).

6.3.7. Discussion and conclusions

On the basis of the mammalian biostratigraphic evidence, it is proposed that the interglacial deposits at Itteringham should be correlated with OIS 7 and that both temperate substages within that period are probably represented. This interpretation is based upon the parallels between the sequence at Itteringham and that at Aveley (6.1), in particular, the combination of P. antiquus and Crocidura in the lower deposits and the presence of woolly mammoth in the upper interglacial horizons. A Last Interglacial age for the site cannot be supported, given the presence of Crocidura and M. primigenius in these deposits.

The majority of the vertebrate remains (from bed d) at Itteringham could therefore be attributed to Substage 7c, reflecting a temperate peak in the first part of the interglacial, with the development of woodland and summer temperatures around 2°C higher than at present. This period is characterised by a distinctive fauna with clear woodland affinities. Significant mammalian species from this time include:

- Crocidura sp., a white-toothed shrew
- Palaeoloxodon antiquus, straight-tusked elephant
- Dama dama, fallow deer
The record of *D. dama* is significant in that this species has not previously been recognised as part of the Stage 7 mammalian fauna. The present study is the first to identify two distinctive faunal groupings, corresponding with smaller-scale climatic fluctuations within this interglacial. Correlation of the lower part of the Itteringham sequence with the lower part of the sequence at the ‘type locality’ of Aveley (6.1) has demonstrated that *D. dama* is a genuine inclusion in the fauna of the early temperate peak in Stage 7. Its presence in the British Isles agrees well with supporting information which suggests the development of deciduous woodland conditions at this time.

A short period of cooler conditions (? Substage 7b) may be represented by the erosional phase noted at the top of bed d. The return of temperate conditions (? Substage 7a) is shown in beds dm and e. The presence of woolly mammoth is of biostratigraphic significance here. It is important to note that, as with other sites such as Aveley (6.1), the mammoth occurs in a fully interglacial environment.

The top of the interglacial sequence is capped unconformably by Devensian gravels and *in situ* organic deposits, yielding a typical Last Glacial mammalian assemblage of *D. torquatus, L. lemmus* and *M. gregalis*. The water vole remains recovered from these cold stage deposits are referable to the modern *A. terrestris*, with clearly-differentiated thicker enamel on the concave edges of the molars.
6.4. TUNNEL CEMENT WORKS QUARRY (TQ 575777) AND LION PIT TRAMWAY CUTTING S.S.S.I. (TQ 598783), WEST THURROCK, ESSEX (TQ 598783)

6.4.1. Location of the site

The Lion Pit tramway cutting is located on the north side of the London Road, West Thurrock, immediately adjacent to Mill Lane and approximately 1km north of the River Thames (see Figure 5.11). The Tunnel Cement Works Quarry (not shown on the map) is situated at the extreme western end of the brickearth outcrop (TQ 575777).

6.4.2. History of research

The presence of flint artefacts and bones from a gravel at the West Thurrock Tunnel Cement Works Quarry was first reported by Abbott (1890), and the existence of a rich Palaeolithic site in the area has been known since the turn of the century, although no full description has ever been published. Brief mentions of several exposures at West Thurrock were provided by Hinton and Kennard (1900, 1907), Kennard (1916), Dibley and Kennard (1916) and Warren (1923a, b), all referring to exposures in the side of a tramway cutting leading into one of the numerous chalk quarries in the area, but it was not until some years later that Kennard apparently discovered the Levallois working-floor in ‘Middle Terrace deposits against a chalk cliff’ (Dibley and Kennard 1916). Warren (1923b) subsequently referred to a rich industry of tortoise cores and Levallois flakes in the basal gravel at West Thurrock, underlying brickearth, and also to a Levallois working floor at the foot of a buried cliff and covered by fluvial deposits up to a height of 50ft O.D. (Warren 1943). However, despite Warren’s impressive collection of worked flints from the site, the Lion Pit was overlooked for several decades while greater attention was given to other Levallois sites in the Lower Thames, such as Botany Pit, Purfleet (5.1), Northfleet (6.5) and Crayford (6.18).

The mammalian and molluscan remains collected by Abbott were rediscovered in 1974 in the Wellcome Institute for the History of Medicine, London, and were described by Carreck (1976). As previously stated, these are known to have come from the Tunnel Cement Works Quarry, north of London Road, West Thurrock. In the mid-1980s,
attempts were made to find the precise location of Warren’s working floor at the Lion Pit tramway cutting. Detailed notes given by Warren to the Nature Conservancy Council enabled the overgrown sections to be relocated and controlled excavation undertaken in 1984, as part of the the Geological Conservation Review project (Bridgland and Harding 1985; Bridgland 1994). In October 1995, the site was once more reopened for an excursion visit by the Quaternary Research Association and three new sections were cut. Bulk samples were collected by the author from exposures of unoxidised brickearth, thought to be the equivalent of the fossiliferous West Thurrock brickearth described by Whitaker (1889) and Abbott (1890) (see Figure 6.15). These samples have to date yielded a single mouse incisor (the first record of a small mammal from the site) and a new molluscan assemblage for the site (see below; Harding et al. in prep.).

Differences between the faunal and archaeological assemblages from West Thurrock and the neighbouring sites of Grays (5.2) and Little Thurrock were recognised by early workers such as Hinton (1910b), Kennard (1916) and Warren (1923a), who concluded that the former were significantly younger. However, palynological studies have failed to differentiate between them, and both have been ascribed to the Ipswichian Interglacial (West 1969; Carreck 1972; Hollin 1977; Gibbard et al. 1988; Gibbard 1994; Gibbard, in Bridgland 1994). Most recently, the West Thurrock interglacial sediments have been attributed to OIS 7, primarily on the basis of their position within the Lower Thames terrace sequence (Bridgland and Harding 1994, 1995). There is strong palaeontological support for this correlation, as the mammalian evidence outlined below will demonstrate.

6.4.3. Geological background and provenance of mammalian remains

The West Thurrock sequence has been exposed at a number of different locations, several of which have yielded mammalian remains. Whitaker (1889) recorded the following beds, resting against a buried Chalk cliff at Gibb’s Chalk Quarry, London Road, south of West Thurrock:
4. Irregular gravelly soil
3. Bedded sand with loam, over 15ft
2. Rubbly chalk
1. Chalk with flints

Hinton and Kennard (1900) noted bones of *Bos primigenius*, rhinoceros and elephant from this section, presumably from unit 3. Similar sections of brickearth banked against a buried Chalk cliff were described by Hinton (1901) at the Thames Works Quarry, 800m north-east of West Thurrock. Remains of *Mammuthus primigenius*, *Bos* and *Equus* were obtained from the brickearths.

Abbott’s (1890) section at the Tunnel Cement Works Quarry consisted of:

7. Mixed stony clay and loam, contorted by periglacial action. Large flints present, aligned along the curves of the contortions, 10ft (3m)
6. Coarse, subangular gravel in a light sandy matrix, contorting underlying Bed E and at 80 yards from the cliff, truncating it. Crushed flints and compressed sands and clays observed above and below the contact, up to 18 inches (0.45m)
5: Calcareous clay, impersistent, containing mammalian and molluscan remains, up to 5ft (1.5m)
4: Fine sand, without current-bedding, becoming rather marly towards the top, up to 35ft (10.5m)
3': Clay lenticle, thinning for over 600 yards (540m), containing mammalian remains, up to 3ft (0.9m)
3: Light brownish-grey sand, very current-bedded in the lower part, passing into clay or silt, containing mammalian remains, over 30ft (9m)
2: Sandy gravel near base of cliff, containing well-rounded pebbles of flint, with abundant quartz, jasper, quartzites, lydianstone and chert and a few volcanic and metamorphic rocks. The gravel visibly coarsened and became more ‘obliquely-bedded’ away from the cliff, base not seen (floor of the pit 10ft (3m) O.D.)
1: Buried Chalk cliff to the north, exceeding 50ft (15m) in height.
Abbott collected mammalian remains from Beds 3 and 3', including part of an elephant skeleton from the former. At the top of 3', he noted a layer several metres long and up to 25cm thick of crushed ivory.

The Lion Pit tramway cutting was first re-excavated and described by Hollin (1977), who recorded a Chalk cliff rising from 6 to 16m O.D. and apparently sinking below ordnance datum beneath the terrace deposits to the south. Near the cliff, the terrace deposits comprised 9m of sand, overlain by 2m of brickearth containing molluscs and ostracods, and finally by an upper sand to an elevation of 15m O.D. These deposits were seen to rise towards the cliff, with the entire section capped by colluvial deposits (‘trail’) (Hollin 1977).

In 1983/4, a new road cutting (TQ 590780) 0.9km to the west of the tramway cutting provided similar sections banked against Chalk on the southern side of the Purfleet Anticline. The deposits comprised a massive bed of sand, that was proved from 6.5m O.D. (the road surface) to 7.9m O.D., where it was overlain by c.2.5m of grey silty clay (brickearth), its upper two-thirds oxidised to brown. Above the brickearth was a further sand bed, which was in turn overlain by gravelly, clayey sand of probable colluvial origin (Bridgland 1994) (Figure 6.14). The unoxidised part of the brickearth yielded pollen spectra of Ipswichian affinities (Gibbard, in Bridgland ibid). To the south, the deposits were unconformably overlain by a well-bedded medium to coarse sandy gravel, ascribed to the Mucking Gravel.
Figure 6.14 Section through the deposits of the Mucking Formation seen in a road cutting in 1983-4 (from Bridgland 1994).

The Lion Pit tramway cutting was subsequently re-investigated by Bridgland and Harding (1994, 1995), who opened three sections, the first located at the site of the fossil cliff (Figure 6.15, Section 1) and the remaining two immediately to the south (Figure 6.15, Sections 2 and 3). Section 1 was in the area of Warren’s working floor, at the northern limit of the Pleistocene deposits, where they abut the old river cliff. Up to 12m of well-bedded Pleistocene sediments were revealed, overlying a surface eroded in Coombe Rock, which slopes progressively southwards but appears to level off towards the south, where it is broken up by scour features and/or solution hollows. Four separate lobes of Coombe Rock project from this sloping surface and are interbedded with the waterlain sediments (Bridgland and Harding 1994).
Figure 6.15 Plan of the Lion Pit tramway cutting, showing the relative positions of the GCR and QRA sections (modified from Bridgland and Harding 1995).

The sequence overlying the Coombe Rock in Section 1 is summarised as follows (from Bridgland and Harding 1994):

6. Overburden: unbedded gravelly, clayey sand
(5. Upper gravel (present in Sections 2 and 3 only), up to 3m)
4. Upper sand. Interbedded fine sands and silts, including cross-stratified and ripple-laminated horizons, 2m
3. Silty clay (brickearth), unbedded and oxidised, 0.5m
2. Lower sand. Coarse at base, becoming silty and clayey in higher levels (possibly matrix introduced from Bed 3 above), with pebble ‘stringers’. This unit is horizontally-bedded throughout. The upper 1m forms a distinctive clay-enriched unit, capped with a pebbly layer 0.2m thick.
1. Basal gravel, containing large, scarcely-abraded flint nodules, together with smaller gravel clasts in a sand matrix. This bed is divided in two by a seam of horizontally-bedded sand, showing deformation structures. A large amount of worked flint (some refitting), including characteristic Levallois artefacts, has come from this horizon.

Base: Coombe Rock (junction with Chalk not seen).
The thick sequence of sands, silts and clays extends from 2m O.D. to just over 13m O.D. In 1995, a further three sections were cut (Figure 6.15, Sections 4, 5 and 6), revealing further exposures of brickearth above sand (Figure 6.16).

Figure 6.16 Section through the Lion Pit tramway cutting, showing the relations of the various deposits in Sections 1-6 (modified from Bridgland and Harding 1995).

The stratigraphic position of the West Thurrock interglacial deposits in relation to the Lower Thames terrace sequence is of considerable significance. They lie beneath a gravel that has been mapped as part of the ‘Floodplain (Mucking) Gravel’, but which Gibbard (1994) identified as a separate ‘West Thurrock Gravel’. Gibbard assigned the ‘West Thurrock Gravel’ to the Devensian, based upon its superposition above the West Thurrock interglacial sediments, which he attributed to the Ipswichian. This interpretation is not supported by Bridgland (1994), who assigned the West Thurrock interglacial deposits to Stage 7 and the upper gravel in the Lion Pit tramway cutting to the Mucking Upper Gravel, equated with OIS 6 (see Figure 2.8).

6.4.4. Palaeontology

The following species list has been compiled from material formerly in the Wellcome Institute and now curated in the Natural History Museum, London. Ten mammalian species have been confirmed in the present study. The presence of early hominds, as attested to by the Levallois working floor in the tramway cutting, is restricted to the pre-
interglacial cold episode. Carreck (1976) did not list *Equus ferus* or *S. kirchbergensis*, both of which were recorded by Abbott (1890). The presence of both of these species has now been confirmed and 3 other previously unpublished species added to the species list: *Apodemus* sp. (indeterminate mouse), cf. *Vulpes vulpes* (fox) and *Ursus* cf. *arcos* (brown bear). The record of *Hippopotamus amphibius* (Abbott ibid) was most probably based upon a misidentification, since no example of this species has been found in the collections. A record of *Megaloceros giganteus* (Abbott ibid) could also not be verified. 71 specimens were examined.

Species List (Mammalia) from interglacial deposits at West Thurrock, Essex.

**Rodentia**

*Apodemus* sp., indet. mouse*

**Carnivora**

? *Vulpes vulpes* L., red fox

*Ursus* cf. *arctos* L., brown bear

**Proboscidea**

*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant

*Mammuthus primigenius* (Blumenbach), woolly mammoth

Elephantidae sp., indet. elephant

**Perissodactyla**

*Equus ferus* Boddaert, horse

*Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros

*Stephanorhinus kirchbergensis* (Jäger), Merck’s rhinoceros

**Artiodactyla**

*Cervus elaphus* L., red deer

*Bos primigenius* Bojanus, aurochs

*Bison priscus* Bojanus, bison

Bovidae sp., indet. large bovid (*Bos* or *Bison*)

* new species collected by the author
Table 6.5 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apodemus sp.</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. V. vulpes</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>U. cf. arctos</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>24</td>
<td>33.8</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>3</td>
<td>4.22</td>
<td>1</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>S. hemitoechus</td>
<td>6</td>
<td>8.45</td>
<td>2</td>
</tr>
<tr>
<td>S. kirchbergensis</td>
<td>4</td>
<td>5.63</td>
<td>2</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. elaphus</td>
<td>2</td>
<td>2.81</td>
<td>1</td>
</tr>
<tr>
<td>B. primigenius</td>
<td>16</td>
<td>22.53</td>
<td>1</td>
</tr>
<tr>
<td>B. priscus</td>
<td>1</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>10</td>
<td>14.08</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6.5 Breakdown of the mammalian species list from West Thurrock, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.4.5. Palaeoenvironmental and palaeoclimatic interpretation

The presence of Apodemus sp., U. arctos, P. antiquus and S. kirchbergensis suggest the presence of nearby deciduous or mixed woodland, although by far the most important habitat appears to be open grassland. This is attested to by the presence of large grazing or semi-grazing herbivores, such as M. primigenius, S. hemitoechus, C. elaphus, E. ferus, B. priscus and B. primigenius, which make up nearly 85% of the assemblage. Fully interglacial conditions are indicated.

New samples of the brick-earth collected by the author from Section 5 in September 1995 yielded a molluscan fauna, including Bithynia tentaculata, Lymnaea peregra, Planorbis sp., Gyraulus albus, Valvata piscinalis, Sphaerium sp., Pisidium amnicum,
Pisidium casertanum, Pisidium moitessierianum, Pisidium cf. subtruncatum (R.C. Preece pers. comm.). Of these, the last 5 are new records for the site. Anodonta, Hippeutis complanatus, Lymnaea truncatula and Pupilla muscorum were also listed by Woodward (1890), Carreck (1972) and Hollin (1977). These species indicate the presence of slowly-moving fresh water with adjacent grassland/and or marshy habitats. Possible fragments of Corbicula have also been identified in the assemblage (R.C. Preece pers. comm.), although further specimens are required to make a firm identification.

6.4.6. Biostratigraphy and correlation

The West Thurrock mammalian assemblage was attributed to the Ipswichian interglacial by Carreck (1972, 1976) on the basis of its similarity to Ilford (6.2) (assigned to the Ipswichian on palaeobotanical grounds by West et al. 1964) and Crayford (6.18) (then also considered to be Ipswichian in age e.g. by Stuart 1976). More recently, this correlation has been endorsed by Gibbard (1994, 1995b), on the basis of further palynological analyses. However, re-examination of the mammalian evidence in the present study strongly supports the attribution of the West Thurrock interglacial deposits to Stage 7 by Bridgland (1994), on the basis of the presence of the diagnostic temperate 'Mammuthus-Equus' assemblage.

Mammalian studies

The West Thurrock Elephantidae are dominated by remains of Mammuthus primigenius (85% of the elephant specimens), compared with only 3.5% for Palaeoloxodon antiquus. This conforms perfectly with the characters established for the Stage 7 fauna, illustrated at sites such as Ilford (Uphall Pit) (6.2), where M. primigenius is always more abundant than P. antiquus. The co-existence of these two species and their relative abundances is considered an important diagnostic feature of the Stage 7 interglacial. An important biostratigraphic feature of the West Thurrock woolly mammoths is that their molars are of small size, with a relatively low plate count. They therefore fall within the range established for the 'Ilford type', a primitive form that is characteristic of the Stage 7 interglacial.
The presence of *Stephanorhinus kirchbergensis* at West Thurrock is also extremely significant, since this species is unknown from deposits of Ipswichian age (Stuart 1976, 1982). The occurrence of this species has also been unequivocally verified in the present study at Ilford (6.2) (*contra* Stuart 1976) and Crayford (6.18), thereby confirming a pre-Ipswichian age for these deposits and demonstrating that *S. kirchbergensis* was a regular component of the Stage 7 interglacial. As illustrated at Ilford, *S. kirchbergensis* occurred in much smaller numbers than *S. hemitoechus* in Substage 7a deposits, reflecting the predominance of open grassland conditions over forest habitats at that time.

Other important elements of the West Thurrock assemblage include *E. ferus, Bos primigenius* and *Bison priscus*, which are comparable in size to the large forms found at Ilford (see 6.2). Notable absences from the West Thurrock assemblage include *Dama dama* and *Hippopotamus amphibius*.

The occurrence of Levallois artefacts at West Thurrock is also important in demonstrating a pre-Ipswichian age for the site, since there is no evidence for human presence in Britain during any part of the Last Interglacial. The appearance of the Levallois technique has been cited as a stratigraphic marker in the Thames Valley (Bridgland and Harding 1994, 1995; Bridgland 1996). Its appearance in the Lion Pit tramway cutting in the Mucking Lower Gravel suggests a Stage 8 date for these deposits (see also Botany Pit, Purfleet (5.1)).

**Palynological studies**

The West Thurrock brickearths have been ascribed to the Ipswichian Interglacial (West 1969; Carreck 1972; Hollin 1977; Gibbard *et al.* 1988; Gibbard 1994, 1995b; Gibbard, in Bridgland 1994)

**6.4.7. Discussion and conclusions**

Despite the attribution of the West Thurrock temperate-climate deposits to the Ipswichian Interglacial on the basis of palynological evidence, it is concluded here that correlation with the earlier Stage 7 interglacial is more appropriate. This is based upon
the evidence from terrace stratigraphy, which considers the interglacial sediments to be part of the Mucking Formation (Bridgland 1994), and the extremely close resemblance of the mammal fauna (a characteristic *Mammuthus-Equus* assemblage) to that from the upper part of the Stage 7 'type sequence' at Aveley (6.1). Important indicator species include the 'Ilford type' mammoth, in conjunction with *P. antiquus*, *E. ferus*, *S. hemitoechus*, *C. elaphus* and large bovids. The presence of *S. kirchbergensis* is also critical, since this species is unknown from Ipswichian deposits. A pre-Ipswichian age is also indicated by the presence of humans, as witnessed by Levallois artefacts, in deposits pre-dating the main interglacial. Correlation with Substage 7a is therefore suggested. Amino acid analyses on Mollusca collected by the author in 1995 are currently being undertaken.
6.5. THE EBBSFLEET VALLEY, NORTHFLEET (BAKER'S HOLE), KENT (TQ 615735)

6.5.1. Location of the site

The Ebbsfleet is a small tributary stream that joins the Thames from the south at Northfleet, immediately to the west of Gravesend (Figure 6.17). The various sites that made up this famous Levalloisian locality lay on a spur of land between two arms of the valley, but are now only points in space near the Northfleet Sewage Works, the deposits having been almost completely quarried away (Wymer 1968). The varied nomenclature applied to the sites investigated by different workers, together with the progressive expansion of quarries in the Ebbsfleet valley, has resulted in confusion over who investigated what and where (Wenban-Smith 1995). R.A. Smith's excavations took place in the Southfleet Pit, which was confusingly referred to by some collectors as 'New Barn Pit' or 'Baker's Hole', even though the real Baker's Hole was originally an archaeologically sterile quarry, some 500m to the west of Smith's site. However, the name Baker's Hole stuck and has since been applied not just to Smith's site but also to those investigated by others, thereby giving the misplaced sense that they are all one and the same site, when in fact they are separated by several hundred metres and comprise completely unconnected Pleistocene sequences (Wenban-Smith *ibid*).

The separate quarries in the Ebbsfleet valley have now merged into two (mostly landfilled), one to the north of the footpath between Northfleet and Swanscombe (known as Bevan's Pit) and one to the south (new Baker's Hole, incorporating Barracks Pit and Southfleet Pit, together with the original Baker's Hole). All of the Pleistocene sites known in the Ebbsfleet valley are contained within the new Baker's Hole, including Kerney and Sieveking's Northfleet site, Burchell's Ebbsfleet Channel site and Smith's Southfleet Pit ('Baker's Hole') (Wenban-Smith *ibid*) (see Figure 6.18).
6.5.2. History of research

The Baker's Hole Complex was the most prolific Levalloisian site in Britain, producing an estimated 100,000 flakes and implements (Dewey 1932). The first published report of the site was by Spurrell, who collected large quantities of flint artefacts (including classic Levallois cores) and fauna, including mammoth, rhinoceros, horse, deer and bison, from "a kind of beach" in a tramway cutting (Spurrell 1883a, 102, 1883b) (Figure 6.18). Spurrell did not identify any distinct stratigraphic units, making it difficult to provenance his finds. Between 1909 and 1910, systematic excavations were undertaken on behalf of the British Museum, under the direction of R.A. Smith, during which both mammalian remains and artefacts were recovered from a deposit of chalk and flint.
rubble (‘Coombe Rock’) in the north-west corner of the Associated Portland Cement Company’s Southfleet Pit (Smith 1911) (Figure 6.18), subsequently and erroneously known as Baker’s Hole.

Figure 6.18 Plan of the surviving remnants of the Baker’s Hole Complex, Northfleet and locations of previous investigations (contours are pre-quarrying)
(from Wenban-Smith 1995).

The Coombe Rock was interpreted by Reid (in Smith, 1911) as a solifluction deposit, formed under the periglacial conditions that followed the interglacial represented at Swanscombe. The mammalian remains included teeth of woolly mammoth and narrow-nosed rhinoceros, although the majority were in a fragmentary and poorly-preserved
condition (Smith *ibid*). The similarity of Smith’s and Spurrell’s faunal and lithic collections suggest that they were investigating the same deposit, some 150m apart (Wenban-Smith 1995). A description of the Southfleet Pit deposits and their contained archaeology was also provided by Abbott (1911).

Further accounts of the Southfleet Pit exposures were published by Dewey (1930, 1932), who described “a working floor...lying under masses of unassorted chalk and flint rubble” (Dewey 1930, 148) and observed gravel and sand-filled channels cut into the upper surface of the Coombe Rock, in which mammoth tusks occurred (Figure 6.19). In the 1930s, extensive studies of the deposits were carried out by J.P.T. Burchell, to the west of Smith’s Southfleet Pit site. Burchell also made substantial collections of lithics and fauna, although the precise location of many of his trenches is unknown. However, the area of his main site, containing the ‘Temperate Bed’, was identified by Carreck (1972) and is now scheduled as an Ancient Monument (Figure 6.18, Site B). On the basis of molluscan remains, Burchell (1935b, 1957) concluded that his ‘Temperate Bed’ was a fluvial deposit, laid down during an interglacial period, thereby providing evidence of at least one return to warm/interglacial conditions following the deposition of Smith’s Coombe Rock.

In the 1950s and 1960s, investigations were continued at Burchell’s main site by Carreck, who also opened two new sections, the first opposite the north side of the main site (Figure 6.18, Site F) and the second 300m to the north-west, located beneath the Northfleet Allotments and first identified by A.T. Marston (Figure 6.18, Site A). Above the Coombe Rock, Carreck identified a series of gravels and loams, which he interpreted as a temperate-climate fluvial aggradation (Carreck 1972). An extensive faunal assemblage was collected from Carreck’s Horizon VI, including red deer, lion, wolf, woolly mammoth, horse and molluscs (Carreck *ibid*). During the late 1960s and the 1970s, Burchell’s main site and Marston’s Northfleet Allotments site became the focus for new excavations by the British Museum. Large quantities of lithics and faunal remains were recovered and it was concluded that the Temperate Bed of site B and Horizon VI of site A were of Ipswichian age (Kerney and Sieveking 1977). Kerney and Sieveking (*ibid*) interpreted the material from their Site A as the remains of a specialised Palaeolithic hide-working area, on the basis of supposed faunal ‘artefacts’ and polished flint nodules. This idea has since been rejected, following re-interpretation of the
faunal material as naturally broken (A.P. Currant in Wenban-Smith 1995) and the flint nodules as naturally polished (Wenban-Smith *ibid*).

Summaries of these excavations and the archaeology were provided by Wymer (1968) and Roe (1981). The most recent excavations were carried out by F. Wenban-Smith, who re-investigated Sites A, B, D and E between 1990 and 1994. Lithic, mammalian and molluscan assemblages were recovered (Wenban-Smith 1995).

### 6.5.3. Geological background and provenance of mammalian remains

The Pleistocene deposits in the Ebbsfleet valley overlie a sloping bench, decending from 12m to 3m O.D. and cut into the Coombe Rock and underlying Chalk. This bench is locally covered by 3-6m of brickearth, with underlying gravel filled channels, but in places, the Coombe Rock has been eroded and the later deposits are banked against it, resting on solid Chalk as low as 3m O.D. The surface of the deposits rises to approximately 23m O.D. (Dewey 1930, 1932; Wymer 1968).

![Diagram of the geological section](image)

Figure 6.19 Section at the original Baker’s Hole site (N. Davey, after Dewey 1930).
The stratigraphical sequence presented below is that described in Bridgland (1994), based on a summary of observations made over a long period by numerous workers, including Burchell (1933, 1935a, b, 1936a, b, c, 1954, 1957), Boswell (1940), Zeuner (1945, 1946, 1954) and Kerney and Sieveking (1977). All that now remain of Burchell's Ebbsfleet valley locality are two residual islands of deposits (Figure 6.18, Sites B and C) and a NNW-SSE trending face (Site A). No indications of thickness of the various beds are given, due to variability in different parts of the channel.

12. 'Trail' (as Bed 9, formerly undifferentiated from 9).
11. Sandy 'fluvial brickearth'.
10. 'Cailloutis' (thin gravel bed), yielding Levallois artefacts.
9. 'Trail', gravelly 'loam' with rafts of Coombe Rock. Published descriptions and illustrations suggest that this bed (and possibly Bed 7) were cryoturbated.
8. Silt, (aeolian/colluvial 'brickearth'), decalcified in the upper part with bands of ferruginous staining near the top and the open ground indicator, *Pupilla muscorum*, in the lower part.
7. Upper Coombe Rock, with derived artefacts and terrestrial Mollusca.
6. Freshwater, fossiliferous silt, containing 40 species of terrestrial, marsh and freshwater molluscs, including *Corbicula fluminalis*, together with vertebrate remains.
5a. Buried soil, developed in the top of Bed 5. This intensely-rubified weathering horizon was first recognised by Zeuner (1945, 1955), who considered it to be indicative of an interglacial climate. Catt (1979), however, observed that the reddened horizon contains less illuvial clay than would be expected in an interglacial soil, an observation supported by Kemp (1991, 1995), who considered that the surviving material represents only the basal part of a truncated soil profile.
5. Silt (brickearth), interbedded with numerous minor lobes of 'Coombe Rock' and/or gravel. This bed contains open ground and marsh molluscs, small vertebrates (Carreck 1972) and large mammal remains. A total thickness of over 6m is indicated. Records of sections excavated by the British Museum (in Bridgland 1994) suggest aqueous bedding and suggest interdigitation with (or incision through) Beds 2 and 4.
4. Gravel, with remains of *Coelodonta antiquitatis*, *Mammuthus primigenius* and *Equus ferus*, together with artefacts (concentrated in Bed 4a ?). Separation from Bed 2 is unclear in the absence of Bed 3, all evidence of which has been removed by quarrying. Reworked Palaeogene shells and flint pebbles occur in this bed (Carreck 1972).
4a. Palaeolithic horizon at the base of Bed 4, with a mixture of handaxes, cores and flakes (including Levallois flakes and cores), fresh and unpatinated. Remains of *M. primigenius*, *C. antiquitatis* and *E. ferus* were also recovered from this bed, together with small mammals (Burchell 1935a, 1936a).

3. Sand, containing mollusc, small vertebrate remains (*Arvicola, Microtus* sp. and *Clethrionomys glareolus*) and *Megaloceros giganteus* (Burchell 1936a; Carreck 1972).

2. Coarse gravel, cryoturbated into or filling scour/solution hollows in the top of Bed 1. Built up to more than 2m at the edge of the channel, where it is interbedded with lenses of Coombe Rock and appears to interdigitate with the lower part of Bed 5.

1. Main Coombe Rock deposit. The working floor at Baker’s Hole (Smith’s Southfleet Pit site) was at the base of this deposit.

Base: Frost-shattered Chalk.

Figure 6.20 Section excavated at Northfleet (from Bridgland 1994, after Kerney and Sieveking 1977). This is believed to coincide with Burchell’s main ‘Ebbsfleet Channel’ section. Numbers refer to the description in the text.
Burchell (1936a) demonstrated that the channel had been eroded prior to the deposition of the basal Coombe Rock (Bed 1). The Coombe Rock occupied the channel, prior to being largely removed by erosion and its denuded remnant covered by coarse gravel (Bed 2). This gravel was overlain in turn by a fossiliferous sand (Bed 3) and then an implementiferous gravel (Bed 4). Beds 2-4 were interpreted by Burchell and Zeuner as fluviatile, although this was disputed by Kerney and Sieveking (1977), who attributed them to solifluction. Kerney and Sieveking's section (Figure 6.20) shows the edge of a channel cut into frost-shattered and soliflucted Chalk, filled with a lag gravel and then overlain by fluviatile silts, which interdigitate with further lobes of gravel and Coombe Rock near the sides of the channel. Following widening of the channel, a second, more widespread gravel lag was deposited in its deepest part (possibly Burchell's Bed 4). However, in the absence of the intervening fossiliferous Bed 3, it is impossible to distinguish Beds 2 and 4 from a succession of gravels that interdigitate with the silt of Bed 5 (Bridgland 1994).

The upper part of the sequence (the brickearth of Bed 5 and above) was deposited over a wider area than the Lower Channel deposits. Artefacts were obtained by Burchell (1933) from these deposits, although it is difficult to relate these finds to the beds now recognised. The particle-size distribution and mineralogical characteristics of the brickearth suggest that it is predominantly of loessic origin, although with the addition of sand and gravel (Catt and Weir, in Bridgland 1994). A higher spread of Coombe Rock (Bed 7) was also noted by Burchell (1935a), containing derived artefacts. The recognition of this and other subordinate beds of Coombe Rock within the upper loessic (fluvially redeposited?) sequence led to the widespread use of the term 'Main Coombe Rock' to describe Bed 1. Burchell (1936c) recorded an additional fluviatile cycle at the top of the sequence, within what was formerly described as 'trail' (Beds 10-12), although these were not recognised by Zeuner (1945, 1946, 1954, 1959).

The complex sequence of deposits has been previously correlated with a wide range of sites of varying ages. Reid (in Smith 1911) compared the Coombe Rock exposures at Northfleet to those on the Sussex coast, although he considered the presence of S. hemitoechus at the former locality to be incongruous, since C. antiquitatis is present in the latter. Smith (ibid) therefore suggested that the single tooth, on which the identification of S. hemitoechus was based, was probably derived from an earlier
deposit. In the light of further finds of this species at Northfleet (13 specimens seen by the author in the Natural History Museum, London) and the confirmed co-existence of *S. hemitoechus* and *C. antiquitatis* at various sites attributed to Stage 7 in the present study (such as Ilford (Uphall Pit) (6.2) and Crayford (6.18)), secondary derivation seems unlikely. The mammalian assemblage from Northfleet was also correlated with those from the ‘Middle Terrace’ of the Thames by Newton (in Smith 1911) and Bromehead (in Dewey et al. 1924), who considered that Bed 1 at Northfleet had been deposited during the period of erosion that followed deposition of the ‘Middle (Taplow) Terrace’.

Burchell (1931), Dewey (1932) and Breuil (in Sandford 1932) correlated the cold period indicated by the Main Coombe Rock with the second of the two East Anglian glaciations recognised at that time, which would seem to imply a Saalian age. Breuil (*ibid*) correctly interpreted the Northfleet artefacts as ‘early Levallois’ and suggested that the deposits were earlier than, or contemporary with, the nearby Crayford sediments (now ascribed to the late Saalian Mucking Formation by Bridgland 1994, see 6.18). Burchell (1933, 1957) disputed Bromehead’s interpretation of the Main Coombe Rock as a post-Taplow Terrace accumulation, arguing that Coombe Rock had never been found to overlie that terrace. Instead, he proposed that the gravels and brickearths cut into the Main Coombe Rock were of probable ‘Taplow’ age and likened the Northfleet sequence to comparable sequences both at Crayford and in the Grays area (almost certainly the sediments at West Thurrock, see 6.4).

King and Oakley (1936) also assigned the Main Coombe Rock to the Saalian stage, whereas Zeuner (1945) proposed correlation of the fluvial temperate-climate aggradation with both his Main and Late Monastirian sea levels, at 150 000 years B.P. and 125 000 years B.P. respectively. He attributed both high-sea level phases to the ‘last interglacial’, although the dating of his Main Monastirian would now be considered to fall within Stage 6. Oakley and King (1945) later revised their attribution of the Main Coombe Rock to the Saalian, on the basis of artefact typology. They considered artefacts from the working floor at the base of the sequence to be of ‘late Levalloisian’ affinities and consequently suggested that the overlying Coombe Rock was of post-Saalian age. A Saalian age was nevertheless upheld by Breuil (1947) and Tester (1958).
Kerney and Sieveking (1977) on the other hand, attributed the temperate sediments at Northfleet to the Ipswichian Stage, principally on the basis of their elevation.

Most recently, some interpretations have swung back in favour of a pre-Ipswichian age for the Northfleet interglacial. Although the Northfleet deposits occur in a tributary valley (and steeper gradients might therefore be expected), the elevation of the waterlain sediments, between 7.5m and 12m O.D. suggests an association with the Taplow/Mucking Formation of the Lower Thames (Bridgland 1994). This interpretation would therefore imply correlation of the temperate-climate beds at Northfleet with the interglacial deposits contained within the Mucking Formation, such as at Aveley (6.1) and West Thurrock (6.4). Although regarded as Ipswichian by many previous authors, these deposits have been correlated with Stage 7 of the oxygen isotope record in the present study. The underlying fluviatile and aeolian beds at Northfleet would consequently be ascribed to Stage 8, whereas the sediments above the temperate-climate silt probably date from Stage 6. An Ipswichian age for the temperate deposits is however, favoured by Gibbard (1994, 1995b), despite the fact that no pollen spectra have been recovered. A Wolstonian age is therefore inferred by Gibbard (ibid) for the deposits pre-dating the interglacial and a Devensian age for those that post-date it.

6.5.4. Palaeontology

The following species list has been compiled from specimens in the British Geological Museum, Keyworth, Dartford Museum, Ipswich Museum and the Natural History Museum, London. Material collected during the most recent excavations by Wenban-Smith was not available for analysis during the present study, although any additional species listed (Wenban-Smith 1995) have been added to the list below. The presence of 11 species was confirmed by the present study, to which may be added 7 small mammal species listed by Wenban-Smith (ibid), Crocuta crocuta (identified on the basis of gnawed bone by Carreck 1972) and Homo (on the basis of artefacts). The final list therefore comprises 20 species. Because of the unavailability of material from the most recent excavations (Wenban-Smith 1995), it was not possible to provide a breakdown of the mammalian species list showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals, since any such list would be incomplete.
Species List (Mammalia) from the interglacial beds at Northfleet, Kent

**Insectivora**
*Neomys* sp., indet. water shrew†

**Primates**
*Homo* sp., indet. hominin (artefacts)

**Lagomorpha**
*Lepus* sp., indet. hare†

**Rodentia**
*Lemmus lemmus* (L.), Norway lemming†
*Clethrionomys glareolus* (Schreber), bank vole†
*Arvicola terrestris cantiana* (Hinton), water vole†
*Microtus agrestis* (L.), field vole†
*Microtus agrestis* (L.)/*Microtus arvalis* (Pallas), field or common vole†
*Microtus oeconomus* (Pallas), northern vole†
*Microtus* sp., indet. vole

**Carnivora**
*Canis lupus* L., wolf
*Crocuta crocuta* Erxleben, spotted hyaena*
*Panthera leo* (L.), lion

**Proboscidea**
*Palaeoloxodon antiquus* Falconer and Cautley, straight-tusked elephant
*Mammuthus primigenius* (Blumenbach), woolly mammoth
Elephantidae sp., indet. elephant

**Artiodactyla**
*Equus ferus* Boddaert, horse
*Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros
*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros
Rhinocerotidae sp., indet. rhinoceros

**Bovidae**
*Megaceros giganteus* (Blumenbach), giant deer
*Cervus elaphus* L., red deer
Bovidae sp., indet. large bovid (*Bos or Bison*)
6.5.5. Palaeoenvironmental and palaeoclimatic interpretation

A single record of *Coelodonta antiquitatis* from the Main Coombe Rock deposits at the base of the sequence (Bed 1) (Wenban-Smith 1995) suggests that open conditions prevailed at that time. Although this species has been recovered from fully interglacial contexts, for example in the Lower Brickearth at Crayford (6.18), its occurrence in frost-shattered, mass-movement Coombe Rock deposits indicates that prevailing conditions were cold and open, as opposed to temperate and open. The occurrence of *in situ* artefacts below Bed 1 also indicates the presence of humans at this time.

The fluvial gravel overlying the Main Coombe Rock deposits (Beds 3 and 4) contains evidence of a temperate climate at the time of deposition, in the form of *Neomys* sp. and *Bithynia tentaculata* (Wenban-Smith 1995). Remains of large grazers and grazer-browsers, including *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Stephanorhinus hemitoechus*, *Equus ferus*, *Megaloceros giganteus*, *C. elaphus* and large bovids (Wenban-Smith *ibid*) suggest the presence of open grassland. The small mammal assemblage is dominated by the grassland voles *Microtus oeconomus* and *Microtus agrestis* but the presence of a single specimen of *Clethrionomys glareolus* implies the existence of woodland in the vicinity. Aquatic habitats are indicated by *Neomys* sp. and *Arvicola*. *Lemmus lemmus* is also recorded from this bed (Wenban-Smith *ibid*). Today this species is mainly confined to the Palaearctic tundra and open montane areas, birch and willow scrub (Corbet 1966) but it appears to have had somewhat broader ecological tolerances in the past. Its presence in otherwise ‘temperate’ assemblages at Hoxne (4.1), in the Upper Middle Gravel at Swanscombe (4.2) and at Barnham (4.5) possibly indicates the closing phases of interglacials and the development of more open vegetation.

Molluscan and ostracod remains from the freshwater silts (Beds 5 and 6) suggest that deposition occurred in a marshy swamp, surrounded by open grassland. Nearby shady woodland is also indicated by the presence of *Azeca goodalli*, *Clausilia bidentata* and *Discus rotundatus* at the base of the silts (Burchell 1957; Kerney, in Wenban-Smith
Fully interglacial conditions are indicated by *Corbicula fluminalis* and *A. goodalli* (Burchell 1957; Preece, in Bridgland 1994).

The mammalian assemblage from the silts, listed by Wenban-Smith (*ibid*), offers much the same information, being dominated by *M. primigenius*, *E. ferus* and *C. elaphus*, with smaller numbers of large bovids and *Stephanorhinus hemitoechus*. These large herbivores suggests the proximity of substantial areas open grassland, an inference which is supported by the presence of grassland voles, including *Microtus agrestis* and abundant *Microtus oeconomus*. Possible stands of woodland in the vicinity are also indicated by the tentative identification of a pine grosbeak or parrot cross-bill (Wenban-Smith *ibid*). Aquatic habitats are suggested by a record of *Arvicola* and confirmed by the presence of fish remains, including three-spined, stickleback (*Gasterosteus aculeatus*), Cyprinidae, pike (*Esox lucius*) and eel (*Anguilla anguilla*) (Wenban-Smith *ibid*). The Cyprinidae and their associated predator, the pike, reflect the presence of still or slow-flowing water, with summer water temperatures of at least 18° C (Wheeler 1969). The freshwater silts have also provided an important record of tree frog (*Hyla* sp.). Based upon the present day ranges of European tree frogs, the presence of this species suggests that the climate during this interglacial was slightly warmer than the present day, with mean July temperatures higher than 17-18°C.

Higher up in the sequence in Bed 6, species diversity decreases, woodland elements disappear and the assemblage becomes dominated by *Pupilla muscorum*, indicating the development of open grassland and possibly cooler conditions (Burchell 1957). This is paralleled by an apparent transition from open water conditions at the base to stagnation and drying out at the top (Wenban-Smith *ibid*) and evidence of a zone of weathering at the top of Bed 5 (Kemp 1991). Deposition of the overlying Coombe Rock (Bed 7) indicates a return to cold conditions.
6.5.6. Biostratigraphy and correlation

Mammalian studies

Detailed examination of the Northfleet mammalian assemblage reveals that it contains a distinctive suite of species that is considered to be characteristic of the Stage 7 interglacial in the present study.

Important characteristics of the assemblage include the co-abundance of *Mammuthus primigenius* with *Equus ferus*, a combination that is apparent at a wide range of sites now widely attributed to Stage 7. The mammoth remains from Northfleet are particularly significant because of the presence of individuals of 'Ilford type'. This primitive form is characterised by a combination of small size and relatively low plate count in its teeth, a combination that has been noted as a consistent feature of the mammoths from contemporary sites, including the Uphall Pit at Ilford (6.2), Brundon (6.6), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Crayford (6.18). The occurrence of the 'Ilford type' mammoth is therefore considered to be of biostratigraphic significance in demonstrating a Stage 7 age. However, the presence of 'Ilford type' teeth, apparently derived from the Main Coombe Rock preceding the interglacial, suggests that this small form was already present in Britain in Stage 8 (Wenban-Smith 1995). The co-existence of *Palaeoloxodon antiquus* with *Mammuthus* is also an important diagnostic character of the Stage 7 interglacial, with the former always occurring in smaller numbers than the latter.

The Carnivora from Northfleet are represented by a particularly large form of *Panthera leo* and by *Canis lupus*. This compares well with records from other localities (all of which have been attributed to Stage 7 in the present study), including the upper part of the sequence at Aveley (6.1), Uphall Pit at Ilford (6.2), Stoke Tunnel (6.7), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Crayford (6.18), where lion remains are also of significantly large size. The presence of *Crocuta crocuta* has been inferred on the basis of a gnawed bone (Carreck 1972) but is also consistent with a Stage 7 age, having been recovered from Stanton Harcourt, Hutton Cave (6.23), Oreston (6.24) and Crayford. Unlike the Ipswichian Interglacial, when this species was
comparatively abundant, Stage 7 interglacial deposits have yielded only limited numbers.

Stuart (in Sutcliffe and Kowalski 1976) noted that the remains of *Arvicola* were of primitive type, thereby implying a pre-Ipswichian age. This would appear to lend support to a pre-Ipswichian age, although these remains could unfortunately not be traced during the present study. The presence of *Microtus oeconomus* is also significant, since this species apparently became abundant during the Stage 7 interglacial, to the virtual exclusion of other species of *Microtus*. Analysis of first lower molars of this species from a range of sites during the present study has demonstrated a progressive increase in size through time, culminating in a particularly large form in Stage 6 (see Chapter 3, Figure 3.24). Although the *M. oeconomus* remains collected during the recent excavations at Northfleet (Wenban-Smith 1995) were not available for analysis, it is possible to predict that these specimens would be of comparable size to those measured from the Lower Channel at Marsworth (6.10) and Crayford (6.18), averaging between 2.8 and 2.9mm in length. A range of occlusal morphologies within these molars would also be expected in specimens of this age (see Chapter 3).

The rhinoceroses at Northfleet are represented by *Stephanorhinus hemitoechus* and *Coelodonta antiquitatis* (Figure 3.47). The presence of this latter species is extremely significant, since it is unknown from any other interglacial in Britain. *C. antiquitatis* appears to have become relatively widespread during the Stage 7 interglacial in response to the development of steppe-grassland conditions, and is recorded from Ilford (Uphall Pit) (6.2), Crayford (6.18) and Oreston (6.24). Other important elements of the Northfleet fauna include a large form of *Cervus elaphus* and large bovids. These are comparable in size to other large Stage 7 populations, such as from Ilford (Uphall Pit).

Having considered the Northfleet mammalian assemblage as a whole, certain conclusions may be drawn as to the age of the site. Several points make the assemblage difficult to reconcile with an Ipswichian age, such as the presence of *Mammuthus* and *Equus* in Bed 5 (attributed to zones Ip I-IIb by Gibbard 1995b). It is therefore concluded that the mammalian assemblage from Northfleet should be assigned to the earlier Stage 7 interglacial, rather than the Ipswichian, on the basis of a distinctive and diagnostic ‘classic’ *Mammuthus-Equus* assemblage.
Malacological studies

The presence of *Corbicula fluminalis* presents a strong case against correlation of the Northfleet deposits with the Last (Ipswichian) Interglacial (Keen 1990; Meijer and Preece 1995).

6.5.7. Discussion and conclusions

On the evidence presented above, correlation of the temperate deposits at Northfleet with Substage 7a of the Stage 7 interglacial is advocated. This is based on the close resemblance of the temperate-climate mammalian assemblage with similar assemblages from the upper sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2), West Thurrock (6.4) and Crayford (6.18). These assemblages are dominated by *M. primigenius* (including individuals of 'Ilford type'), in association with *E. ferus* and *P. antiquus*. Two other species are also of particular biostratigraphic importance, namely *C. antiquitatis* and *M. oeconomus*. The presence of the former is significant because interglacial occurrences of this species are restricted to Stage 7, while the latter is also a consistent feature of Stage 7 assemblages. In addition, the presence of *L. lemmus* at Northfleet suggests comparison with Crayford, from where this species is also recorded. Other typical features of the ‘mammoth-horse’ fauna that are apparent in the Northfleet assemblage include a large lion, red deer and large bovids.

Mammalian records from Bed 1 at Northfleet (the Main Coombe Rock deposit) include *C. antiquitatis* and *Homo* sp. (the latter on the basis of proto-Levallois artefacts). These are therefore interpreted as being of Stage 8 age, a correlation which compares favourably with the evidence at Botany Pit, Purfleet (5.1) and the Lion Pit tramway cutting (6.4), where proto-Levallois industries are also present in association with cold-climate deposits assigned to Stage 8. A mounting body of evidence from the Lower Thames suggests that the appearance of the Levallois in Britain can now be securely dated to the Stage 8 cold episode (Bridgland 1996). The presence of a fully-developed Levallois industry in the fluvialite gravel of Bed 4 is thus compatible with a Stage 7 age for the temperate-climate deposits. Similar lithic assemblages have been noted from a range of other sites also attributed to Substage 7a in the present study, including
The conclusions of the present study are therefore consistent with correlation of the Northfleet sequence with the Mucking Formation of the Lower Thames, spanning Stages 8-6 (Bridgland 1994, 1995). An Ipswichian age, as proposed by Gibbard (1994, 1995b), is refuted here. Other absolute and relative dating techniques have produced results that either support a Stage 7 correlation for the Northfleet interglacial, or at the very least are not inconsistent with such an attribution. Gibbard (ibid) cited support for an Ipswichian age from thermoluminescence dating, which has produced age-estimates of between 149 200 and 115 600 years B.P. on the Northfleet sediments (Parks and Rendell 1988). However, Parks and Rendell emphasised that, because of the limits of the technique, these should be regarded as minimum age-estimates, thereby not ruling out a pre-Ipswichian age. Amino acid analysis of *Lymnaea peregra* from the freshwater silts (Bed 5) has produced ratios of 0.182 ± 0.021 and 0.169 ± 0.038 (Wenban-Smith 1995). These are consistent with a Stage 7 attribution (Bowen et al. 1989), a conclusion supported by heavy mineral analysis of these sediments, which suggests similarity with pre-Eemian continental loesses (Catt and Weir, in Bridgland 1994).
6.6. JORDAN'S PIT, BRUNDON, BALLINGDON, near SUDBURY, SUFFOLK (TL 863417)

6.6.1. Location of the site

Jordan's Pit is located in a former gravel and brickearth pit on the south bank of the River Stour, adjacent to an old railway cutting and to the south-west of the village of Brundon in the borough of Sudbury, Suffolk (Figure 6.21). The land slopes upwards from the flood-plain of the Stour to the much-dissected till plain at Brundon, which lies at about 61m O.D., approximately 30m above the river (Wymer 1985).

6.6.2. History of research

Pleistocene faunal remains have been known from the numerous large pits at Ballingdon Grove since the 1830s (Boswell 1929). The first published reference is of a 'fossil elephant's tooth' from Ballingdon Hill, which was exhibited at a meeting of the Suffolk Institute of Archaeology at Bury St. Edmunds in 1858 (Wymer 1985). An unspecified site 'by the Windmill' was referred to by Whitaker in the Geological Survey Memoir of 1878 (Whitaker et al. 1878) and Evans (1897) also listed 'worked flints' from gravel, although no specific pit was mentioned. The later Geological Survey Memoir records the presence of stratified gravel at the Brundon pit, although the pit itself was not mentioned by name (Boswell 1929). Elephant remains, discovered in 1922, were reported by Morley (1930) but it was not until about 1930, when the pit was greatly extended by Mr P.H. Jordan, that numerous fossils and flint artefacts came to light. Systematic excavations were subsequently carried out between October 1935 and September 1937 by Moir and Hopwood (1939). Further references to the site are provided by Chatwin (1954) and Wymer (1985). The floor of the pit is now ploughed and cultivated, although parts of Moir's sections are still visible (Wymer ibid).
Figure 6.21 Location map of Jordan's Pit, Brundon (modified from Wymer 1985). Palaeolithic findspots are denoted by black circles, Levallois findspots by black and white circles.
6.6.3. Geological background and provenance of mammalian remains

Studies on the evolution of the River Stour and the relationship of its valley to the Anglian Chalky Boulder Clay suggested that the valley system had existed prior to the advance of ice (Boswell 1914, 1929). Sections in the west side of the pit reveal bedded gravels, banked against coarse gravels and possible till on the side of the valley (Wymer 1985). The section recorded by Moir is as follows (from Moir and Hopwood 1939) (Note: the numbering follows Moir’s scheme):

1. Surface humus, 9 inches (23cm)
2. Unstratified sandy clay, up to 8 ft (2.44m).
2a. Contorted, tumbled gravel, reddish in colour, up to 5ft (1.52m). Interpreted as a solifluction deposit.
3. Yellowish gravel, horizontally-stratified, up to 15ft (4.57m). Interpreted as representing renewed fluvial activity by the River Stour. A manganese-rich palaeo-land surface occurs towards the base of this unit, approximately 1ft (30cm) thick, associated with unworn and unpatinated Levallois artefacts, numerous mammalian remains and freshwater and land mollusca.
4. Grey, compact, unstratified clay with stones, up to 2ft (0.61m), containing temperate freshwater shells, including Corbicula fluminalis (Chatwin 1954).
5. Coarse red gravel, stratified with thin streaks of manganese, up to 3ft (0.91m). Interpreted as a meltwater deposit.
6. Chalky Boulder Clay in patches, up to 4ft (1.22m). Glacial deposit.
7. Stratified chalky, sandy gravel or sand, up to 8ft (2.44m). Glacial deposit.

The probable sequence is shown in Figure 6.22, although in no one place was the entire sequence exposed.
Moir recognised that the Stratum 3, with its contained flint implements and organic remains, was underlain and overlain by glacial deposits and consequently regarded it as interglacial in origin (Moir and Hopwood 1939).

6.6.4. Palaeontology

The following species list has been compiled from the collections of the Natural History Museum, London, Ipswich Museum and the Suffolk Archaeological Unit in Bury St. Edmunds. The collections are primarily the work of J.R. Moir and W.E. Sawyer, with additional specimens collected by J.H. and R.P. Tripp, K.P. Oakley and C.D. Ovey and J. Wymer. In the present study, 276 specimens were examined and the presence of 11 mammalian species was confirmed. To this may be added Homo, on the basis of Levallois artefacts. A new record of Stephanorhinus hemitoechus was established.

Species List (Mammalia) from Brundon, Suffolk

**Primates**

*Homo* sp., indet. hominid (artefacts)

**Carnivora**

*Canis lupus* L., wolf

*Ursus* sp., indet. bear

*Panthera leo* (L.), lion

**Proboscidea**
*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant

*Mammuthus primigenius* (Blumenbach), mammoth

**Perissodactyla**

*Equus ferus* Boddaert, horse

*Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros

Rhinocerotidae sp., indet. rhinoceros

**Artiodactyla**

*Megaloceros giganteus* (Blumenbach), giant deer

*Cervus elaphus* L., red deer

*Bos primigenius* Bojanus, aurochs

*Bison priscus* Bojanus, bison

Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 6.6 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carnivora</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lupus</em></td>
<td>1</td>
<td>0.36</td>
<td>1</td>
</tr>
<tr>
<td><em>U. arctos</em></td>
<td>2</td>
<td>0.72</td>
<td>1</td>
</tr>
<tr>
<td><em>P. leo</em></td>
<td>3</td>
<td>1.08</td>
<td>1</td>
</tr>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. antiquus</em></td>
<td>11</td>
<td>3.98</td>
<td>3 (1 juv., 2 adults)</td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>59</td>
<td>21.37</td>
<td>12 (3 juv., 9 adults)</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
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</tr>
<tr>
<td><em>E. ferus</em></td>
<td>124</td>
<td>44.92</td>
<td>13 (2 juv., 11 adults)</td>
</tr>
<tr>
<td><em>S. hemitoechus</em></td>
<td>6</td>
<td>2.17</td>
<td>1</td>
</tr>
<tr>
<td>Rhinocerotidae sp.</td>
<td>1</td>
<td>0.36</td>
<td>1 juv.</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. giganteus</em></td>
<td>7</td>
<td>2.53</td>
<td>2</td>
</tr>
<tr>
<td><em>C. elaphus</em></td>
<td>22</td>
<td>7.97</td>
<td>5 (1 juv., 4 adults)</td>
</tr>
<tr>
<td><em>B. primigenius</em></td>
<td>17</td>
<td>6.15</td>
<td>3</td>
</tr>
<tr>
<td><em>B. priscus</em></td>
<td>5</td>
<td>1.81</td>
<td>2</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>16</td>
<td>5.79</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6.6 Breakdown of the mammalian species list from Brundon, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.
6.6.5. Palaeoenvironmental and palaeoclimatic interpretation

Hopwood described the Brundon mammalian remains as representing a fauna which "lived on open grassy plains, with wooded areas not very far away" (Moir and Hopwood 1939, 13). The presence of open grassland as the dominant environment is highlighted by the numerous remains of *Equus ferus* (124 out of 276 specimens) and by other species such as *Megaloceros giganteus* (7 specimens) and *Stephanorhinus hemitoechus* (6 specimens). Both the 'Ilford-type' woolly mammoth and *Palaeoloxodon antiquus* have only been found in interglacial episodes in the British Pleistocene. Of the 30 species of non-marine Mollusca identified by Kennard (in Moir and Hopwood op. cit.), 13 are freshwater species and 17 are land snails. Since the land species far outnumbered the freshwater forms, Kennard interpreted the deposit as the result of flooding action by a quick-flowing stream. The molluscan assemblage supports the presence of open grassland with a little scrub vegetation, immediately adjacent to the stream. Marsh land and woodland species are absent. Remains of *Corbicula fluminalis* and *Belgrandia marginata*, which today have a southern European distribution and are unable to adapt to cold winters, confirm the interglacial nature of the deposit.

6.6.6. Biostratigraphy and correlation

Mammalian studies

The Brundon mammalian assemblage has traditionally been assigned to the Ipswichian Interglacial (Stuart 1976, 1982), although this has been challenged in more recent years by Wymer (1985, 1988) and Sutcliffe (1995a), who regarded it as pertaining to a pre-Last Interglacial temperate stage, correlated with Stage 7.

The present study concurs with the latter correlation, based upon the great similarity of the Brundon assemblage to sites such as the upper part of the sequence at Aveley (6.1) and Ilford (Uphall Pit) (6.2). In all respects, the Brundon fauna is typical of the 'mammoth-horse' assemblages that are encountered at sites of Stage 7 age, as will be demonstrated below.

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The Brundon Proboscidea are dominated by *Mammuthus primigenius*, including molars that may be described as being of 'Ilford type', on account of their small size and low plate count. This feature was first noted by Moir and Hopwood (1939). Using plate index measurements (*i.e.* the number of plates which lie in a 10cm length of molar), these authors were also able to show that 90° of the Brundon *M. primigenius* molars had a plate index in excess of 8, compared to 60° for Ilford. This was interpreted as an indication that the Brundon deposits were slightly younger than those at Ilford (6.2), since they contained a greater number of more advanced specimens. The Brundon assemblage also includes *Palaeoloxodon antiquus*, which accounts for 15.3% of the elephant remains. The co-existence of *M. primigenius* and *P. antiquus* is characteristic of the Stage 7 interglacial, with the former exceeding the latter in abundance.

The most commonly encountered mammal at the site is *Equus ferus*, which makes up almost 45° of the assemblage. The Brundon horse is a large caballine form but shows no other particular feature of biostratigraphic importance. Moir and Hopwood (*ibid*) considered the Brundon horse metapodia to be more slender than those from Crayford (6.18) and consequently deemed them to be more recent in age. However, the significance of these findings is questioned here, since Moir and Hopwood themselves acknowledge that other skeletal elements from the Brundon *E. ferus* sample are relatively robust. The slight differences between certain elements from Brundon and Crayford are therefore not considered by the present study to accurately reflect the relative ages of these two localities.

The Brundon Carnivora are represented by a large form of *Panthera leo, Ursus arctos* and *Canis lupus*. Other elements of the Brundon assemblage include abundant large bovids (38 specimens), of which *B. primigenius* is more common than *B. priscus*, moderately abundant *C. elaphus* (22 specimens) and smaller numbers of *M. giganteus* (7 specimens). In terms of both the species represented and their relative abundance, the Brundon assemblage is an extremely close match with the upper part of the sequence at Aveley. Correlation with this site is therefore proposed.
Malacological studies

Kennard (in Moir and Hopwood 1939) compared the molluscan assemblage to that from Ilford (6.2) and Stutton (6.8), sites now considered to be of Stage 7 age (Sutcliffe 1995a). The presence of Corbicula fluminalis is also extremely significant, since this species is unknown from deposits of Last Interglacial age.

6.6.7. Discussion and conclusions

To conclude, the mammalian biostratigraphic evidence strongly suggests that the Brundon interglacial deposits should be correlated with Stage 7 of the oxygen isotope record. This is on the basis of the presence of M. primigenius and E. ferus, neither of which is known from deposits of Ipswichian age. A pre-Last Interglacial age is further supported by C. fluminalis and Homo. The presence of a Levallois industry is also significant, since this technology appears to have first entered Britain during Stage 8 (see 5.1 and 6.4), before becoming more widespread during Stage 7.

The combination at Brundon of the ‘Ilford type’ mammoth and E. ferus, together with P. antiquus, a large form of P. leo and large herbivores, including M. giganteus, C. elaphus, B. primigenius and B. priscus is extremely similar to that from the upper part of the sequence at Aveley (6.1) and Ilford (6.2), both in terms of the species represented and relative abundance. Correlation with the later part of the Stage 7 interglacial, (possibly Substage 7a), is therefore proposed. In addition, the height of the Brundon deposits is comparable to that at Stutton (6.8), a site that is also now widely regarded as being of Stage 7 age. The attribution of a Stage 7 age to the site has also received some support from Uranium series dating of bones, which has resulted in ages of 230 000 ± 30 000 and 174 000 ± 30 000 B.P. (Szabo and Collins 1975). These are slightly older than the Substage 7a correlation proposed here and would fit better with a 7c age. However, the similarity of the Brundon assemblage to that from the upper part of the Aveley sequence clearly indicates that Brundon relates to the later (and not the earlier) part of the Stage 7 interglacial.
6.7. STOKE BONE BED, IPSWICH, SUFFOLK: STOKE TUNNEL (TM 162434), PIPE TRENCH (TM 161433), MAIDENHALL (TM 161429) AND HALIFAX JUNCTION (TM 162429)

6.7.1. Location of the site

In the Stoke area of Ipswich and lying within the loop of the Gipping/Orwell River, a spur of high ground rises to 38m O.D., against which up to 30m of Pleistocene deposits are banked. The main railway line crosses this spur of land in a tunnel, at the southern end of which is located the principal area of interest for mammalian remains, the Stoke Bone Bed, which lies at about 8m O.D. (Figure 6.23). These deposits are known to extend for nearly a kilometre southwards, underlying a terrace at about 12-14m O.D. (Wymer 1985). Faunal remains have also been recovered from Maidenhall, 400m south of the Tunnel site and fossiliferous deposits are probably present over the whole area between these two places, except in the very middle, where they are bisected by a dry valley.

6.7.2. History of research

Around 1846, a railway tunnel was cut through the Stoke Hills at Ipswich by the Eastern Union Railway (Wymer 1985). Shortly after its completion, mammalian remains were discovered at the London end of the tunnel and were examined by Joseph Prestwich, before being moved to Ipswich Museum, where they came to the attention of Miss Nina Layard. The tunnel site was subsequently mentioned in the Geological Survey Memoir of 1885, but it was not until 1908 that Layard decided to reopen some of the sections in an attempt to relocate the fossiliferous deposits. There is some confusion in the literature as to whether this was successful. Layard (1920) herself reports that the attempt failed, although in an earlier account (Layard 1912), a photograph clearly shows the presence of the black fossiliferous horizon from which mammalian remains were later recovered. In 1919, it was announced that the cliff would again be sectioned for the construction of new railway sidings, thereby giving Layard the opportunity to make a full reinvestigation of the deposits (Layard 1920). A large quantity of fossil mammalian remains were recovered from a black Bone Bed and from underlying purple clays, together with freshwater shells and a small number of worked flints, including a
Figure 6.23 Location of the Stoke Bone Bed deposits (modified from Wymer 1985). 1 = Maidenhall, 2 = Stoke Tunnel. Palaeolithic findspots are denoted by black circles, Levallois findspots by black and white circles.

Levallois tortoise core from the bone bed. Fragments of carapace of *Emys orbicularis* were also found in association with remains of *Mammuthus primigenius*, reportedly the
first discovery of this co-occurrence and confirmation of the temperate nature of the deposits (Layard 1920).

A new exposure of the Bone Bed was made in 1948 in the grounds of Luther Road School, where a tunnel about 1.5 x 1.2m at a depth of 6.1m was bored close to, and parallel with the railway line, on the opposite side to Layard’s excavations. The tunnel bored right through two mammoth skulls, a rhinoceros astragalus and the complete skeleton of a large bovid. At around the same time, trenching for the new Maidenhall Estate, a short distance to the south, revealed more faunal remains and Levallois artefacts (Wymer 1985). Additional brief accounts of the mammalian remains from the Stoke Tunnel area are given by Spencer (1959, 1967).

In August 1975, an excavation was conducted by J. Wymer immediately to the north of Layard’s 1919 excavation, which succeeded in exposing a further 60m² of the Bone Bed (Wymer 1985). In the same year, during the laying of the foundations for Stoke High School at Maidenhall, numerous remains of elephant were uncovered in deep drainage pipe trenches by mechanical digger, including the virtually complete skeleton of a woolly mammoth. Arrangements were then made for systematic excavation on the School site, which was carried out in May 1976. The actual spot was close to the Halifax railway junction and is now part of one of the school playgrounds. Part of the 1975 Tunnel excavation site was re-opened in 1977 for the INQUA meeting and further collections of faunal material were made by R. Markham of Ipswich Museum. The relative positions of the Stoke Tunnel and Maidenhall sites are shown in Figure 6.24.
Preliminary pollen analyses of the Stoke bone bed, undertaken by Turner (in West 1977b), showed similarities with zone Ip IV of the Ipswichian Interglacial and the mammalian assemblage was also placed within the latter part of this stage by Stuart (1976, 1979, 1982). However, despite the initial correlation of the Stoke sites with the Ipswichian, it now seems likely that the deposits relate to a pre-Last Interglacial temperate stage, equivalent to OIS 7.
6.7.3. Geological background and provenance of mammalian remains

The local solid geology consists of London Clay and Reading Beds, which have since been eroded and now slope steeply down towards the river. On the south-east side of these eroded Tertiary clays, interglacial Pleistocene deposits (loams, sands and silts) are banked against the lower part of the slope. These are covered by up to 18m of soliflucted or colluvial deposits, resulting in a section some 30m deep (Wymer 1985). The history of sedimentation at the site is one of infilling, during a temperate phase, of a fluvial channel. The overlying soliflucted or colluvial deposits may thus conceivably represent the ensuing cold stage. The following section was recorded by Layard (1920) (Figure 6.25):

9. Black humus, 2ft (60cm)
8. Coarse red gravel, 8ft (2.40m)
7. Laminated loams and brickearth, 6ft (1.80m)
6. Iron-stained sandy clay, containing poorly-preserved mammal bones and a thin gravel band with flint artefacts, 1½ft (45cm)
5. Clay, varying in colour from white (apparently containing no bones) to a deep purple (very rich in bones, although in a fragile condition), 6ft (1.80m)
4. ‘Chalky boulder clay’, ½ft (15cm)
3. ‘Middle glacial sands’, 6ft (1.80m)
2. Red gravels, containing reworked Red Crag marine shells, 3ft (90cm)
1. Base: Red Crag sands
The purple clays at the foot of the cliff were thought to be the source of the richest mammalian remains, until the rediscovery of the 'black bone bed', first noticed by Layard in her 1908 excavations. The bone bed was hidden behind and beneath the projecting cliff and was reported to plunge steeply, overlying the purple ossiferous clays at 8m O.D., 13.5m from the top of the railway cutting. Bones and teeth were extremely plentiful in these black seams and were in considerably better condition than those from the underlying clays (Layard 1920). Although there is considerable lithological variation between the Tunnel Site and Maidenhall, the level at which the faunal remains occur is very similar. However, whereas at the Tunnel, the bones were in the black organic horizon or the purple clays, at Maidenhall, the bones lay in a brown clay or mottled grey-brown silt and were covered by a loam which was stony in its upper part.
Dark sandy patches within the bone bed at Maidenhall yielded rich microvertebrate remains (Wymer 1985).

At Maidenhall, according to Wymer (1985), the top metre consisted of a mixed deposit of loam, gravel, chalky patches and occasional lumps of Crag. He attributed this to either a glacial deposit or a solifluction spread, comparable to the extensive coarse, unbedded gravel deposits which overlie the fluviatile sequence at the Tunnel Site. Although Layard (1920) recorded a few centimetres of Boulder Clay beneath the bone bed, nothing of this nature was encountered at Maidenhall. The sands and gravels containing reworked Crag Mollusca, which were found at the base of Layard’s section and at the base of the Maidenhall section, are thought to represent fluvial deposition, prior to the silting-up of that part of the River Orwell (Wymer 1985).

6.7.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London, Ipswich Museum and the Suffolk Archaeological Unit at Bury St. Edmunds. 464 specimens were examined during the present study, from collections made by N.F. Layard. The presence of 14 mammalian species was confirmed, to which may be added Homo, on the basis of artefactual evidence. Three new, previously unpublished records were also identified: wood mouse Apodemus sylvaticus, straight-tusked elephant Palaeoloxodon antiquus and roe deer Capreolus capreolus. Wymer (1985) recorded fox Vulpes vulpes and further microfaunal remains, including mole and shrew, but these could not to be located during the present study.

The preservation of all material is generally very fresh. The lithological variation in the fossiliferous deposits accounts for the distinctive preservation types observed in the mammalian material. Layard’s collection from the Tunnel is uniformly dark brown-black in colour, while material from Maidenhall tends to be of an orange-brown colour. A few bones from a seam of white clay near the Halifax junction are pale grey-white in colour. Within all of the species represented, there appears to be a high proportion of associated remains of single individuals. This is particularly noticeable in the case of the lion, wolf and mammoth.
Species list (Mammalia) from the Stoke Tunnel and Maidenhall bone beds, Suffolk

**Primates**
*Homo* sp., indet. hominid (artefacts)

**Rodentia**
*Arvicola terrestris cantiana* (Hinton), water vole (intermediate form)
*Microtus agrestis* (L.) or *Microtus arvalis* (Pallas), field or common vole
*Microtus oeconomus* (Pallas), northern vole
*Microtus* sp., indet. vole
*Apodemus* cf. *sylvaticus* (L.), wood mouse

**Carnivora**
*Canis lupus* L., wolf
*Ursus* cf. *arctos* L., brown bear
*Panthera leo* (L.), lion

**Proboscidea**
*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant
*Mammuthus primigenius* (Blumenbach), woolly mammoth
Elephantidae sp., indet. elephant

**Perissodactyla**
*Equus ferus* Boddaert, horse
*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros
Rhinocerotidae sp., indet. rhinoceros

**Artiodactyla**
*Cervus elaphus* L., red deer
*Capreolus capreolus* (L.), roe deer
*Bos primigenius* Bojanus, aurochs
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 6.7 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (°o)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. t. cantiana</td>
<td>43</td>
<td>9.26</td>
<td>10 (1 juv., 9 adults)</td>
</tr>
<tr>
<td>M. agrestis/ M. arvalis</td>
<td>1</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td>M. oeconomus</td>
<td>4</td>
<td>0.86</td>
<td>3</td>
</tr>
<tr>
<td>Microtus sp.</td>
<td>11</td>
<td>2.37</td>
<td>2</td>
</tr>
<tr>
<td>A. sylvaticus</td>
<td>1</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. lupus</td>
<td>17</td>
<td>3.66</td>
<td>1</td>
</tr>
<tr>
<td>U. arctos</td>
<td>11</td>
<td>2.37</td>
<td>2</td>
</tr>
<tr>
<td>P. leo</td>
<td>19</td>
<td>4.09</td>
<td>1</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>4</td>
<td>0.86</td>
<td>1</td>
</tr>
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<td>M. primigenius</td>
<td>77</td>
<td>16.59</td>
<td>14</td>
</tr>
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<td>Perissodactyla</td>
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<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>160</td>
<td>34.48</td>
<td>9 (3 juv., 6 adults)</td>
</tr>
<tr>
<td>C. antiquitatis</td>
<td>1</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td>Rhinocerotidae sp.</td>
<td>2</td>
<td>0.43</td>
<td>1</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. elaphus</td>
<td>76</td>
<td>16.37</td>
<td>4</td>
</tr>
<tr>
<td>C. capreolus</td>
<td>1</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td>B. primigenius</td>
<td>20</td>
<td>4.31</td>
<td>3</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>16</td>
<td>3.44</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.7 Breakdown of the mammalian species list from the Stoke Bone Bed, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.7.5. Palaeoenvironmental and palaeoclimatic interpretation

E. ferus is the most abundantly represented of the large herbivores, with 160 specimens recorded (34.48°o of the assemblage). This suggests the presence of large areas of open grassland in the vicinity of the site, an inference supported by the remains of other large grazers and grazer/browsers (M. primigenius, C. antiquitatis, C. elaphus and large bovids) and grassland rodents such as M. agrestis/ M. arvalis and M. oeconomus. However, the presence of A. sylvaticus, U. arctos, P. antiquus and C. capreolus is considered to reflect the proximity of deciduous or mixed woodland. A nearby source of still or slowly-flowing freshwater with well-vegetated margins is indicated by A. t. cantiana and E. orbicularis. Freshwater shells, including Lymnaea and Planorbis, were also recovered from the bone bed (Layard 1920), together with remains of fish and amphibians (Wymer 1985).
The mammalian assemblage is fully interglacial in character, as indicated by the occurrence of *P. antiquus, A. sylvaticus, C. capreolus* and *B. primigenius*, which are known only from temperate episodes in the Pleistocene. This is confirmed by the record of *E. orbicularis*, since this species requires mean July temperatures of 17-18 C, combined with considerable amounts of prolonged sunshine, in order to hatch its eggs (Stuart 1979, 1982). In contrast, the presence of *C. antiquitatis* suggests a cold climate. It is therefore possible that a continental climate prevailed that could encompass both ‘warm’ and ‘cold’ indicators.

6.7.6. Biostratigraphy and correlation

Mammalian studies

The Stoke Tunnel mammalian assemblage has traditionally been regarded as reflecting the latter part of the Ipswichian Interglacial (Stuart 1976, 1982). However, re-evaluation of many sites formerly attributed to the Ipswichian by Sutcliffe (1976, 1995) and Wymer (1985, 1988) has suggested that the Stoke Tunnel interglacial deposits should be correlated with a pre-Last Interglacial temperate stage, equated with Stage 7 of the oxygen isotope record.

The present study concurs with the latter correlation, based upon the great similarity of the Stoke Tunnel assemblage to sites such as the upper part of the sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2) and Brundon (6.6). In every respect, the Stoke Tunnel fauna is typical of the ‘mammoth-horse’ assemblages that are encountered at sites of Stage 7 age, as will be demonstrated below.

The Stoke Tunnel assemblage is dominated by abundant remains of a large form of *Equus ferus* and by *Mammuthus primigenius*. Layard (1920) noted that remains of horse were especially numerous and described them as being of large size but slender build. The assemblage also contains smaller numbers of *Palaeoloxodon antiquus* (approximately 5% of the elephant specimens), the co-existence of which with *M. primigenius* is considered an important characteristic of the Stage 7 interglacial by the present study. The Stoke Tunnel Carnivora are represented by *Panthera leo* (most abundant), followed by *Ursus arctos* and *Canis lupus*. Parallels were drawn between
the remains of lion from Stoke Tunnel and those from Crayford, on the basis of their extremely large size (Layard 1920). A complete hind foot of *P. leo* (from the end of the terminal phalanges to the calcaneum) was measured as 45cm long (Layard *ibid*). Specimens of brown bear were also stated to be of “unusual size” (Layard *ibid*, 216) but the wolf varied in size, with both large and small individuals represented, again similar to the situation at Crayford (6.18).

Other elements of the Stoke Tunnel assemblage include abundant *C. elaphus* (76 specimens) and smaller numbers of *B. primigenius* (20 specimens). Layard (1920) also commented upon the exceptionally large size of these remains, the circumference of one antler base of *C. elaphus* measuring approximately 25cm at the base. In terms of both the species represented and their relative abundance, the Stoke Tunnel assemblage is an extremely close match with the upper part of the sequence at Aveley. Correlation with this site is therefore proposed.

**Palynological studies**

Turner (in West 1977b) determined that pollen from the fossiliferous deposits at Maidenhall was of interglacial, boreal character and suggestive of zone Ip IV of the Ipswichian Interglacial.

6.7.7. **Discussion and conclusions**

The presence of *M. primigenius, E. ferus* and humans (in the form of a primary-context Levallois industry) argues strongly against an Ipswichian age for the Stoke Tunnel interglacial deposits. Contrary to the palynological evidence, the present study therefore attributes the deposits to Stage 7 of the oxygen isotope record on the basis of strong mammalian biostratigraphic evidence. The Stoke Tunnel mammalian assemblage is most similar to that from the upper part of the sequence at Aveley (6.1), both in terms of the species represented and relative abundance. Correlation with the later part of Stage 7 (possibly Substage 7a) is therefore advocated. Critical species include the co-abundance of *M. primigenius* and *E. ferus*, together with *P. antiquus*, a large form of *P. leo* and large herbivores, including *C. elaphus* and *B. primigenius*. 

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6.8. STUTTON, SUFFOLK (centred around TM 150330)

6.8.1. Location of the site

The mammalian material under consideration here comes from the low cliff deposits (approximately 5.6m high) of the Stour estuary, on the western side of Holbrook Bay (Figure 6.23).

6.8.2. History of research

The first published account of the geology is by Whitaker et al. (1878), who described the foreshore exposures and noted the presence of bone and tusk fragments and non-marine Mollusca. A later account by Taylor (1890) also mentions the discovery of remains of 'hairy elephant, flint chips and an abundance of shells'. Although no systematic excavations have been conducted at the locality, continued collecting over a long period of years by (among others), J. Evans (1897), J.R. Moir, S. H. Warren and H.E.P. Spencer (Cranbrook 1951; Spencer 1954, 1958a) has gradually resulted in a sizeable collection of faunal remains and artefacts, including Levallois flakes (Wymer 1985). The deposits were attributed to the terminal phases of the Ipswichian (zones Ip III-IV) on the basis of pollen analyses (Sparks and West 1963). Further references to the mammalian assemblage are made by Stuart (1976, 1982) and Sutcliffe (1995).

6.8.3. Geological background and provenance of mammalian remains

Whitaker et al. (1878) described a low cliff of fine sand and bedded loam (brickearth) with occasional lenses of gravel. The grey sands and loams, from which fauna and Levallois artefacts have been recovered, are thought to overlie patches of gravel containing earlier palaeolithic artefacts (Wymer 1985). The majority of the sequence in the present cliff appears, however, to rest directly on London Clay. No section drawings are known.
6.8.4. Palaeontology

The following species list has been compiled from material in Ipswich Museum and in the British Geological Survey Museum at Keyworth. The presence of 14 mammalian species at the site has been confirmed by the present study, including new records of the extinct small mouse *Apodemus maastrichtiensis* (only the third record of this species from Britain) and narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*). To the list may be added *Homo* on the basis of Levallois artefacts. Remains of *Neomys fodiens* (water shrew), beaver (*Castor fiber*) and northern vole (*Microtus oeconomus*), recorded by Stuart (1982), and bear (*Ursus* sp.) and wild boar (*Sus scrofa*), recorded by Spencer (1958a), could unfortunately not be traced during the present study. 131 specimens were examined. The preservation of the material is relatively fresh and the bones a pale grey base colour, streaked with orange (some quite deeply stained).

Species list (Mammalia) from Stutton, Suffolk

**Insectivora**

*Sorex cf. araneus* L., common shrew

**Primates**

*Homo* sp., indet. hominid (artefacts)

**Rodentia**

*Arvicola terrestris cantiana* (Hinton), water vole (intermediate form)

*Microtus agrestis* (L.), field vole

*Microtus agrestis* (L.) or *Microtus arvalis* (Pallas), field or common vole

*Microtus* sp., indet. vole

*Apodemus cf. maastrichtiensis* van Kolfschoten, extinct small mouse

*Apodemus cf. sylvaticus* (L.), wood mouse

**Carnivora**

*Panthera leo* (L.), lion

**Proboscidea**

*Palaeoloxodon antiquus* Falconer and Cautley, straight-tusked elephant

*Mammuthus primigenius* (Blumenbach), woolly mammoth

Elephantidae sp., indet. elephant

**Perissodactyla**
Equus ferus Boddaert, horse
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros
Rhinocerotidae sp., indet. rhinoceros

Artiodactyla
Megaloceros giganteus, giant deer
Cervus elaphus L., red deer
Bos primigenius Bojanus, aurochs
Bison priscus Bojanus, bison
Bovidae sp., indet. large bovid (Bos or Bison)

Table 6.8 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

6.8.5. Palaeoenvironmental and palaeoclimatic interpretation

The presence of A. sylvaticus and P. antiquus (2.3% and 3% respectively of the mammalian assemblage) suggest the presence of nearby deciduous or mixed woodland, although by far the most important habitat appears to be open grassland. This is attested to by the presence of grassland voles, Microtus spp. (7% of the assemblage), together with abundant large grazing or part-grazing herbivores, such as M. primigenius, C. elaphus, E. ferus, B. priscus, B. primigenius, M. giganteus and rhinoceroses, which make up over half of the assemblage.

The presence of a nearby source of still or slowly-moving freshwater with well-vegetated banks is suggested by the predominance of remains of Arvicola in the small mammal assemblage. This is corroborated by the presence of the freshwater bivalve Corbicula fluminalis (Sparks and West 1963) and remains of waterbirds, including goose (Anser sp.) and mallard (Anas platyrhinus) (Spencer 1958a). However, the presence of the brackish water mollusc Pseudamnicola confusa (Sparks and West 1963) also suggests a tidal influence. In addition to Corbicula, Sparks and West (ibid) reported a further 79 species of non-marine Mollusca from the Stutton brickearth, including 7 species that are today absent from the British Isles. The presence of C. fluminalis, Belgrandia marginata, Potomida littoralis, Vallonia pulchella, Bithynia
troscheli, Azeca menkeana and Clausilia pumila, which today have more southerly and continental distributions, suggest the presence of temperate but rather continental conditions during the time of the Stutton interglacial.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insectivora</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. araneus</td>
<td>1</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td><strong>Rodentia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. t. canhiana</td>
<td>36</td>
<td>27.48</td>
<td>4</td>
</tr>
<tr>
<td>M. agrestis</td>
<td>1</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td>M. agrestis or M. arvalis</td>
<td>2</td>
<td>1.52</td>
<td>2</td>
</tr>
<tr>
<td>Microtus sp.</td>
<td>6</td>
<td>4.58</td>
<td>2</td>
</tr>
<tr>
<td>A. maastrichtiens</td>
<td>1</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td>A. sylvaticus</td>
<td>3</td>
<td>2.29</td>
<td>1</td>
</tr>
<tr>
<td><strong>Carnivora</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. leo</td>
<td>5</td>
<td>3.81</td>
<td>1</td>
</tr>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>4</td>
<td>3.05</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>26</td>
<td>19.84</td>
<td>6 (1 juv., 5 adults)</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>2</td>
<td>1.52</td>
<td>1</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>8</td>
<td>6.1</td>
<td>2</td>
</tr>
<tr>
<td>S. hemitoechus</td>
<td>1</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td>Rhinocerotidae sp.</td>
<td>1</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. giganteus</td>
<td>2</td>
<td>1.52</td>
<td>1</td>
</tr>
<tr>
<td>C. elaphus</td>
<td>19</td>
<td>14.5</td>
<td>4 (1 juv., 3 adults)</td>
</tr>
<tr>
<td>B. primigenius.</td>
<td>1</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td>B. priscus</td>
<td>2</td>
<td>1.52</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>10</td>
<td>7.63</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.8 Breakdown of the mammalian species list from Stutton, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.8.6. Biostratigraphy and correlation

The site of Stutton has been attributed both to the Ipswichian Interglacial by Sparks and West (1963) and Stuart (1976, 1982) and to a pre-Ipswichian temperate stage, correlated with Stage 7 of the oxygen isotope record, by Sutcliffe (1976, 1995a), Wymer (1985, 1988) and Shotton (1986).
Mammalian studies

The Stutton mammalian assemblage was assigned to the Ipswichian Interglacial by Stuart (1976, 1982). During zone Ip III, the arrival of *M. primigenius* and *E. ferus* (which had been absent in the earlier part of the interglacial) coincided with regional vegetational changes from closed mixed oak forest to more open temperate forest, with abundant *Carpinus* (hornbeam) (Stuart 1976).

However, the results of the present study agree with the conclusions of Sutcliffe (1976, 1995a), Wymer (1985, 1988) and Shotton (1986), who placed Stutton in a pre-Last Interglacial temperate stage, correlated with Stage 7. This is based on the extremely close similarity of the mammalian assemblage from Stutton to that from the upper part of the sequence at Aveley, designated for the purposes of the present work as the 'type locality' for Stage 7 (6.1).

The Stutton Elephantidae are dominated by remains of *Mammutthus primigenius* (84% of the 29 identifiable elephant specimens), compared with only 13% for *Palaeoloxodon antiquus*. This corresponds exactly with evidence from other sites attributed to Stage 7 in the present study, such as Ilford (Uphall Pit) (6.2), where *M. primigenius* is always more abundant than *P. antiquus*. The co-existence of these two species in these ratios is considered a characteristic of the Stage 7 interglacial. An important biostratigraphic feature of the Stutton mammoths is that their molars of small size, with a relatively low plate count. This is exemplified by a virtually complete right third lower molar (953-153-1 from Ipswich Museum) which has only 19 plates. The Stutton mammoth may therefore be referred to as 'Ilford type', a primitive form that is diagnostic of the Stage 7 interglacial.

After *M. primigenius*, the second most abundant species is *C. elaphus*. The Stutton red deer is larger in size than that from sites attributed to Stages 11 and 9 in the present study (Lister 1981) and has coronate antlers but no other particular features of biostratigraphic significance. This is very much the same situation with the remains of *E. ferus* and the large bovids, which are comparable in size to the large forms found at Ilford (6.2). Notable absences from the Stutton assemblage include *Dama dama* and *Hippopotamus amphibius*.
The water vole remains from Stutton are assigned to the advanced morphotype of *A. t. cantiana*, on the basis of the absence of visible enamel differentiation. This suggests that the Stutton deposits are of younger age than the Stage 9 interglacial.

A new record of the extinct small mouse *Apodemus maastrichtiensis* has been established on the basis of a first lower molar, using characters identified by van Kolfschoten (1990, 1991). The length of the Stutton m1 was 1.50mm and the width 0.9mm, both well within the range defined for *A. maastrichtiensis* (see Chapter 2). Apart from its small size, the Stutton specimen also displays certain morphological characters that support its attribution to this species. In the Stutton specimen, the cusps are steep-sided, the front of the tooth has only a low connection with the back and the posterior chevron angle is quite acute but would broaden out with wear, as would be expected in *A. maastrichtiensis* (van Kolfschoten *ibid*). The combination of size and morphological characters therefore suggest attribution of the Stutton specimen to the smaller *Apodemus* species. This is only the third record of *A. maastrichtiensis* in Britain, this species also being recorded from the Hoxnian site of Barnham, Suffolk (Schreve 1993; Ashton *et al.* 1994b (4.5) and from the Cromerian Complex site of Boxgrove, West Sussex (Pitts and Roberts 1996). On the continent, the latest known occurrence of this species is from Saalian levels at the sites of Maastricht-Belvedere and Wageningen-Fransche-Kamp in the Netherlands (van Kolfschoten 1990).

When considered as a whole, the Stutton assemblage is absolutely typical of the later part of the Stage 7 interglacial and compares very closely with other assemblages, such as the upper part of the Aveley sequence (6.1), the Uphall Pit at Ilford (6.2), Northfleet (6.5) and Brundon (6.6). These assemblages are characterised by an abundance of woolly mammoth (often but not always including the ‘Ilford type’ mammoth) and horse. Straight-tusked elephant is usually present but always in much smaller numbers than mammoth. The narrow-nosed rhinoceros is also a common component of Stage 7 faunas in the Thames valley and eastern England, again apparently more abundant than Merck’s rhinoceros. The predominance of *M. primigenius* over *P. antiquus* and *S. hemitoechus* over *S. kirchbergensis* very much reflects the nature of this part of this particular interglacial, with open grassland, as opposed to woodland, being the most common habitat. Other large herbivores, including large bovids, red deer and giant deer are also important elements of the late Stage 7 fauna, with lion as the most abundant
predator. In all these respects, the mammalian assemblage from Stutton conforms perfectly.

The records of *Neomys fodiens*, *Castor fiber* and *Microtus oeconomus* reported by Stuart (1982) and *Ursus* sp. and *Sus scrofa* reported by Spencer (1958a) would not be out of place in this assemblage and are consistent with a Stage 7 attribution. In particular, the presence of *M. oeconomus* is characteristic of the later part of Stage 7; it is recorded from numerous other sites attributed to this phase in the present study.

The occurrence of Levallois artefacts at Stutton is also important in demonstrating a pre-Ipswichian age for the site, since there is no evidence of human presence in Britain during any part of the Last Interglacial. Proto-Levallois artefacts first appear in cold-stage sediments attributed to OIS 8 in the Thames valley (Bridgland 1994, see Purfleet 5.1 and Lion Pit tramway cutting, West Thurrock 6.4). A fully-fledged Levallois industry is present at various sites in Britain including Brundon, Northfleet, Stoke Tunnel and Stutton itself, all temperate-stage deposits which have yielded the same distinctive mammoth-horse fauna.

**Malacological studies**

The abundance of *Corbicula fluminalis* in the Stutton brickearth strongly suggests that the site is of pre-Last Interglacial age (Keen 1990; Bridgland 1994; Meijer and Preece 1995).

**Palynological studies**

A pollen sample obtained from unoxidised sediments beneath the foreshore yielded pollen of zone Ip III age. The Stutton sequence was thus estimated to represent parts of zones Ip III and possibly IV of the Ipswichian Interglacial (Sparks and West 1963).

**6.8.7. Discussion and conclusions**

Despite the attribution of the Stutton deposits to the Ipswichian Interglacial on the basis of palynological evidence and Uranium-series dates on bone of 125 000 ±20 000 years
B.P. (equivalent to OIS 5e) (Szabo and Collins 1975), it is concluded here that the mammalian assemblage should be placed instead within the earlier Stage 7 interglacial. This is based upon the co-occurrence at Stutton of *M. primigenius* and *E. ferus*. A pre-Ipswichian age is supported by the presence of the freshwater mollusc *Corbicula fluminalis* and of humans, as witnessed by Levallois artefacts, neither of which are known from Last Interglacial deposits. The extremely close resemblance of the Stutton mammal fauna (a characteristic *Mammuthus-Equus* assemblage) to that from the upper part of the sequence at Aveley (6.1) and Ilford (6.2) also suggests that the assemblage should be correlated with the later part of the Stage 7 interglacial (possibly Substage 7a).

The presence of brackish Mollusca at Stutton in levels attributed to zone Ip III would apparently confirm the continuation of high sea-levels at this time. It is consequently difficult to see when the lowering of sea-level occurred, which would have permitted the immigration into Britain of *M. primigenius*, *E. ferus* and humans, if Stutton were truly of Ipswichian age. *Hippopotamus* is apparently absent, despite the fact that this species has been recorded from early zone Ip III sediments at Swanton Morley (Stuart 1976). Its presence at Stutton in deposits also considered on palynological grounds to be of this age (Sparks and West 1963) might therefore be expected in a collection of 70 large mammal remains.

The combined evidence from a variety of sources therefore proposes that the Stutton deposits, along with many others that were once attributed to the Ipswichian on palynological grounds, belong to a separate, earlier interglacial, correlated with Stage 7 of the oxygen isotope record.
6.9. HARKSTEAD, SUFFOLK (TM 191333)

6.9.1. **Location of the site**

The low cliff (approximately 5.6 m high), from which the mammalian remains have been recovered, is located on the eastern side of Holbrook Bay, on the north side of the Stour estuary (Figure 6.23).

6.9.2. **History of research**

Systematic excavations have never been carried out at the site, although substantial collections of mammalian bones and artefacts have been made over the years. H.E.P. Spencer, former curator at Ipswich Museum, recorded the discovery in 1948 of bones of a small elephant, horse, red deer, aurochs or bison (Spencer 1962, 1970). Other remains, found at a later date, included a possibly complete skeleton of a woolly mammoth (Wymer 1985), although the existence of this has not been confirmed in the present study. Some of the material was found *in situ*, in brickearth at the base of the cliff, while the remainder was collected from the foreshore. At one very low tide, a pair of tusks was reportedly seen protruding from the mud of the beach (Wymer *ibid*). Fresh Levallois artefacts, apparently contemporary with the mammalian remains, have also been recovered from the brickearth (Wymer 1985). The Harkstead brickearths were assigned to terminal parts of the Ipswichian Interglacial on the basis of comparison with palynological analyses from similar deposits at nearby Stutton (Sparks and West 1963). The mammalian remains were also attributed to the Ipswichian Interglacial by Stuart (1976, 1979, 1982). However, an Ipswichian age has been questioned in more recent years by Wymer (1985, 1988) and Shotton (1986), who preferred a Stage 7 correlation.

6.9.3. **Geological background and provenance of mammalian remains**

No descriptions or drawings of the Harkstead deposits have been found in the literature, other than references to 'brickearth' (for example Spencer 1962). However, the mammalian remains are known to be from the same cliff deposits as those from nearby Stutton. The Stutton brickearths are thought to overlie patches of gravel containing
earlier palaeolithic artefacts (Wymer 1985), although the majority of the deposits rest directly on top of London Clay.

6.9.4. Palaeontology

The following species list has been compiled from material in Ipswich Museum. The presence of 9 mammalian species is confirmed by the present study, to which may be added Homo on the basis of artefactual evidence (Wymer 1985). These include previously unpublished records of an indeterminate leporid (hare or rabbit), vole Microtus sp., narrow-nosed rhinoceros Stephanorhinus hemitoechus and possible bison Bison priscus. A record of straight-tusked elephant Palaeoloxodon antiquus (Stuart 1982) was not seen. 93 specimens were examined. The preservation of the material is fairly fresh and the bones are pale grey in colour, stained with orange.

Species list (Mammalia) from Harkstead, Suffolk

Primates
Homo sp., indet. hominid (artefacts)

Lagomorpha
Leporidae sp., indet. hare or rabbit

Rodentia
Arvicola terrestris cantiana (Hinton), water vole (intermediate form)
Microtus sp., indet. vole

Proboscidea
Mammuthus primigenius (Blumenbach), woolly mammoth

Perissodactyla
Equus ferus Boddaert, horse
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros

Rhinocerotidae sp., indet. rhinoceros

Artiodactyla
Cervus elaphus L., red deer
Bos primigenius Bojanus, aurochs
Bison priscus Bojanus, bison
Bovidae sp., indet. large bovid (Bos or Bison)
Table 6.9 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lagomorpha</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Leporidae sp.</td>
<td>1</td>
<td>1.07</td>
<td>1</td>
</tr>
<tr>
<td><strong>Rodentia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. t. cantiana</td>
<td>23</td>
<td>24.73</td>
<td>3</td>
</tr>
<tr>
<td>Microtus sp.</td>
<td>1</td>
<td>1.07</td>
<td>1</td>
</tr>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. primigenius</td>
<td>19</td>
<td>20.43</td>
<td>3 (2 juv., 1 adult)</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>4</td>
<td>4.3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. elaphus</td>
<td>8</td>
<td>8.6</td>
<td>1</td>
</tr>
<tr>
<td>B. primigenius</td>
<td>18</td>
<td>19.35</td>
<td>3</td>
</tr>
<tr>
<td>B. priscus</td>
<td>1</td>
<td>1.07</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>15</td>
<td>16.12</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
</tbody>
</table>

### Table 6.9 Breakdown of the mammalian species list from Harkstead, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

#### 6.9.5. Palaeoenvironmental and palaeoclimatic interpretation

The inferred palaeoenvironmental and palaeoclimatic conditions are the same as those described for Stutton (6.8), with temperate, rather continental conditions prevailing. The combined presence of *O. cuniculus* and microtine rodents with large herbivores, such as *M. primigenius*, *C. elaphus*, *E. ferus*, *B. priscus*, *B. primigenius* and *S. hemitoechus* strongly indicate the proximity of abundant open grassland, with woodland indicators apparently absent or in such low frequencies that they have not been recovered in this relatively small assemblage.

The presence of a nearby source of still or slowly-moving freshwater with well-vegetated banks is suggested by the presence of *Arvicola* in the small mammal assemblage. This is corroborated by the finding of European pond terrapin (*Emys*
orbicularis) (Stuart 1979). The presence of this species also suggests fully interglacial conditions with mean summer temperatures of at least 17-18 C.

6.9.6. Biostratigraphy and correlation

Mammalian studies

The Harkstead mammalian assemblage has been assigned to the Ipswichian Interglacial (zone Ip III) by Stuart (1976, 1982). However, the results of the present study place Harkstead in a pre-Last Interglacial temperate stage, correlated with Stage 7. This is based on the extremely close similarity of the mammalian assemblage from Harkstead to that from the upper part of the sequence at Aveley (6.1).

The Harkstead assemblage is characterised by an abundance of large herbivores, particularly M. primigenius (although it cannot be determined whether these are of 'Ilford type', since no adult teeth were seen in the course of the present study) and large bovids, with large forms of E. ferus and C. elaphus, and rhinoceroses also well-represented.

The water vole remains from Harkstead are assigned to the intermediate morphotype of A. t. cantiana, on the basis of the absence of visible enamel differentiation. This suggests that the deposits are of younger age than the Stage 9 interglacial.

The Harkstead assemblage compares very closely with other mammoth-horse assemblages, such as the upper part of the Aveley sequence (6.1), Ilford (Uphall Pit) (6.2), Northfleet (6.5) and Brundon (6.6). Correlation with OIS 7 is therefore suggested. This is supported by the evidence of human presence (as attested to by Levallois artefacts) (Wymer 1985).

Palynological studies

A pollen sample obtained from unoxidised sediments beneath the foreshore at the neighbouring site of Stutton (6.8) yielded pollen of zone Ip III age. The Stutton sequence was thus estimated to represent parts of zones Ip III and IV of the Ipswichian

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Interglacial (Sparks and West 1963). On the basis of its similarity to Stutton, the sequence at Harkstead was also claimed to represent the terminal zones of the Ipswichian (Stuart 1979, 1982).

6.9.7. Discussion and conclusions

It is concluded that contrary to the palynological evidence, the Harkstead mammalian assemblage corresponds most closely with sites that have been attributed in the present study to the Stage 7 interglacial, based upon the occurrence of *M. primigenius* and *E. ferus* and humans. The combination of *Mammuthus* and *Equus*, in conjunction with *S. hemitoechus, C. elaphus, B. primigenius* and *Bison priscus*, most closely resembles that from the upper part of the sequence at Aveley (6.1) and correlation of the deposits with the later part of the interglacial (possibly Substage 7a) is therefore proposed.
6.10. THE LOWER CHANNEL, COLLEGE FARM, PITSTONE QUARRY, MARSWORTH, BUCKINGHAMSHIRE (SP 932145-6)

6.10.1. Location of the site

The site at College Farm is located 11km east of Aylesbury and approximately 3km NNE of Tring.

6.10.2. History of research

The large Chalk pit with its overlying Pleistocene deposits was first described by Evans and Oakley (1952). In 1976, mammalian remains were noticed by the employees of the Tunnel Cement Company’s Pitstone Works, during the stripping of topsoil and Pleistocene overburden, prior to the northward extension of their ‘No. 3 Pit’. The finds were reported to the Pitstone Local History Society, whose members carried out a rescue excavation, recovering a large quantity of material, including the remains of *Hippopotamus*, which were identified by A.P. Currant of the Natural History Museum. The mammalian remains were found to be restricted to the fill of a shallow fluviatile channel (henceforth referred to as Marsworth I or the Upper Channel) and associated pond-like depressions, cut into the involuted surface of a local spread of soliflucted and involuted sands and gravels (Coombe Rock).

Further quarrying exposed a second channel (Marsworth II or the Lower Channel) in 1980, also containing mammalian and other organic remains, but this time lying beneath the local gravel spread (and therefore below Marsworth I). The relative positions of the two channels are shown in Figure 6.26. The lower channel provided evidence of an older temperate episode, separated from the younger *Hippopotamus* channel by intervening periglacial sediments. The major interest of the site therefore lies in the stratigraphic superposition of two separate channels, both containing evidence of fully-temperate conditions. The Upper Channel has been correlated with the Ipswichian Interglacial, whereas the Lower Channel has been attributed to a post-Hoxnian/pre-Ipswichian interglacial, equated with Stage 7 of the oxygen isotope record (Green *et al.* 1984). It is this latter channel that is of interest to the present discussion.
The Upper Channel has now been completely destroyed but other parts of the exposures have been safeguarded as a Site of Special Scientific Interest. The immediate surroundings of College Farm are now a wildfowl and conservation area.

Figure 6.26 Relative positions of the Pleistocene fossiliferous deposits in Pitstone No. 3 quarry, Marsworth, showing the alignment of sections illustrated in Figure 6.27 (from Green et al. 1984).

6.10.3. Geological background and provenance of mammalian remains

The following description of the Lower Channel is from Green et al. (1984), with additional observations from Evans and Oakley (1952) (Figure 6.27):

At the base of the sequence, a channel up to 35m wide is cut into Chalk bedrock at approximately 125m O.D. The Lower Channel is infilled with sediments indicative of deposition by a shallow stream, consisting of gravelly sands (henceforth referred to as ‘Layer 3’) below, passing upwards into organic mud (‘Layer 2’) (Figure 6.27). Remains of vertebrates are present in both Layers 3 and 2, while the organic mud has yielded additional rich collections of molluscs, ostracods, beetles, pollen and plant macrofossils. Lumps of travertine, containing Mollusca and bearing occasional impressions of leaves of temperate woodland species, are also present in clasts up to 0.8m long. The organic mud is confined to the area indicated in section E-F (see Figure 6.26), whereas the gravelly sands have been traced continuously in this section. These in turn are overlain
by chalky muds containing many small chalk pellets. Lenses of water-laid sand and fine gravel are also present. These largely-colluvial deposits (‘Layer 1’) are up to 4m thick and have been recorded both within, and beyond, the Lower Channel. Mammalian remains were recovered from these deposits and are discussed further in 7.4.

The channel-infill deposits are covered by a coarser head of chalk and flint debris (Coombe Rock), 2-3m thick. This deposit forms a level surface, approximately 4.5 square kilometres in area. It can be traced across the site of the Lower Channel and for a substantial distance beyond it, fanning out from the mouth of the Tring Gap, a prominent dry valley penetrating the Chiltern scarp. The surface of this area and of the lowest point of the Gap lie at approximately 130m O.D. At the south-west end of the pit, the Chalk was seen to be overlain by approximately 6m of Coombe Rock, in turn overlain by a thin band of light brown chalky clay with angular flint fragments and chalk pellets and then by a dark brown clayey, flinty soil.

Frost polygons, exceeding 0.9m across, were also observed, associated with the ‘festooning’ of the light brown flinty and chalky clay into the Coombe Rock (Evans and Oakley 1952). These deposits are interpreted as reflecting the solifluction of chalk debris from the scarp slope of the Chilterns. Subsequent exposure to arctic conditions resulted in the festooning and formation of polygons.

At B (Figure 6.26), the Upper Channel, up to 8m wide, was cut into the surface of the cryoturbated Coombe Rock, truncating the involutions. The Upper Channel lay at approximately 130m O.D. and contained finely-stratified sandy gravel and marl. Several small pond-like depression, containing similar deposits, were also noted nearby. Abundant mammalian remains were collected from this channel, although no other fossiliferous material was present.
The presence of *Hippopotamus* in the Upper Channel led Green *et al.* (1984) to propose an Ipswichian age for these upper temperate deposits. The Lower Channel, on the other hand, was considered to represent a post-Hoxnian/pre-Ipswichian interglacial, correlated with Stage 7 (*Green et al. ibid*). The intervening period of periglacial conditions would therefore be representative of Stage 6, a severely cold episode according to the oxygen isotope record.

### 6.10.4. Palaeontology

The following species lists have been compiled from material in Aylesbury Museum and in the Natural History Museum, London, collected by J. Evans and during rescue excavations co-ordinated by D. Parish of Aylesbury Museum. Only specimens from the temperate-climate deposits of the Lower Channel (Layers 3 and 2) are considered here. Material from Layer 1 is described in 7.4. The presence of 12 species was confirmed in the Lower Channel, including previously unpublished records of an indeterminate leporid (hare or rabbit), *Vulpes vulpes* (fox), *Palaeoloxodon antiquus* (straight-tusked elephant), *Bos primigenius* (aurochs) and cf. *Bison priscus* (bison). Some specimens were
examined. Hundreds of indeterminate fragments were collected but a substantial amount of material consists of complete, well-preserved bones and teeth. Material is generally medium brown in colour but teeth from the organic mud are often dark-stained.

Species List (Mammalia) from the Lower Channel, Marsworth, Buckinghamshire

Layer 3 (Fossiliferous gravelly sand below the organic mud):

**Lagomorpha**
Leporidae sp., indet. hare or rabbit

**Rodentia**
Microtus oeconomus (Pallas), northern vole
Microtus sp., indet. vole

**Carnivora**
Canis lupus L., wolf (small)
Vulpes vulpes (L.), fox
Ursus arctos L., brown bear
Panthera leo (L.), lion

**Proboscidea**
Palaeoloxodon antiquus (Falconer and Cautley), straight-tusked elephant
Mammuthus primigenius (Blumenbach), woolly mammoth

Elephantidae sp., indet. elephant

**Perissodactyla**
Equus ferus Boddaert, horse

**Artiodactyla**
Cervus cf. elaphus L., red deer
Cervidae sp., indet. deer
Bos primigenius Bojanus, aurochs
cf. Bison priscus Bojanus, bison
Bovidae sp., indet. large bovid (Bos or Bison)
Layer 2 (organic mud):

**Lagomorpha**
Leporidae sp., indet. hare or rabbit

**Carnivora**
*Canis lupus* L., wolf (small)
*Vulpes vulpes* (L.), fox
*Ursus arctos* L., brown bear
*Panthera leo* (L.), lion

**Proboscidea**
*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Perissodactyla**
*Equus ferus* Boddaert, horse

The distribution of the organic mud within a limited spatial area shows it to be highly localised, as a result of lateral variation in the sedimentation. The mammalian assemblages from Layers 3 and 2 are therefore not considered to be widely separated in time and are consequently considered as one below.

Table 6.10 provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lagomorpha</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leporidae sp.</td>
<td>4</td>
<td>0.47</td>
</tr>
<tr>
<td><strong>Rodentia</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. oeconomus</td>
<td>5</td>
<td>0.59</td>
</tr>
<tr>
<td>Microtus sp.</td>
<td>1</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>Carnivora</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. lupus</td>
<td>44</td>
<td>5.27</td>
</tr>
<tr>
<td>V. vulpes</td>
<td>5</td>
<td>0.59</td>
</tr>
<tr>
<td>U. arctos</td>
<td>31</td>
<td>3.71</td>
</tr>
<tr>
<td>P. leo</td>
<td>37</td>
<td>4.43</td>
</tr>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>2</td>
<td>0.23</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>193</td>
<td>23.14</td>
</tr>
<tr>
<td>Elephantidae</td>
<td>82</td>
<td>9.83</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>293</td>
<td>35.13</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. elaphus</td>
<td>1</td>
<td>0.11</td>
</tr>
<tr>
<td>Cervidae sp.</td>
<td>3</td>
<td>0.35</td>
</tr>
<tr>
<td>B. primigenius</td>
<td>49</td>
<td>5.87</td>
</tr>
<tr>
<td>cf. B. priscus</td>
<td>2</td>
<td>0.23</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>82</td>
<td>9.83</td>
</tr>
</tbody>
</table>

Table 6.10 Breakdown of the mammalian species list from the Lower Channel at Marsworth, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.10.5. Palaeoenvironmental and palaeoclimatic interpretation of the Lower Channel deposits.

In the organic mud of the Lower Channel, the pollen spectra and plant macrofossils are dominated by herbs. Gramineae are best represented, with subsidiary amounts of Cyperaceae and many grassland herbs (Green et al. 1984). The small quantities of arboreal and shrub pollen present consist mainly of Pinus, with occasional Picea, Abies, Betula, Quercus, Ulmus, Alnus, Salix, Juniperus and Ribes. Pollen from aquatic species is present (Potamogeton, Hippuris and Butomus) and spores of Lycopodium clavata and Selaginella selaginoides have also been recorded from near the top of the interglacial sequence (Green et al. ibid).
The ostracod fauna is indicative of a permanently flowing stream, probably quite shallow and rich in aquatic plants (J.E. Robinson, in archives of A.P. Currant). The samples are dominated by *Prionocypris serrata*, a species associated with aquatic vegetation and permanently flowing water. *Candona neglecta*, *Potamocypris* sp. and *Ilyocypris bradyi* are also present. These species prefer stable, cool temperatures, typical of chalkland streams (Robinson *ibid*).

The Mollusca from the lower part of the sequence contain both marsh and aquatic species, including *Oxyloma pfeifferi* and *Sphaerium corneum*. In the upper part of the sequence, these are replaced by a land assemblage dominated by grassland species, such as *Pupilla muscorum* (Green et al. 1984). *Limax* sp., *Milax* sp., *Clausilia* spp., *Lymnaea truncatula*, *Lymnaea peregra*, *Trichia hispida*, *Arianta arbustorum* and *Gyraulus laevis* are also recorded (D.H. Keen, in archives of A.P. Currant), together with many fragments of the woodland indicators *Azeca goodalli* and *Clausilia bidentata* (possibly reworked from an earlier source) (Green *et al.* 1984). The blocks of travertine contain molluscs that are characteristic of temperate woodland habitats, including *A. goodalli*, *C. bidentata* and *D. rotundatus*. Leaf impressions in the travertine are of temperate woodland species and include the thermophilous *Acer* (Green *et al.* *ibid*).

Eighty species of Coleoptera are present and suggest a temperate, marshy grassland habitat, dominated by *Glyceria maxima*, the foodplant of *Donacia semicuprea* and *Notaris acridulus*. The beetles are indicative of fully temperate conditions, although the presence of the central and southern European weevil *Stomodes gyroscollis* suggests a degree of continentality. Late in the sequence, an increase in less thermophilic indicators occurs, including *Pycnoglypta larida*, *Arpedium brachypterum* and *Olophrum fuscum*. The assemblage is also notable for the abundance of the small carnivorous beetle *Oxytelus gibbulus* (Green *et al.* 1984).

The mammals from the Lower Channel are indicative of predominantly grassland habitats. Species characteristic of open environments are the most abundantly represented, such as *Equus ferus* (over 35% of the assemblage), *Mammutus primigenius* (over 23%), large bovids (15.93%) and *Microtus oeconomus*. Woodland habitats are also suggested by the presence of *Palaeoloxodon antiquus* and *U. arctos*, although these species are easily outnumbered by open environment indicators. The
presence of *P. antiquus* and the 'Ilford type' mammoth are indicative of fully temperate conditions, since these species are only known from warm episodes in the Pleistocene (Stuart 1982; this study). All the species identified in Layer 2 are present in Layer 1, thereby reaffirming the suggestion that no significant difference exists between the two levels.

### 6.10.6. Biostratigraphy and correlation

**Mammalian studies**

Re-examination in the present study of the mammalian biostratigraphic evidence at sites such as Aveley (6.1), has demonstrated that it is now possible to differentiate, using mammalian faunas, not only a Stage 7 interglacial fauna but also two distinct temperate peaks within this interglacial. Comparison of the mammalian assemblage from the Lower Channel at Marsworth with those from the upper part of the sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2), the Lion Pit tramway cutting (6.4), Northfleet (6.5) and Stanton Harcourt (6.11) reveals a number of strong similarities. Correlation of the Lower Channel temperate deposits with Substage 7a of the oxygen isotope record is therefore proposed.

The Marsworth Lower Channel fauna is dominated by *Mammutbus primigenius* and *Equus ferus*, a combination which is common in assemblages of this age. The Marsworth mammoths are particularly interesting because both the 'Ilford type' mammoth and 'fully evolved' specimens are present (A.M. Lister pers. comm.). The 'Ilford type' mammoth is characterised by a combination of small size and relatively low plate count in its teeth, whereas 'fully evolved' specimens have a higher lamellar frequency.

The presence of the 'Ilford type' mammoth is considered diagnostic of the Stage 7 interglacial but the occurrence of both primitive and more advanced types in the Lower Channel is consistent with an age towards the end of this temperate period, since fully-evolved forms appear to have completely replaced the 'Ilford type' by Stage 6 (see Marsworth cold-climate deposits 7.4, Stanton Harcourt Gravels 7.5 and Balderton 7.6).
The presence of *Palaeoloxodon antiquus* in combination with *M. primigenius* is also highly characteristic of the Stage 7 interglacial, although the former is always present in much fewer numbers than the latter. The evidence from Marsworth is wholly consistent with this observation, since *P. antiquus* making up just over 1% of the identifiable elephant remains.

The remains of *Equus ferus*, *Bos primigenius* and cf. *Bison priscus* from the Lower Channel are indicative of animals of relatively large in size, which compares well with the evidence from other Stage 7 sites, although no further features of biostratigraphic importance are present. The Lower Channel Carnivora are also comparable with those from the upper part of the sequence at Aveley (6.1). *Panthera leo* (Figure 3.38) is the most abundantly represented, followed by *Canis lupus* and *Ursus arctos*. As at Aveley, the lion from the Lower Channel at Marsworth is notable for its large size, while the wolf is relatively small, comparing well with other Stage 7 specimens from Hutton Cave (6.23) and Oreston (6.24) and being markedly smaller than most Devensian populations (see Figure 3.28).

With regard to the small mammals at this site, the presence of a large form of *Microtus oeconomus* is also typical of the Stage 7 interglacial. A progressive increase in size in this species has been documented throughout the later Middle Pleistocene in the present study, reaching a maximum in the cold stage immediately preceding the Last Interglacial (see Table 3.6). The mean length of the first lower molars from Marsworth (2.78 ± 0.067, n = 6) is slightly smaller than that at Crayford (6.18) (2.87 ± 0.041, n = 12) (t = 1.21, p = 0.24), thereby suggesting that the Marsworth sample is slightly older. However, a considerable difference in size is observed between the Lower Channel at Marsworth and sites attributed in the present study to Stage 6, which show the *M. oeconomus* from the former to be significantly smaller than the *M. oeconomus* from the latter. The accumulated evidence therefore implies a pre-Stage 6 age for the Lower Channel.
Palynological studies

Green et al. (1984) state that the pollen spectra from the Lower Channel bear no clear resemblance to established floras of either Hoxnian or Ipswichian Interglacial age, or indeed of Devensian (interstadial) age. This lends weight to the correlation of these deposits with a post-Hoxnian/pre-Ipswichian interglacial stage, previously unrecognised in the pollen record.

Coleopteran studies

The abundant presence of *Oxytelus gibbulus* in the Lower Channel deposits is considered to be of biostratigraphic significance. This species is known from rare specimens in the Early or Middle Devensian at Upton Warren (Coope et al. 1961) and from a single individual each in Ipswichian deposits at Coston and in presumed Hoxnian deposits at Trysull (Coope, in de Rouffignac et al. 1995). However, an abundance of *O. gibbulus* occurs only at sites now widely regarded as being of Stage 7 age, such as Aveley (6.1), Stanton Harcourt (6.11), Stoke Goldington (6.16) and Strensham (6.17). Correlation of the Lower Channel deposits with these localities (and consequently with a post-Hoxnian/pre-Ipswichian Stage 7 temperate episode) is therefore suggested (Green et al. 1984).

6.10.7. Discussion and conclusions

The stratigraphic relationship of the Lower Channel to the Upper Channel, from which it is separated by evidence of intervening periglacial conditions, clearly indicates that the former temperate-climate deposits must pre-date the latter. It is consequently proposed that the Lower Channel is representative of a pre-Ipswichian interglacial, correlated with Stage 7 of the oxygen isotope record, an interpretation that is wholly consistent with the evidence from mammalian biostratigraphy.

The Lower Channel assemblage compares extremely closely with those from numerous sites attributed to Stage 7 in the present study, in particular the upper part of the sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2), Stoke Tunnel (6.7) and Stanton Harcourt (6.11). Critical biostratigraphic indicators include the primitive ‘Ilford type’
mammoth, in association with *P. antiquus*, *E. ferus* and large forms of *P. leo* and *M. oeconomus*. Correlation with Substage 7a is therefore proposed.

Evidence from the Lower Channel beetle assemblage, particularly the abundant presence of *O. gibbulus*, is also consistent with this correlation. Although the pollen assemblage from the Lower Channel has not provided any firm biostratigraphic evidence, the very fact that it does not resemble either known Hoxnian or Ipswichian pollen profiles also lends support to correlation of the deposits with a previously unrecognised post-Hoxnian/pre-Ipswichian interglacial.

The discovery of the Marsworth Upper and Lower Channels is of profound importance in the understanding of the British Quaternary sequence and mammalian biostratigraphy. The unequivocal stratification of a *Mammuthus-Equus*-dominated temperate assemblage below a *Hippopotamus* assemblage demonstrates conclusively that the former pre-dates the latter, contra Stuart’s (1976) model incorporating these two distinctive faunas within a single Ipswichian Interglacial.

The blocks of travertine in the Lower Channel have not been reworked from a very great distance and it therefore seems likely that they date to an earlier period within the same interglacial. Unfortunately, no mammals have been recovered from the travertine, but evidence from molluscs and leaf impressions indicates fully temperate and dense woodland conditions.

This is reminiscent of prevailing conditions in the lower part of the sequence at Aveley (6.1) and Itteringham (6.3), both of which have been attributed in the present study to the earlier temperate peak in Stage 7, Substage 7c. If mammalian remains were present in the Lower Channel travertine, they would consequently be expected to include *Crocidura*, in association with a small mammal assemblage of woodland affinities. Further sampling of the travertine would be recommended in order to investigate this.

Uranium series dating of the travertine blocks themselves has produced a range of age-estimates of between 140 and 170 000 years B.P. (Green et al. 1984). These dates imply age-equivalence with Stage 6, a correlation that seems unlikely given the fully temperate nature of the deposits. Assigning the Lower Channel deposits to an interstadial within
Stage 6 is equally implausible, since the mammalian fauna is clearly representative of the same fully interglacial conditions that are witnessed at other sites, such as Ilford (6.2). It is therefore suggested that the Uranium series dates should be regarded as indicative of a pre-Ipswichian age for the Lower Channel, but are probably underestimating the true age of the deposits.
6.11. DIXS PIT, STANTON HARcourt, OXFORDSHIRE (SP 413054)

6.11.1. Location of the site

The village of Stanton Harcourt is situated approximately 7 km west of Oxford. The gravel pit of interest to this study forms part of the Dix Pit complex and lies to the south-west of the village, two kilometres west of the River Thames. The area was an abandoned airfield, before being turned over to gravel extraction in the 1970s.

6.11.2. History of research

The deposits of the Summertown-Radley terrace of the Upper Thames have been the focus of investigation since the end of the 19th century (Prestwich 1882; Pocock 1908; Sandford 1924, 1926; Dines 1946). Sandford (1924, 1926) was the first to recognise that the main part of the Summertown-Radley aggradation contained the remains of cold-climate mammals, overlain by mammalian and molluscan faunas of temperate affinities, but it was not until the 1980s that commercial gravel extraction in the Stanton Harcourt area revealed a tripartite sequence of deposits indicative of a succession of climatic episodes, from temperate to periglacial and back to temperate again (Figure 6.28).

Figure 6.28 Idealised section through the Summertown-Radley Formation (modified from Bridgland 1994).
The importance of these deposits lies in the fact that the earlier of these two temperate episodes (represented by the Stanton Harcourt Channel Deposits) has been widely attributed to a post-Hoxnian, pre-Ipswichian interglacial period, thought to equate with Stage 7 of the oxygen isotope record (Briggs and Gilbertson 1980; Shotton 1983c; Briggs et al. 1985; Bowen et al. 1989; Bridgland 1994 and Buckingham et al. 1996). Since 1990, systematic investigations have been carried out at the site and large collections of mammalian material made from the Channel Deposits by K. Scott and C. Buckingham. More than 550 large vertebrate remains have been reported, together with 4 handaxes, a core, 2 flakes and a possible chopping tool. However, most of the artefacts show signs of wear (some of which is considerable) and their contemporaneity with the interglacial Channel deposits cannot therefore be demonstrated. The site is scheduled for landfill at the end of 1997.

6.11.3. Geophysical background and provenance of mammalian remains

The lithostratigraphic classification of the Summertown-Radley terrace deposits is presented in Table 6.11 (after Bridgland 1994):

<table>
<thead>
<tr>
<th>Formation</th>
<th>Member</th>
<th>Climate</th>
<th>OIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summertown</td>
<td>Unnamed upper gravel at Eynsham</td>
<td>Cold</td>
<td>5d-2?</td>
</tr>
<tr>
<td></td>
<td>Eynsham Gravel</td>
<td>Temperate</td>
<td>5e</td>
</tr>
<tr>
<td></td>
<td>Stanton Harcourt Gravel</td>
<td>Cold</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Stanton Harcourt Channel Deposits</td>
<td>Temperate</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Unnamed lower gravel at Summertown</td>
<td>Cold</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 6.11 Stratigraphical subdivisions of the Summertown-Radley Formation and correlations with oxygen isotope stages.
The full sequence has unfortunately never been observed in one place but the upper interglacial sediments (the Eynsham Gravel) were once visible at their type locality, Station Pit, in the village of Eynsham, only 4 km upstream from Stanton Harcourt. Nevertheless, although all five members of the Summertown-Radley aggradation have never been recorded in direct superposition, the combination of supporting information points clearly to a cold-warm-cold-warm-cold succession, encompassing two separate interglacials.

The Stanton Harcourt site shows two of the five members now recognised within the Summertown-Radley Formation: the Stanton Harcourt Channel Deposits and the Stanton Harcourt Gravel. The member of interest in this chapter is the interglacial Stanton Harcourt Channel Deposits. The overlying cold-climate gravels (Stanton Harcourt Gravel Member) will be only briefly mentioned here, their mammalian fossils being discussed in greater detail in 7.5.

The original ground surface lies at 70m O.D., dipping at a very low gradient to the east and the Stanton Harcourt Gravel (the main deposit of commercial interest) has been extracted to between 64 and 64.50m O.D. These gravels were interpreted as being deposited under cold, periglacial conditions (Bryant 1983; Seddon and Holyoak 1985) and usually overlie unconformably Jurassic Oxford Clay (Figure 6.29). However, in a restricted area of the pit, the Stanton Harcourt Gravel was found to overlie the Stanton Harcourt Channel Deposits (Figure 6.29).

These temperate-climate deposits consist of silt, sand, gravel and organic sediments, frequently overlying a boulder or cobble bed and occupying a shallow, SW-NE trending, linear depression (60-70m wide and up to 1.5m deep) in Oxford Clay bedrock (Briggs and Gilbertson 1980; Briggs et al. 1985; Bridgland 1994; Buckingham et al. 1996).

Gravel at the base of the Channel deposits is dense and poorly-sorted, with a sandy or silty matrix, and lying above cobbles and boulders (Buckingham et al. 1996). It is overlain by moderately-sorted, cross-bedded gravel, often showing signs of iron-staining. As the gravel thins laterally, silt and sand beds dominate. Large vertebrate remains and chunks of wood form part of the cobble and boulder bed at the base. These are more frequent in the marginal areas of channel and are often imbricated, stacked on
underlying silt and sand units. The preferred orientation of the clasts within the Channel Deposits suggests that dominant flow was towards the north or north-east. This is consistent with the former position of the Thames in this area (Buckingham et al. ibid).

A number of other shallow scours in the bedrock were observed, the deepest reaching approximately 63m O.D. The Channel deposits are punctuated by erosive horizons, suggesting some channel migration but it is not certain whether the scours in the bedrock represent sequential events or whether they are merely variations in erosive rates in different parts of the channel (Buckingham et al. ibid).

**Figure 6.29** Composite section through the deposits at Stanton Harcourt (from Bridgland 1994, after Briggs et al. 1985).

The bipartite division of the Summertown-Radley Terrace deposits proposed by Sandford (1924, 1926) recognised only the Stanton Harcourt Gravel and the Eynsham Gravel. The Eynsham Gravel contained a mammalian assemblage of temperate character, including abundant *Hippopotamus amphibius*, *Stephanorhinus hemitoechus*,
The presence of Hippopotamus amphibius in the Eynsham Gravel has been recorded at six sites in the Summertown-Radley Terrace: Eynsham, Wytham, Radley, Iffley, Abingdon and Dorchester (Sandford 1924, 1965; Briggs et al. 1985). This species is an important stratigraphical marker for the Ipswichian Interglacial and there consequently seems little doubt that the Eynsham Gravel should be correlated with Substage 5e. Corbicula fluminalis has also been recorded from the Eynsham Gravel, an occurrence which appears inconsistent with the presence of Hippopotamus (Keen 1990). However, the record of C. fluminalis is based upon a single abraded fragment from Radley (Sandford 1924; Kennard and Woodward 1924) and it therefore seems highly likely that this specimen is derived. At Summertown, Magdalen Grove and Stanton Harcourt itself, Corbicula is found in abundance and without Hippopotamus (Prestwich 1882; Sandford 1924; Bridgland 1994), suggesting that these sites represent an earlier temperate phase (Bridgland 1994). The presence of Equus ferus in association with Hippopotamus is also apparently anomalous, but again, this may be due to reworking of the former from an older deposit.

The cold climate gravel that underlies the temperate-episode Eynsham Gravel is the same deposit that overlies the interglacial Stanton Harcourt Channel Deposits, namely the Stanton Harcourt Gravel. The Stanton Harcourt Channel Deposits therefore provide critical evidence for the existence of an additional post-Hoxnian/pre-Ipswichian interglacial, due to their position below deposits of Ipswichian age (Eynsham Gravel), from which they are separated by sediments recording a period of colder conditions (Stanton Harcourt Gravel).

In addition, the presence of an unfossiliferous gravel above the Hippopotamus-bearing gravel was observed at Eynsham and a further cold climate gravel was recognised beneath the interglacial beds with Corbicula at Summertown and Magdalen Grove (Sandford 1924). Mammalian remains, comprising Mammuthus primigenius, Equus ferus and Bos primigenius, were reported from this gravel (Sandford ibid).

The Summertown-Radley sequence provides important support for the Thames terrace sequence outlined by Bridgland (1994) (Figure 5.20) and correlations with the oxygen isotope record have been proposed for the various lithostratigraphic units (see Table
6.11). Following downcutting after deposition of the Wolvercote Gravel, the lower gravel at Summertown was deposited. This is considered to represent cold-climate conditions prior to the deposition of the Stanton Harcourt Channel Deposits, and is consequently assigned to Stage 8. The Stanton Harcourt Channel Deposits themselves are attributed to Stage 7 and are separated from the *Hippopotamus*-rich Eynsham Gravel (Substage 5e) by a further cold-climate gravel (the Stanton Harcourt Gravel), attributed to Stage 6 (see 7.5). The uppermost unfossiliferous gravel, above the Eynsham Gravel, is thought to represent the beginning of the cold half-cycle that followed the Ipswichian, and is consequently assigned to Substages 5d-2 (cf. Maddy et al. 1997).

The above interpretation is not, however, favoured by Gibbard (1985), who does not accept that the Stanton Harcourt Channel Deposits occupy a lower stratigraphical position within the Summertown-Radley Formation. Gibbard (ibid) attributes both the Stanton Harcourt Channel Deposits and the Eynsham Gravel to a single Ipswichian Interglacial, citing thermoluminescence dates on the Stanton Harcourt Gravel by Seddon and Holyoak (1985) of 91 000 (± 8 000) and 93 000 (± 9 000), which imply a Devensian age for the Gravel. Even if these age-estimates were ‘reliable’, Gibbard’s scheme requires the Stanton Harcourt Gravel to be younger than the Ipswichian Eynsham Gravel, an assertion which the stratigraphic position of the former below the latter simply cannot support. It therefore seems likely that the dates are suspect, particularly in the light of a date of a radiocarbon date of 35 000 years B.P. by the same authors from a similar stratigraphic level.

6.11.4. Palaeontology

The following species list has been compiled from personal observation of small collections in the Oxford University Museum and the Natural History Museum, London, from species lists provided by Buckingham et al. (1996), Scott and Buckingham (1997) and K. Scott (pers. comm.). Nine species are listed.
Species List (Mammalia) from the Stanton Harcourt Channel, Oxfordshire

**Carnivora**
cf. *Canis lupus* L., wolf
*Ursus arctos* L., brown bear
*Crocuta crocuta* (Erxleben), spotted hyaena
*Panthera leo* (L.), lion

**Proboscidea**
*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant
*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Perissodactyla**
*Equus ferus* Boddaert, horse

**Artiodactyla**
*Cervus elaphus* L., red deer
Cervidae sp., large deer (possibly *Megaloceros giganteus*, giant deer)
*Bison priscus* Bojanus, bison
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Because of the unavailability of material from the most recent excavations (Buckingham et al. 1996), it was not possible to provide a breakdown of the mammalian species list showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals, since any such list would be incomplete. However, according to K. Scott (pers. comm.), over 750 specimens had been collected up to May 1997, of which approximately 450 have been identified. I am extremely grateful to her for the following information. The most abundant species is *Mammuthus primigenius* with 329 elements identified, including 83 complete or partial tusks, 68 isolated teeth, 10 mandibles and 3 maxillae with dentition. *Bison* sp. is the second most abundant species, with 69 specimens, including several skulls with horn cores. Twenty-two specimens of *Equus ferus*, 18 of *Palaeoloxodon antiquus*, 5 of *Ursus arctos*, 3 of *Cervus elaphus* and 1 each of *Panthera leo* and *Crocuta crocuta* were also recovered during the most recent investigations. This compares well with the relative species abundances noted by the author in collections housed in the University Museum in Oxford and the Natural History Museum in London. The mammalian bones show no
signs of substantial rolling and abrasion and may thus be considered contemporary with the Channel deposits.

6.11.5. Palaeoenvironmental and palaeoclimatic interpretation

Only the Stanton Harcourt Channel Deposits, which are of interest to this chapter, will be discussed here.

Pollen from the Channel deposits is poorly preserved, although 30 taxa have been recorded, consisting mainly of aquatics and waterside plants (Buckingham et al. 1996; Scott and Buckingham 1997). Pollen from terrestrial species includes alder, birch, pine, blackthorn and elder, with other thermophilous species, such as oak, indicated by abundant pieces of wood. However, the predominant environment is one of herb-rich grassland (Buckingham et al. ibid), a conclusion very much supported by the mammalian assemblage, which is dominated by large grazing herbivores, such as *Mammuthus primigenius*, *Bison* sp. and *Equus ferus*. The mammalian assemblage also includes woodland species, such as *Palaeoloxodon antiquus* and *Ursus arctos*, although these are far less abundant than open grassland indicators. Fully interglacial conditions are suggested on the grounds of the presence of *P. antiquus* and the ‘Ilford type’ mammoth (see below), both of which are known only from temperate episodes in the Pleistocene.

Evidence from Mollusca and Coleoptera from the Stanton Harcourt Channel supports the inferences drawn from the mammalian assemblage. The molluscs from the Channel indicate the presence of fresh water and the absence of dense forest in the vicinity, while the Coleoptera are, for the most part, inhabitants of thinly-vegetated, sunny ground, only a few shade-loving species being present. The occurrence of *Corbicula fluminalis* and *Potomida littoralis* suggests warm conditions at the time of deposition of the Channel sediments (Keen 1990), as does the insect fauna, which is dominated by species which today have a predominantly southern distribution, thereby suggesting a climate as warm or possibly warmer than the present day (Buckingham et al. 1996). Fish remains have also been recovered from the Channel, including stickleback, pike, perch and eel (Buckingham et al. ibid), together with specimens of frog and bird (K. Scott pers. comm.).
6.11.6. Biostratigraphy and correlation

Mammalian studies

As a whole, the Stanton Harcourt Channel assemblage is a very close match with those from the upper part of the sequence at Aveley (6.1) and Ilford (Uphall Pit) (6.2), both in terms of species composition and abundance. The Stanton Harcourt Channel assemblage is dominated by *Mammuthus primigenius*, exclusively of 'Ilford type' (A.M. Lister pers. comm.). This suggests correlation of the Channel Deposits with a range of sites now widely regarded as being of Stage 7 age, including the Uphall Pit at Ilford (6.2), Northfleet (6.5) Brundon (6.6) and the Lower Channel at Marsworth (6.10). The presence of comparatively small numbers of *Palaeoloxodon antiquus* in association with *M. primigenius* is equally important. The Stanton Harcourt Channel assemblage is also characterised by the presence of *Equus ferus*, together with large forms of *Bison* sp. and *Cervus elaphus*. As at Aveley, a large form of *Panthera leo*, *Ursus arctos*, and *Canis lupus* are recorded. The single specimen of *Crocuta crocuta* also corresponds well with a Stage 7 age, since this species has been recovered in small numbers at comparable open sites, such as Crayford (6.18).

Malacological studies

The presence at Stanton Harcourt of *Corbicula fluminalis* is considered to be a strong indication that the deposits are of pre-Ipswichian age, since this species is not known from Stage 5e deposits (Keen 1990). The single record of *Corbicula* from Radley (Sandford 1924; Kennard and Wooward 1924) is based upon an abraded specimen, which is almost certainly reworked (Bridgland 1994).

6.11.7. Discussion and conclusions

On the basis of mammalian biostratigraphic evidence, the present study correlates the Stanton Harcourt Channel Deposits with Stage 7 of the oxygen isotope record. This is on the basis of the close correspondence of the mammalian assemblage with that from the upper part of the sequence at Aveley (6.1), both in terms of the species represented and relative abundance. Critical species include the co-occurrence of *M. primigenius* of
the characteristic 'Ilford type' and *E. ferus*, together with *P. antiquus*, a large form of *P. leo* and large herbivores, including *Bison* sp. and *C. elaphus*.

The mammalian biostratigraphy is therefore wholly consistent with the stratigraphic scheme of Bridgland (1994) and has received further support from both molluscan evidence (presence of *Corbicula fluminalis*) and amino acid geochronology (Bowen *et al.* 1989). The evidence from Stanton Harcourt also allows some important observations to be made about the whole question of differentiating the Stage 7 interglacial from the Ipswichian. This is particularly well illustrated in the mammalian biostratigraphic model presented by Stuart (1976, 1982), which requires the temperate *Mammuthus-Equus*-dominated assemblages of the British late Middle Pleistocene to be later in time than *Hippopotamus* assemblages, so that both may be accommodated within a single Ipswichian Interglacial. The presence in the Stanton Harcourt area of a channel containing an interglacial 'mammoth-horse' assemblage apparently stratified below deposits containing *Hippopotamus* would appear to demonstrate that the reverse is true, with the mammoth-horse assemblage being the older of the two. This corresponds to the fact that a 'mammoth-horse' assemblage has never been observed to overlie a *Hippopotamus* assemblage (Sutcliffe 1975, 1976; Stringer *et al.* 1986).

The Ipswichian age for the Stanton Harcourt Deposits, advocated by Gibbard (1985), is therefore refuted by the findings of the present study, on the grounds that it is inconsistent with all of the above lines of evidence. Any such correlation demands not only the acceptance of dubious thermoluminescence dates, but also contravenes basic stratigraphic principles by placing the 'Devensian' Stanton Harcourt Gravel below the *Hippopotamus*-rich Eynsham Gravel. According to this model, if the Stanton Harcourt Channel Deposits were indeed Ipswichian, the Eynsham Gravel would have to be of Holocene age, a scenario which is at best unlikely. Although the complete stratigraphic sequence has not been observed in any one locality, the mammalian biostratigraphic evidence provides a compelling argument that the Stanton Harcourt Channel Deposits genuinely occupy a lower position in the Summertown-Radley Formation than the Eynsham Gravel and therefore relate to a pre-Ipswichian interglacial.

The recognition of two distinct interglacial channel fills within the Summertown-Radley Formation is of evident importance to the establishment of a new British stratigraphic
framework and, most significantly, serves to reinforce the conclusions already drawn on the basis of mammalian biostratigraphy at sites in the Lower Thames, such as Aveley (6.1).
6.12. LEXDEN BRICK PIT, near COLCHESTER, ESSEX (TL 978253)

6.12.1. Location of the site

The former brick pit lies between Colchester and Lexden, on the south side of the Colne valley (Figure 6.30).

Figure 6.30 Location of Lexden (modified from Wymer 1985). Black circles mark Palaeolithic findspots.
6.12.2. History of research

The first published reference to the site is by Fisher (1868b), who provided a description of the geology. John Brown of Stanway also recorded a visit to the site in his unpublished notebook, preserved in the archives of the Natural History Museum, London, during which he obtained the peat-stained bones and teeth of woolly mammoth, narrow-nosed rhinoceros and numerous remains of insects and plants. A short review of the site and a reassessment of the coleopteran and palaeobotanical evidence was given in Shotton et al. (1962).

6.12.3. Geological background and provenance of mammalian remains

The site lies on London Clay at approximately 18m O.D. and forms part of a terrace that extends to a maximum of 13.5m above the floor of the present-day Colne valley (Colne Terrace No. 3) (Ellison and Lake 1986). The deposits consist mainly of clays (brickearth) stratified above gravels, although in part of the pit a 9m wide channel, containing peat and organic clay, was visible between the brickearth and gravel (Fisher 1863b; Shotton et al. 1962). The following section was observed by Fisher (1863b) (Figure 6.31):

6. Brown, sandy brickearth, 2.7m
5. White clay, 0.3m
4. White gravel and yellow clay, thin
3. Peat, containing mammalian, coleopteran and plant remains, up to 0.3m
2. Fine, grey carbonaceous clay with rootlets in upper part, 0.9m
1. Coarse, clayey gravel, 2.1m+

Figure 6.31 Section through the brick pit at Lexden (modified from Fisher 1863b).
Brown (unpublished, in Shotton et al. 1962) recorded a similar sequence, although differing slightly in details of thickness.

6.12.4. Palaeontology

The following species list has been compiled from material collected by J. Brown of Stanway and now housed in the Natural History Museum, London, the British Geological Survey Museum at Keyworth and the Sedgwick Museum of Geology, Cambridge. The presence of three species at Lexden was confirmed by the present study, including a previously unpublished record of Palaeoloxodon antiquus. Thirty-seven specimens were examined. All specimens are stained black and preservation is fairly good, although many of the specimens are rather brittle.

Species list (Mammalia) from Lexden, Essex

Proboscidea
Palaeoloxodon antiquus (Falconer and Cautley), straight-tusked elephant
Mammuthus primigenius (Blumenbach), woolly mammoth

Perissodactyla
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros

Table 6.12 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>1</td>
<td>2.7</td>
<td>1</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>18</td>
<td>48.65</td>
<td>6</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. hemitoechus</td>
<td>18</td>
<td>48.65</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.12 Breakdown of the mammalian species list from Lexden, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.
6.12.5. Palaeoenvironmental and palaeoclimatic interpretation

West (in Shotton et al. 1962) examined palaeobotanical remains from the crevices of one of the mammoth teeth and from a fragment of peat. These yielded the following plant macrofossils: seeds of *Stellaria graminea* and nuts of *Carex rostrata* and *Carex* spp. With regard to the frequency of arboreal pollen, only *Pinus* is present in any amount (and this probably the result of long-distance transport). Thermophilous trees such as *Quercus* and *Ulmus* are represented by only one and two grains respectively. Non-arboreal pollen is by far the dominant component of the assemblage, especially grasses and sedges, *Armeria* and *Artemisia*. *Stellaria* seed and *Botrychium* spores are also present. All of the aforementioned records indicate the immediate proximity of open grassland to the site. Unusually high pollen frequencies of light-demanding *Plantago*, indicative of swamp vegetation in or around a pool, were also recorded. These are interpreted as the result of disturbed vegetation, possibly resulting from trampling by large mammals. Mosses, characteristic of fenlands and streamsides with calcareous water, were also recovered. The high frequencies of non-arboreal pollen and the low presence of thermophilous trees led West to conclude that the climate was ‘severe’, although this is contradicted by both the coleopteran and mammalian evidence.

The insect assemblage is dominated by remains of *Donacia semicuprea*, which feeds on *Carex*. Five species of stagnant water beetle, three species of dung beetle (*Aphodius*, *Cercyon* and *Platystethus*) and the carcass beetle *Thanatophilus* were also recovered. These species are all found in Britain at the present day and thus do not support a rigorous climate (Shotton et al. ibid). The combined palaeoenvironmental evidence is therefore suggestive of a temperate climate, although possibly slightly cooler than at present, with open grassland conditions around a pool. The presence of *M. primigenius* and *S. hemitoechus* would also confirm the availability of open grassland. A temperate climate is supported by the occurrence of *P. antiquus*, since this species is known only from temperate episodes (Stuart 1982; Lister et al. 1990).
6.12.6. Biostratigraphy and correlation

Mammalian studies

The mammalian assemblage from Lexden has previously been attributed to the Ipswichian Interglacial, probably zone Ip IV, by Stuart (1976, 1982). Sutcliffe (1995a) however, suggested that the Lexden deposits should be attributed to Stage 7, although no reasons were given for this re-assessment. Analysis of the mammalian remains during the course of the present study supports the attribution of Lexden to Stage 7 on the basis of the following lines of evidence.

An important component of the Lexden assemblage is the woolly mammoth *M. primigenius*. The small size of the Lexden *M. primigenius* molars and their low plate count was first recognised by Adams (1877-81), features which are particularly well-illustrated in a left and right third upper molar (probably from the same individual) (36426, Natural History Museum). These specimens count only 19 plates and thus fall within the range of the so-called ‘Ilford type’ mammoth (see Chapter 3). The degree of annulation in some of these molars is also particularly pronounced, a feature which may be of potential biostratigraphic significance (although it is by no means present in all ‘Ilford type’ mammoth specimens).

The presence of the ‘Ilford type’ *M. primigenius*, in combination with *P. antiquus* and *S. hemitoechus* is critical to the understanding of the age of the Lexden site. The co-occurrence of these three species is characteristic of the later part of the Stage 7 interglacial and is encountered at several other sites in Britain, including the upper part of the sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2) and Brundon (6.6).

Palynological studies

No conclusions as to the age of the deposits were reached by West (in Shotton *et al.* 1962) on the basis of the palynological evidence, although it was later suggested that the deposits should be attributed to Ip zone IV by Stuart (1976, 1982).
6.12.7. Discussion and conclusions

Shotton et al. (1962) recognised that the height of the terrace deposits at Lexden and the association of *M. primigenius* and *S. hemitoechus* was very similar to that at Ilford, although they stopped short of proposing a firm correlation. Analysis of the mammalian remains however, fully supports the attribution of the Lexden deposits to the later part of the Stage 7 interglacial, possibly correlated with Substage 7a. This is based upon the presence of the ‘Ilford type’ mammoth, in conjunction with *S. hemitoechus* and *P. antiquus*. Even though Lexden has yielded only three taxa, the biostratigraphic information is strong enough to suggest this correlation.
6.13. SELSEY (SZ 861926) and WEST WITTERING (SZ 975985), WEST SUSSEX

6.13.1. Location of the site

The site is located on the shore of the east coast of Selsey Bill, a short distance to the south-west of the lifeboat station (Figure 6.33).

Figure 6.33 Map of the coast at Selsey, showing the position of the interglacial deposits (modified from West and Sparks 1960).
6.13.2. History of research

Remains of Quaternary mammals and molluscs in the Selsey area have been known since the middle of the 19th century. The first published reports were of the discovery in 1841, by a coastguard, of a jaw of a straight-tusked elephant (originally reported as mammoth) on the west side of Selsey Bill (Dixon 1850). The profusion of remains of mammoth in the Selsey interglacial deposits was also commented on by Godwin-Austen, who remarked that the mammoth remains "are tolerably abundant, and there is this point of geological interest attaching to these specimens, that they do not here occur as single and detached teeth, or portions of tusks, as happens in the overlying gravel beds; but so many parts of the animal have been found together, as to leave no doubt but that entire skeletons lie embedded in this deposit" (Godwin-Austen 1857, 50). In March 1909, the skeleton and teeth of a young 'mammoth' were exposed in a detrital mud at very low tide, following severe easterly gales (Heron-Allen 1912) and further finds have since been periodically eroded out of the shoreline deposits up until the present day (Heron-Allen 1911, 1912).

During the early part of the 20th century, rapid coastal erosion on the east coast of Selsey Bill resulted in the exposure of raised beach shingle deposits and brickearth for nearly 200m (Parfitt et al. in prep.). In May 1956, four schoolboys discovered bones of narrow-nosed rhinoceros (Stephanorhinus hemitoechus) in interglacial detrital muds, close to the lifeboat station on the east coast. A subsequent rescue excavation, undertaken by local people in conjunction with the Natural History Museum, successfully recovered the partial skeleton of a mature individual. The deposits were uncovered only at extreme low spring tides, seldom allowing more than two hours work at a time for their investigation (Parfitt et al. ibid). Following this discovery, a report on the deposits was made by West and Sparks (1960), who assigned them to the Last Interglacial on palynological grounds.

In January 1961, the remains of a straight-tusked elephant (Palaeoloxodon antiquus) were discovered in the same deposit. These were excavated by the Natural History Museum, together with remains of beaver (Castor fiber) and pond terrapin (Emys orbicularis). Four fresh flint artefacts were also recovered from the detrital peats (Parfitt et al. in prep.). Other tools, including Levallois flakes and Mousterian handaxes
have been recorded from the raised beach, which overlies the fossiliferous deposits (Wymer 1988). Further coastal erosion was halted by the construction of a sea wall in the late 1950s, although destruction of the channel infill by the sea continued for at least a decade. At the present day, the remaining part of the channel is completely covered by modern beach pebbles. Despite the initial correlation of the site with the Ipswichian, the Selsey deposits are now widely regarded as pertaining to a pre-Last Interglacial temperate stage, equivalent to OIS 7 (Jones and Keen 1993; Keen 1995; Sutcliffe 1995a; Parfitt et al. in prep.).

6.13.3. **Geological background and provenance of mammalian remains**

Selsey lies at the seaward end of a ‘staircase’ of raised beaches, ranging in altitude from the inter-tidal zone at Selsey itself to 43.5m O.D. at Boxgrove (Roberts et al. 1995). The Selsey deposits lie on or just below O.D. and consist of freshwater organic muds, overlain by estuarine clays, which form the fill of a NW-SE trending channel, cut into Eocene Bracklesham Beds. A brackish influence, associated with a marine transgression and regression, is first detected at -1.76m O.D. (West and Sparks 1960), followed by marine conditions, under which 2-3m of raised beach gravel were deposited, reaching a height of 7.5m O.D. The whole sequence is capped by brickearth. The following sequence in the channel infill was described by West and Sparks (1960) (Figure 6.34):

3. Grey silty clay with abundant *Hydrobia*, immediately prior to marine transgression. High content of organic mud at the base, where there is a gradual transition from Bed 2.
2. Dark brown coarse detrital mud with wood, shells and skeletons of narrow-nosed rhinoceros and straight-tusked elephant. Shelly except at the base. Conformable through rapid transition with Bed 1 in the centre of the channel but clearly unconformable on Bed 1 at the edges of the channel (probably the result of fluctuating water levels).
1. Variable green or brown freshwater silt or clay with varying proportions of organic mud, with bands of pebbles, frequently black flints. On the west side of the channel,
This bed contains erratic boulders (including hard sandstone, liver-coloured quartz, whitish weathered granite and pink quartz porphyry). Remains of horse were also recovered.

On the seaward side, the channel deposits disappear into the sea; at the landward end, they disappear beneath the modern beach.

The above sequence was interpreted as having accumulated at a time of ameliorating climate and rising sea level. The raised beach deposits exposed at the back of the shore probably represent a later part of the same high sea level. Comparable descriptions were made by Reid (1892). Reid, however, interpreted the basal greenish clay (Bed 1) as a temperate deposit on the basis of its molluscan fauna, whereas West and Sparks (1960) suggested that the plant remains from this bed indicated cold conditions.

A similar sequence of foreshore deposits was described by Reid (1892) and Johnson (1901) at West Wittering, approximately 11 km north-west of Selsey. Here, a channel cut into Eocene clay contained a basal gravel overlain by a fossiliferous laminated peaty clay, the lower part freshwater and the upper part estuarine. Ninety-four species of...
plants, thirty-nine Molluscan taxa, including *Corbicula fluminalis*, ostracods and bones of elephant, rhinoceros and water vole were recorded from the peaty clay (Reid *ibid*; Johnson *ibid*). The raised beach shingle observed at Selsey was seen to extend over the channel.

It is therefore concluded that the Selsey and West Wittering deposits belong to the same series of freshwater and estuarine deposits, antedating the raised beach and lying in channels cut into Eocene clay.

6.13.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London and in the Booth Museum, Brighton. The collections are largely the work of E. Heron-Allen, the Natural History Museum and H. Willett, with additional specimens collected by H.B.A Radcliffe, R.G. West, J.B. Ogle and A.F. Outen. A total of 244 specimens was examined in the present study and the presence of 13 mammalian species confirmed, to which may be added *Homo* on the basis of artefacts. Nine previously unpublished species were identified: a shrew *Sorex* sp., European beaver *Castor fiber*, bank vole *Clethrionomys glareolus*, water vole *Arvicola* sp., field or common vole *Microtus agrestis* or *Microtus arvalis*, woolly mammoth *Mammuthus primigenius*, red deer *Cervus elaphus*, roe deer *Capreolus capreolus* and aurochs *Bos primigenius*. A record of fallow deer *Dama dama*, listed by Sutcliffe (in West and Sparks 1960) was not confirmed, while the record of hippopotamus *Hippopotamus amphibius*, listed by the same author, was found to have been based upon a specimen of straight-tusked elephant *Palaeoloxodon antiquus*.

Two states of preservation are apparent. Remains of *Equus ferus* from Bed 1 are brownish grey in colour, while specimens from Bed 2 are stained black. Both are very well-preserved.

Species list (Mammalia) from Selsey and West Wittering, West Sussex

**Insectivora**

*Sorex cf. araneus* L., common shrew
Primates
Homo sp., indet. hominid (artefacts)

Rodentia
Castor fiber L., beaver
Clethrionomys glareolus (Schreber), bank vole
Arvicola sp., indet. water vole
Microtus agrestis (L.)/ Microtus arvalis (Pallas), field or common vole

Proboscidea
Palaeoloxodon antiquus (Falconer and Cautley), straight-tusked elephant
Mammuthus primigenius (Blumenbach), woolly mammoth

Perissodactyla
Equus ferus Boddaert, horse
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros

Rhinocerotidae sp., indet. rhinoceros

Artiodactyla
? Megaloceros giganteus (Blumenbach), giant deer
Cervus elaphus L., red deer
Capreolus capreolus (L.), roe deer
Bos primigenius Bojanus, aurochs

Table 6.13 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
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<tbody>
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<td>Insectivora</td>
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<td></td>
</tr>
<tr>
<td>S. cf. araneus</td>
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<td>0.4</td>
<td>1</td>
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<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. fiber</td>
<td>1</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>C. glareolus</td>
<td>1</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>Arvicola sp.</td>
<td>4</td>
<td>1.63</td>
<td>2</td>
</tr>
<tr>
<td>M. agrestis or M. arvalis</td>
<td>1</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>33 (min.)</td>
<td>14.34</td>
<td>1</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>15</td>
<td>6.14</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
</tbody>
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<table>
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<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
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<tbody>
<tr>
<td>Perissodactyla</td>
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<td>1</td>
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<td><em>C. elaphus</em></td>
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<td>1</td>
</tr>
<tr>
<td><em>C. capreolus</em></td>
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<td>0.81</td>
<td>1</td>
</tr>
<tr>
<td><em>B. primigenius</em></td>
<td>35</td>
<td>14.34</td>
<td>2</td>
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</tbody>
</table>

Table 6.13 Breakdown of the mammalian species list from Selsey, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.13.5. Palaeoenvironmental and palaeoclimatic interpretation

Pollen spectra from the top of Bed 1 (zone b) are characterised by high non arboreal pollen (N.A.P.) values, indicating an open, relatively treeless regional vegetation (West and Sparks 1960). This is supported by the occurrence of *E. ferus* (West and Sparks *ibid*), a species which is considered to prefer open conditions. *Betula* and *Pinus* are the most abundantly represented tree species, while the N.A.P. component is dominated by Gramineae and Cyperaceae, with rich local aquatic and marsh vegetation also present. The majority of the plant macrofossil remains are from species that are found in Scandinavia, although five aquatic/marsh species have more southerly distributions. No arctic or subarctic indicators were recovered (West and Sparks *ibid*). The combination of thermophilous aquatic and marsh flora and treeless parkland elements suggests an environment that may have no modern analogue.

The unconformity between Beds 1 and 2 is interpreted as reflecting a fluctuating water level (West and Sparks *ibid*). This is supported by a change to a much more organic sediment with abundant wood fragments, a rise in *Salix* and Cyperaceae pollen and a reduction in macrofossils of aquatic plants, which suggests the development of marginal carr communities. An increase in arboreal pollen (A.P.) frequencies and a corresponding decrease in NAP is apparent in zone c, with *Betula* at first being the most abundantly represented tree taxon. The increase in *Betula* pollen, together with the
presence of a stone of *Prunus avium*, is interpreted as reflecting a slight amelioration in the climate. Further up the sequence in zone d, *Pinus* replaces *Betula* as the predominant tree pollen type and *Quercus* appears for the first time in significant quantities. Herb pollen is virtually absent but Filicales are common. *Quercus* becomes the dominant tree in zone e (represented by over 50% of the total tree pollen at the end of the zone). Thermophilous plants, including *Hedera* are present, together with a high proportion of shallow-water or marsh plants. Frequencies of herbaceous pollen remain low and regional forest cover is interpreted as being fairly complete by this time (West and Sparks *ibid*). Mammalian remains from the detrital mud are indicative of a range of environments, with both woodland and open habitats represented. Remains of *C. fiber*, *C. glareolus*, *P. antiquus* and *C. capreolus* attest to the presence of nearby deciduous or mixed woodland, while *M. agrestis/arvalis*, *M. primigenius*, *E. ferox*, *S. hemitoechus* and *M. giganteus* suggest the availability of open grassland. A nearby source of slow-moving or still water is indicated by *Arvicola* and *C. fiber*, and by a molluscan fauna dominated by *Planorbis laeva* and *P. crista* (West and Sparks *ibid*). The mammalian assemblage is representative of fully temperate conditions, a conclusion supported by the presence of *Emys orbicularis* from equivalent deposits at West Wittering, since this species requires minimum summer temperatures of 17-18°C for the incubation of its eggs (Stuart 1982). The presence of *Corbicula fluminalis* is also consistent with slightly warmer summers (West and Sparks 1960).

Zone f is characterised by high frequencies of *Quercus*, with *Corylus* also prominent. The thermophilous indicators *Hedera* and *Ilex* are also present, together with abundant aquatic and marsh flora, including *Hydrocharis morsus-ranae*, *Lemna cf. minor* and *Stratiotes aloides*, which fruit rarely or never in Britain today. Their presence therefore implies a considerable summer warmth, greater than that of the present day (West and Sparks *ibid*). A change from freshwater to estuarine conditions is indicated by the occurrence of *Hydrobia spp.*, *Scrobicularia plana* and *Phytia myosotis*, which suggests that brackish inter-tidal conditions in an estuarine environment prevailed (West and Sparks *ibid*). This change is accompanied by similar changes in the aquatic and marsh communities, as species tolerant of brackish conditions became more abundant.
6.13.6. Biostratigraphy and correlation

Mammalian studies

In accordance with the palaeobotanical correlation, the remains of *E. ferus* from Bed 1 were assigned to the late Wolstonian-early Ipswichian (zone Ip Ia) and the remainder of the assemblage (Bed 2) to Ip Ib - early IIb by Stuart (1976, 1982). However, re-examination of the evidence during the present study finds this correlation to be untenable on numerous accounts. According to Stuart (1976, 1982), zone Ip IIb faunas typically include *Dama dama* and *Hippopotamus amphibius*, the presence of the latter in particular being considered a crucial piece of evidence in the demonstration of an Ipswichian age for the Selsey deposits (Sutcliffe in West and Sparks 1960). However, it has since come to light that the original record was based on a misidentification (Parfitt *et al.* in prep.). *Hippopotamus* must therefore be dismissed from the Selsey species list, as must *D. dama* (listed by Sutcliffe, in West and Sparks 1960) but for which no evidence could be found during the present study. Stuart (1976, 1982) explained the presence of *Equus ferus* in zone Ip I at Selsey on account of the open grassland environment during the early part of the interglacial but stated that the “later horizons, zones Ib to early IIb, have yielded typical mid-Ipswichian taxa” (Stuart 1982, 125). This quite clearly is not the case, for in addition to the apparent absence of the two important mid-Ipswichian species (*Hippopotamus* and *Dama*) in Bed 2 (zone Ip Ib - IIb) at Selsey, these same deposits actually contain an assemblage that is characteristic of Stuart’s zone Ip III-IV fauna, including *M. primigenius* and *E. ferus*. This is a clear demonstration that the mammalian evidence does not tally with the palynological correlation.

The preferred interpretation of the Selsey interglacial deposits here attributes them to a pre-Last Interglacial temperate episode, equated with Stage 7 of the oxygen isotope record. An important component of the Selsey assemblage is the woolly mammoth *M. primigenius*. The small size of the *M. primigenius* molars and their low plate count fall within the range of the ‘Ilford type’ mammoth, considered to be a biostratigraphic indicator of Stage 7. The presence of the ‘Ilford type’ mammoth, in association with *Equus ferus* and *Homo* at Selsey argues very strongly against an Ipswichian age. The presence of *M. primigenius* also suggests that the Selsey deposits should be correlated with the later part of the Stage 7 interglacial (possibly Substage 7a), particularly in view
of the presence of *E. ferus*, *P. antiquus*, *S. hemitoechus*, *C. elaphus* and *B. primigenius*. The co-occurrence of these species is characteristic of the later part of the Stage 7 interglacial and is encountered at numerous other sites in Britain, including Ilford (Uphall Pit) (6.2) and Brundon (6.6).

**Malacological studies**

The presence of *Corbicula fluminalis* at Selsey is considered to indicate a pre-Ipswichian age for the deposits (Keen 1990; Bridgland 1994; Meijer and Preece 1995).

**Palynological studies**

The Selsey deposits were assigned on the basis of palynology to a period covering the terminal Wolstonian to zone Ip IIb of the Ipswichian interglacial. The palaeobotanical evidence was also considered comparable with that from Eemian sites on the continent, but differences were noted between the sequence from Selsey and that at the Ipswichian type-site as Bobbitshole (Suffolk), although these were considered to be of minor significance (West and Sparks 1960).

**6.13.7. Discussion and conclusions**

To conclude, the mammalian biostratigraphic evidence strongly suggests that the Selsey interglacial deposits should be correlated with Stage 7 of the oxygen isotope record, and more specifically with Substage 7a. This is on the basis of the extremely close similarity of the mammalian assemblage to that from the upper part of the sequence at the Stage 7 ‘type locality’ of Aveley (6.1) and Ilford (6.2), assemblages which are characterised by taxa preferring open but fully temperate conditions. Critical species include the ‘Ilford type’ mammoth and *E. ferus*, together with *P. antiquus* and large herbivores, including *M. giganteus*, *C. elaphus* and *B. primigenius*. The presence of *C. fluminalis* and *Homo* at Selsey is also considered to be of great significance, since both are considered here to indicate a pre-Ipswichian age, while the absence of both *D. dama* and *H. amphibius* in zone IIb deposits would also be surprising if Selsey were genuinely of Ipswichian age. The single record of *Equus ferus* from Bed 1 may therefore relate to either a short episode of cooler conditions prior to the main temperate episode, *i.e.*
Substage 7b, or may be even older (the hiatus between Beds 1 and 2 preventing establishment of the length of time elapsed). Although the attribution of the Selsey temperate-episode deposits to the Ipswichian is contested here, the mammalian evidence nevertheless fits well with the vegetational sequence established by the pollen.

A Stage 7 correlation is also supported on altimetric grounds, since the Selsey raised beach was correlated with that at Black Rock, Brighton (West and Sparks 1960), a site now widely held to be of OIS 7 age (Keen 1995). Aminostratigraphic studies have also favoured a Stage 7 attribution. Ratios of 0.165± 0.019 and 0.154± 0.02 were obtained from Corbicula fluminalis and Valvata piscinalis respectively (Bowen et al. 1989), although the shells did not come from the same channel as that investigated by West and Sparks (Stinton 1985). A similar ratio of 0.164± 0.014 was obtained on C. fluminalis from West Wittering (Bowen et al. 1989).

In summary, the combined evidence from mammalian and molluscan biostratigraphy, archaeology, the altitude of the deposits and amino acid geochronology place the Selsey temperate deposits in the Stage 7 interglacial, an episode apparently indistinguishable on palynological grounds from the Last Interglacial.
6.14 STONE POINT, HAMPshire (SZ 457984)

6.14.1. Location of the site

The fossiliferous estuarine deposits are located on the foreshore at Stone, between Stone Point and the mouth of the Beaulieu River (Figure 6.35).

Figure 6.35 The coast at Stone, Hampshire (modified from Sparks and West 1960).

6.14.2. History of research

The deposits at Stone were first described by Reid (1893), who believed them to be the same age as the fossiliferous muds at Selsey and West Wittering (6.13). Reid (ibid) described an interglacial estuarine clay containing an elephant tusk and abundant brackish water Mollusca and plant remains, overlain by a gravel containing artefacts. Later investigations were carried out by West and Sparks (1960), who assigned the temperate-climate deposits to the Ipswichian, on the basis of palynology. Further investigations were undertaken by Brown et al. (1975) and Green and Keen (1987).

6.14.3. Geological background and provenance of mammalian remains

The interglacial deposits at Stone Point lie within the estuary of the former Solent River and are attributed to the Lepe Gravel Member of the New Forest Formation (Brown et
al. 1975; Green and Keen 1987). West and Sparks (1960) and Brown et al. (1975) recorded the presence of a lower gravel, unconformably overlain by fossiliferous interbedded freshwater peats and estuarine clays up to at least 2m O.D. The lower gravel was considered by Brown et al. (1975) to be the product of torrential depositional conditions in braiding fluvial channels, during a cold period prior to the temperate episode represented by the organic peats and clays. The organic deposits were reported to pass beneath the coarse upper gravel which forms the cliff, this in turn being overlain by approximately 1m of brickearth. The upper gravel was interpreted by West and Sparks (1960) as a raised beach deposit, although this was disputed by Brown et al. (1975), who considered it to be of fluvial origin. Evidence of periglacial disturbance was also noted within the upper gravel (Green and Keen 1987). Although subsequent erosion by the sea has altered the exposures, Brown et al. (ibid) observed that the lower gravel unit could be traced into the cliff, where it was directly overlain by the upper gravel, the intervening organic beds being apparently absent. Following attribution of the organic deposits to the Ipswichian Interglacial by West and Sparks (1960), the overlying gravel and brickearth were interpreted by Brown et al. (1975) and Green and Keen (1987) as Devensian in age.

However, examination of the brickearth deposits which overlie the terrace gravel capping the brackish muds has revealed the presence of a palaeosol of interglacial type, suggested by Reynolds (1987) to have been formed during the Last Interglacial. If this is correct, the underlying fossiliferous muds at Stone Point must be of Stage 7 age or older (Keen 1995; Allen et al. 1996). The similarity of the stratigraphy at Stone Point to that at Selsey, approximately 40km to the east (6.13), in terms of both the altitude of the deposits and their inferred age, suggests that both sets of deposits were laid down in an interglacial prior to the Ipswichian.

6.14.4. Palaeontology

The mammalian remains were not seen during the present study and the following species list has therefore been compiled from Reid (1893) and Brown et al. (1975). The presence of 2 species is noted.
Species list (Mammalia) from Stone Point, Hampshire

Proboscidea
Elephantidae. cf. *Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant

Artiodactyla
*Dama dama* L., fallow deer

6.14.5. Palaeoenvironmental and palaeoclimatic interpretation

The pollen spectra from the freshwater peats at Stone Point were considered by West and Sparks (1960) to be characteristic of the early-temperate stage of an interglacial. High frequencies of *Quercus* were noted, with *Corylus* also prominent. The thermophilous indicators *Hedera* and *Ilex* are also present, together with abundant aquatic and marsh flora. Their presence therefore implies a considerable summer warmth, greater than that of the present day (West and Sparks *ibid*). As at Selsey (6.13), the change from freshwater to estuarine conditions is indicated by the occurrence of *Hydrobia* spp., *Scrobicularia plana* and *Phytia myosotis*, which suggests that brackish inter-tidal conditions in an estuarine environment prevailed (West and Sparks *ibid*; Brown *et al.* 1975). The Mollusca are indicative of open foreshore habitats and saltmarsh. No freshwater species are recorded, suggesting that freshwater streams did not drain into this area. The rise in sea level appears to have been interrupted on several occasions, as witnessed by the development of horizons of *Phragmites* peat (Brown *et al.* *ibid*). The mammalian remains are consistent with fully forested interglacial conditions, since both *Palaeoloxodon antiquus* and *Dama dama* are known only from temperate woodland episodes (Stuart 1982).


Mammalian studies

The mammalian assemblage does not contain any species of biostratigraphic significance. Both *Palaeoloxodon antiquus* and *Dama dama* are known from the
Hoxnian, Stage 9 and Ipswichian Interglacials, although *Dama dama* is not known from the vast majority of sites attributed to Stage 7.

**Palynological studies**

The organic deposits were attributed to Substage IIb of the Ipswichian Interglacial by Sparks and West (1960).

**6.14.8. Discussion and conclusions**

The sequence at Stone Point is a difficult one to interpret and several lines of evidence must be employed in the discussion of the age of the deposits. As a starting point, it is necessary to first consider the elevation of the deposits. The similarity in height of the temperate-climate deposits at Stone Point to those at Selsey (6.13) and the raised beach at Black Rock, Brighton (7.7) is a strong indication that the Stone Point sequence predates the Ipswichian Interglacial. Both Selsey and the Brighton raised beach are now widely regarded as being of Stage 7 age (Keen 1995; 6.13; 7.7). A pre-Ipswichian age is also supported by comparison of the Stone Point sequence with that from Pennington, Hampshire, also within the Solent River terrace system. Here, freshwater pollen and Mollusca, suggestive of an Ipswichian (Substage 5e) age, occur between -3.9 and -5.3m O.D., in a separate, lower terrace (Allen *et al.* 1995). The difference in height and relative position of the Stone Point and Pennington sequences within the Solent River terrace staircase strongly implies that they belong to separate interglacials, with Stone Point being the older. In addition, the recognition of a palaeosol attributed to Substage 5e (Reynolds 1987) within the brickearth overlying the upper gravel at Stone Point provides corroborative evidence that the organic deposits below must pre-date the Ipswichian.

However, the mammalian evidence is rather different to that recovered from nearby Selsey, in that *Dama dama* (a species not generally recognised in the Stage 7 mammal fauna) is present. A possible explanation for this is that the Stone Point temperate-climate deposits relate to an earlier part of the Stage 7 interglacial than Selsey. An important precedent for this has been identified in the present study at Itteringham, where *Dama dama* and *P. antiquus* are also present, in deposits tentatively attributed to
Substage 7c (7.3). The correlation of the Stone Point mammalian assemblage with an early temperate episode in the Stage 7 interglacial would also correspond well with the palaeoecological information from the two mammalian species represented, which indicate the presence of deciduous woodland. Parallels for this exist not just in the organic deposits at Itteringham, but also in the lower part of the sequence at Aveley (6.1), where *P. antiquus* has been found in association with a range of other obligate temperate and woodland indicators. That the Stone Point organic deposits may be slightly older than those at Selsey is supported by the lower elevation of the latter organic deposits, which lie on or just below O.D. (West and Sparks 1960). This would be consistent with a small separation in time, although still within the same interglacial.

It is therefore concluded that the Stone Point temperate-climate deposits should be correlated with the Stage 7 interglacial. This is based upon their position pre-dating deposits of Substage 5e age at Pennington, their position stratigraphically below a palaeosol of putative Substage 5e age and their broadly comparable elevation with other deposits attributed to Stage 7, such as Selsey (6.13). However, the presence of *Dama dama* and *Palaeoloxodon antiquus* suggests that the Stone Point assemblage may relate to an earlier part of the Stage 7 interglacial than Selsey, a supposition that is supported by the slightly higher elevation of the Stone Point deposits. Similarity is suggested with the lower part of the sequence at Aveley (6.1) and the organic deposits (Bed d) at Itteringham (6.3), which are believed to represent the early temperate woodland peak in Stage 7. Correlation of the mammalian assemblage from Stone Point with Substage 7c is therefore tentatively suggested.
6.15. BIELSBECK FARM, near MARKET WEIGHTON, EAST YORKSHIRE (SE 861378)

6.15.1. Location of the site

Bielsbeck Farm (sometimes spelt Bielbecks, Bealbecks or Beele Beck) is located in the Vale of York, approximately 1.25km south of Market Weighton and 625m north-west of North Cliff. A plan of the 1908 excavations by Lamplugh et al. (1910) is shown in Figure 6.36.

Figure 6.36 Plan of excavations at Bielsbeck Farm
(modified from Lamplugh et al. 1910).
6.15.2. **History of research**

The first published reference to the site is by Harcourt (1829) who described the discovery of remains of elephant, rhinoceros, deer, ox, horse and lion, buried in marl deposits beneath gravel. Extraction in the pit began in 1828, when a single bone was recovered, but the remainder of the assemblage was excavated in the summer of 1829. Harcourt recognised that several changes in climate had occurred since deposition of the bones but had no idea of their great antiquity, believing, as he did, that the earth was only 4000 years old. Investigations into the deposits were later carried out by the British Association Committee (Lamplugh et al. 1908b, 1910). Further references to the site are provided by Dawkins (1867a), Lamplugh (1898), Sheppard (1903), Kendall and Wroot (1924), Stather (1925), Melmore (1935), Boylan (1977) and Sutcliffe (1995a). The original marl pit had become flooded by 1908 and the surrounding land is still under agriculture.

6.15.3. **Geological background and provenance of mammalian remains**

In the south-eastern Vale of York, a bench of Lias extends northwards from the River Humber Market Weighton, where it follows the south-western foot of the Wolds escarpment. The fossiliferous Pleistocene deposits are described by Harcourt (1829 and Lamplugh et al. 1910) as resting on red Keuper Marl, near the boundary with the Lias, in a hollow in a former land surface. Harcourt (1829) described the following section in the marl pit from which the bones were recovered (Figure 6.37):

5. Black sand, 9 inches (0.23m)
4. Yellow sand, 1 foot 6 inches (0.45m)
3. White gravel consisting of small pebbles of chalk, with angular fragments of flint, with a few pieces of *Gryphaea* incurva, and fewer pebbles of sandstone, 2 foot 6 inches (0.75m)
2. Blue marl, containing bones and irregularly penetrated by the gravel, 5 feet (1.5m)
1. Commencement of a blacker marl, containing bones, land, marsh and freshwater Mollusca, Coleoptera and plant remains, at least 10 feet (3m)
Mammalian remains, including horns of *Bos primigenius* and jaws of *Panthera leo* reportedly came from the blacker marl (Bed 1), whereas antlers of *Cervus elaphus*, an elephant femur and rhinoceros remains were recovered from Bed 2. Similar sequences were reported by Lamplugh *et al.* (1908b), although with bed thicknesses greater than those recorded by Harcourt.

![Figure 6.37 Section through the deposits at Bielsbeck Farm](modified from Harcourt 1829).

### 6.15.4. Palaeontology

The following species list has been compiled from material housed in the Yorkshire Museum and collected by Harcourt and the British Association. Ninety-six specimens were examined during the present study and the presence of 11 mammalian species confirmed. Preservation of the bones is generally fresh, suggesting that they were not transported far from where they were originally deposited.

**Species List (Mammalia) from Bielsbeck, East Yorkshire**

**Carnivora**

*Canis lupus* L., wolf

*Ursus arctos* L., brown bear

*Panthera leo* (L.), lion
**Proboscidea**
*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant
*Mammuthus primigenius* (Blumenbach), woolly mammoth
Elephantidae sp., indet. elephant

**Perissodactyla**
*Equus ferus* Boddaert, horse
*Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros
Rhinocerotidae sp., indet. rhinoceros

**Artiodactyla**
*Cervus elaphus* L., red deer
*Capreolus capreolus* (L.), roe deer
*Bos primigenius* Bojanus, aurochs
*Bison priscus* Bojanus, bison
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 6.14 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

6.15.5. **Palaeoenvironmental and palaeoclimatic interpretation**

Although the assemblage is relatively small, some deductions can nevertheless be made about the environment at the time of deposition. The presence of open grassland is suggested by the presence of *M. primigenius*, *Equus ferus*, *Stephanorhinus hemitoechus* and large bovids, while woodland habitats are indicated by *U. arcios*, *P. antiquus* and *C. capreolus*. The mammalian assemblage is fully interglacial in character, as indicated by the presence of *P. antiquus*, *S. hemitoechus*, *C. capreolus* and *B. primigenius*, which are known only from temperate episodes in the Pleistocene. The Mollusca from the black marl (Bed 1) include land, marsh and freshwater species, with *Lymnaea* and *Planorbis* being the most abundant (Harcourt 1929). Plant remains, including *Ranunculus*, *Viola*, *Rumex*, *Sparganium* and *Carex* were also recorded (Reid, in Lamplugh et al. 1908b), together with coleopteran remains, including *Donacia* and *Hister* (Lamplugh et al. *ibid*) and bones of an indeterminate duck (Melmore 1935).
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
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<td></td>
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<td><em>C. lupus</em></td>
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</tr>
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<td><em>U. arctos</em></td>
<td>3</td>
<td>3.12</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
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<td>7</td>
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</tr>
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<td></td>
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</tr>
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<td>15</td>
<td>15.62</td>
<td>4 (1 juv., 3 adults)</td>
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<td>11</td>
<td>11.45</td>
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<td>1</td>
</tr>
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<td>Rhinocerotidae sp.</td>
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<td>1 juv.</td>
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<td>Bovidae sp.</td>
<td>4</td>
<td>4.16</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
</tbody>
</table>

Table 6.14 Breakdown of the mammalian species list from Bielsbeck, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.15.6. Biostratigraphy and correlation

Mammalian studies

The Bielsbeck mammalian assemblage is extremely similar to that from the upper part of the sequence at Aveley (6.1, Ilford (Uphall Pit) (6.2) and Brundon (6.6) and contains all the elements required for correlation with Stage 7 age, as will be demonstrated below:

A critical factor is the co-occurrence of *Palaeoloxodon antiquus* with *Mammuthus primigenius*, a combination which is not known from any other interglacial. Rather unusually, remains of *P. antiquus* from Bielsbeck outnumber those of *M. primigenius*. It is possible that some of the indeterminate elephant material may also be of the latter species, although factors such as local conditions or taphonomy may be accountable for the predominance of the former. The single molar of *M. primigenius* is of small size
and has a low plate index measurement of 8, thus conforming to the criteria required for the ‘Ilford type’, a primitive morphotype considered to be diagnostic of the Stage 7 interglacial.

Other significant elements of the Bielsbeck assemblage include *Equus ferus* (11.45% of the assemblage), abundant large bovids (17.69% of the assemblage), of which *Bos primigenius* is more common than *Bison priscus* (10 specimens compared to 3) and moderately abundant *Cervus elaphus* and *Stephanorhinus hemitoechus* (3.12% each of the assemblage). The Bielsbeck Carnivora are represented by a large form of *Panthera leo*, in association with *Canis lupus* and *Ursus arctos*.

No malacological or palynological biostratigraphic studies are known.

6.15.7. Discussion and conclusions

To conclude, the mammalian biostratigraphic evidence strongly suggests that the Bielsbeck interglacial deposits should be correlated with Stage 7 of the oxygen isotope record. This is on the basis of the extremely close similarity of the mammalian assemblage to that from the upper part of the sequence at Aveley (6.1) and Ilford (6.2). Critical species include the ‘Ilford type’ mammoth and *E. ferus*, together with *P. antiquus*, a large form of *P. leo* and large herbivores, including *S. hemitoechus*, *C. elaphus*, *B. primigenius* and *B. priscus*. The combined presence of these large grazing species is most consistent with the later part of the interglacial (possibly Substage 7a).
6.16. STOKE GOLDINGTON, BUCKINGHAMSHIRE (SP 852493)

6.16.1. Location of the site

The site is located in a gravel pit in the valley of the River Great Ouse, approximately 5km NNW of Newport Pagnell (Figure 6.38).

![Figure 6.38 Location of Stoke Goldington (modified from Green et al. 1996).]

6.16.2. History of research

Between 1981 and 1985, a sequence of Pleistocene deposits was exposed in a gravel pit near Stoke Goldington. Investigations into the stratigraphy and palaeontology of the site were carried out by Green et al. (1996). A rich fossil assemblage was recovered from the base of the succession, including pollen, plant macrofossils, molluscs, insects and occasional vertebrates. The nature of the faunal assemblages, in addition to corroborative evidence from Uranium-series dates and amino acid racemisation ratios, led Green et al. (ibid) to propose a Stage 7 age for the site.

6.16.3. Geological background and provenance of mammalian remains

The Stoke Goldington site lies within the valley of the Great Ouse River, beneath a terrace flat at approximately 7m above the present-day floodplain. Horton et al. (1974b) recognised a series of low terraces upstream of Newport Pagnell. The First and Second
Terraces (at 0.6-2m and 0.2-4.5m above the modern floodplain) were assigned to the Devensian by Horton et al. (ibid) on the basis of palynological analogy with terraces below Bedford, from which Early Devensian pollen spectra have been reported (Bell 1970). Deposits of Mid- or Early Devensian age have also been described by Rogerson et al. (1992) from beneath the lowest terrace at Radwell, while Ipswichian material (including remains of *Hippopotamus*) is known from other low terraces near Bedford (Wyatt 1861, 1864; Prestwich 1861, 1864) and at Galley Hill near St. Ives (Preece and Ventris 1983). A Third Terrace has also been identified downstream from Bedford at 8.5-13m above the floodplain (Dury 1952; Edmonds and Dinham 1965; Horton 1970) and at Biddenham (Prestwich 1861, 1864; Wyatt 1862, Harding et al. 1992). A buried channel containing glacial and fluvio-glacial deposits of presumed Anglian age has been mapped in several places beneath the modern floodplain (Horton 1970) and the whole terrace system is known to post-date deposition of the chalky till (Dury 1852; Horton et al. 1974b), widely held to be of Anglian age (Perrin et al. 1979).

The base of the terrace at Stoke Goldington is at approximately 50m O.D. To the north of the quarry, the Upper Lias bedrock has been recorded at 63m O.D. The following stratigraphic sequence is described in Green et al. (1996) (Figure 6.39):

Bed g: Upper Gravel (1.8-4.4m). In the northern part of the quarry, this bed rests directly on top of Bed e. The base of the gravel rises from west to east, suggesting an erosional unconformity, but the boundary with the underlying deposits appears to be gradational. Many beds of loamy sand were present, particularly in the lower part, also chalk; clast size is small and the bedding is often disturbed. The Upper Gravel is generally overlain by a loamy horizon (up to 0.5m) upon which the modern soil is developed. The surface of the upper gravel forms the terrace flat.

Bed f: Upper Channel deposits, consisting of clays, loams or clayey sands, with minor horizons of fine chalky gravel. This bed is absent in the southern part of the quarry but in the middle was approximately 0.7m thick, with a discontinuous clay horizon, in which shells were patchily preserved. These sediments thicken northwards until they are over 3.5m thick and contain several shelly horizons.

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Bed e: Middle Gravel (1.9-3.7m), horizontally well-bedded gravel with sand-filled channels. Clasts up to 31.5mm in diameter. Remains of *Mammutthus primigenius* and *Equus ferus* were present.

Beds b-d: Lower Channel deposits, filling a channel-like depression in the lower gravel (Bed a). The apparent width of the depression was about 20m but the full depth was not visible. However, a thickness of 1.72m of sediment was proved in the axis of the depression, which was estimated to be aligned in a broadly east-west direction. The upper surface of the channel infill attained a height of 52.25m O.D.

Bed d (0.25m) sandy clay with conspicuous colour banding (light grey and ferruginous brown). Shells were present, although becoming less common higher up. The lower boundary with Bed c was sharp.

Bed c² (0.05-0.07m) shelly clay, light grey above and darker with ferruginous mottling below; moderately sharp lower boundary.

Bed c¹ (0.25m) shelly clay, with lenses and irregular inclusions of sand; light grey with darker grey mottling; moderately sharp lower boundary. Remains of elephant, fish and frog present.

Bed c¹ (0.06-0.07m) clay with scattered pebbles; dark grey with ferruginous mottling; plant debris.

Bed b² (0-0.15m) shelly sandy clay with pebbles; light grey with ferruginous mottling; moderately sharp, inclined lower boundary.

Bed b¹ (0-0.15m) sandy clay with gravel; light grey with much ferruginous mottling; shells abundant, molar of *Microtus oeconomus* also present; poorly defined horizontal lower boundary.

Bed a: Lower Gravel (0.5-0.55m), horizontally bedded, free-running gravel; ferruginous brown with 3 iron pan layers in upper 10cm; lag deposit at base comprising single layers of cobbles up to 20cm in diameter. Remains of a large bovid were also present. This gravel resembles fluvial gravels elsewhere between the Newport Pagnell and the Ouse-Ivel confluence but is separately recognisable from Bed e only where it is overlain by the lower channel deposits.
Base: Upper Lias Clay (51m O.D.), very dark bluish grey, weathered to dark ferruginous brown at boundary with overlying gravel.

![Figure 6.39 Section across the Stoke Goldington deposits](modified from Green et al. 1996)

Horizontal stratification in the gravels, both above and below the lower channel deposits, indicates deposition by high-stage flows in a braided river (Green et al. ibid). It is the deposits of the Lower Channel and their underlying and overlying gravels that are of interest to the present study.

**6.16.4. Palaeontology**

The mammalian remains from Stoke Goldington were not seen in the present study and the following species lists have therefore been compiled from Green et al (ibid). The Upper Gravel has yielded 2 taxa, the Lower Channel deposits 2 taxa and the Lower Gravel a single taxon.

**Species List (Mammalia) from Stoke Goldington, Buckinghamshire**

**Lower Gravel:**

**Artiodactyla**

Bovidae sp., indet. large bovid (*Bos* or *Bison*)
Lower Channel deposits:

**Rodentia**

*Microtus oeconomus* (Pallas), northern vole

**Proboscidea**

Elephantidae sp., indet. elephant

Upper Gravel:

**Proboscidea**

*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Perissodactyla**

*Equus ferus* Boddaert, horse

6.16.5. **Palaeoenvironmental and palaeoclimatic interpretation**

The mammalian remains from the Lower Gravel are represented only by a single specimen of a large bovid, which suggests the availability of open grassland in the vicinity of the site. The occurrence of *Bos* in Pleistocene deposits is restricted to temperate episodes, whereas *Bison* is known from both cold and temperate episodes. The presence of this specimen in braided river deposits with a high energy flow, indicates that the climate was probably cold.

Pollen spectra from the Lower Channel deposits at Stoke Goldington are indicative of predominantly open herbaceous vegetation. Pollen of Gramineae is most abundant, together with dry-ground herbs, indicating a valley largely covered by herb-rich calcareous grassland with some disturbed ground. Aquatic plants are also represented (5-15% of the total pollen and spores), with *Potamogeton, Stratiotes, Hydrocharis, Sparganium* and *Nymphaea* most abundant. These suggest the presence of a fairly shallow body of still or slowly-moving water, with a fine substrate. The existence of a floodplain pool, surrounded by wetland is therefore inferred. Low frequencies of arboreal pollen were also recovered, mainly of *Alnus, Betula, Salix, Ribes* and *Populus*, suggesting that these trees and shrubs were present at the water’s edge. Other tree and shrub pollen comprises mainly *Picea* and *Pinus* (although the latter may be over-represented since it is a high pollen producer). Small amounts of *Carpinus, Abies, Corylus, Ilex, Juniperus* and Ericales were also recorded, indicating the presence of
stands of open mixed woodland upon the interfluves (Green et al. 1996). Many of the taxa represented are climatically tolerant and have wide modern ranges. However, arctic species are absent and several of the aquatic plants have present-day lowland distributions, with distributional ‘cores’ further south and east in Europe. A temperate climate is therefore proposed (Green et al. ibid).

The molluscs from the Lower Channel are fully temperate in character and suggests a climate similar to that in Britain at the present day, or possibly slightly more continental. The assemblage from Bed b1 may be divided into three biozones. The first is characterised by species inhabiting well-oxygenated moving water, with a sandy or fine gravel substrate, such as *Valvata piscinalis*, *Bithynia tentaculata*, *Pisidium moitessierianum*, *Corbicula fluminalis* and *Ancylus fluviatilis*. Species characteristic of riverside marshes, wet floodplains, dry grassland and woodland are also present, probably washed in as a result of over-bank flooding. In biozone 2, the predominant mollusc is *Gyraulus laevis*, which prefers clean, well-oxygenated still water. *Pisidium nitidum*, *P. casertanum*, *Sphaerium corneum* and *S. lacustre* are also recorded. The presence of these species implies a transition from moving water to a shallow floodplain pond that became gradually infilled. Biozone 3 is dominated by taxa favouring a muddy and organic-rich water body, such as *Armiger crista*, *Hippus complanatus* and *Acroloxus lacustris*. The trend towards marshy conditions is confirmed by increases in *Lymnaea truncatula* and *Oxyloma pfeifferi*. The absence of moving water species suggests that the pond was completely isolated from fluvial circulation. Some grassland species are also present, including *Vallonia costata* and *Pupilla muscorum*. The scarcity of land snails accompanies diminution of the absolute number of molluscs recovered at the top of the sequence. This may reflect adverse conditions, caused by the final silting-up of the pond, or climatic deterioration (Green et al. ibid).

The presence of a pond or sluggish stream is supported by the ostracod fauna from the Lower Channel, which is dominated by *Candona* spp. and *Herpetocypris* spp. This is consistent with an interpretation of a meander cut-off or floodplain pond environment (Green et al. ibid).

The mammalian remains from the Lower Channel consist of *Microtus oeconomus* and an indeterminate elephant. *M. oeconomus* is today absent from the British Isles and is
most widely distributed in the tundra and taiga zones of northern Europe. Its presence at Stoke Goldington suggests the availability of areas of grassland adjacent to the site and that a more continental climate prevailed than at present.

The Coleoptera from Bed c are indicative of a still or slow-moving aquatic environment. No species characteristic of running water are present, thereby confirming the inferences from the molluscs and ostracods that the pond was isolated from the main river channel. The presence of reeds in the immediate vicinity of the pond is indicated by Notaris bimaculatus, while Carabus granulatus, Loricera pilicornis, Pterostichus nigrita, Calathus melanopephalus and Bembidion obtusum indicate the proximity of meadows. An increase in Glyceria (sweetgrass) at the top of the sequence is indicated by the rise in numbers of Donacia semicuprea and Notaris acridulus. An important feature of the Stoke Goldington coleopteran assemblage is the abundance of dung beetles, particularly Oxytelus gibbulus. This implies that large herbivorous mammals were common in the neighbourhood, perhaps explaining the rarity of trees at this time (Coope et al. 1961; de Rouffignac et al. 1995). Fully temperate climatic conditions, similar to those in Britain today, are suggested by the beetle assemblage, although the presence of O. gibbulus and Aploderus caesus (both central European species at the present day), implies an element of continentality.

The mammalian assemblage from the Upper Gravel is consistent with an open environment, as attested to by the presence of Equus ferus and Mammuthus primigenius. Both these species are known from cold and temperate periods alike, although their occurrence in braided river deposits suggests that the climate had become cooler.

6.16.6. Biostratigraphy and correlation

Mammalian studies

The mammalian remains from the Stoke Goldington deposits unfortunately contain no species of biostratigraphic significance, although the overall composition of the assemblage is consistent with the Stage 7 age inferred from other sources. The Lower Gravel is considered here to reflect a period of cold climatic conditions, prior to the
infilling of the Lower Channel, although no biostratigraphic conclusions can be gleaned from the presence of the indeterminate large bovid. The presence of *Microtus oeconomus* in the Lower Channel is however consistent with a Stage 7 age, since this species appears to have become the dominant element in the British microtine fauna during this period. Its presence has been noted at other sites attributed to Stage 7 in the present study, including the Lower Channel at Marsworth (6.10), Crayford (6.18) and Bleadon Cave (6.22). The mammalian remains from the Upper Gravel comprise *Equus ferus* and *Mammuthus primigenius*, although it is not known whether the latter is of 'Ilford type', the primitive form that is specifically diagnostic of the Stage 7 interglacial, or of the more advanced type, which is found in both Stage 7 and later deposits.

**Malacological studies**

The molluscan assemblage from the Lower Channel at Stoke Goldington contains no species of biostratigraphic significance, with the exception of *Corbicula fluminalis*. The presence of this species strongly suggests a pre-Ipswichian age for the deposits (Keen 1990; Green *et al.* 1996)

**Coleopteran studies**

The abundant presence of *Oxytelus gibbulus* at in the Stoke Goldington Lower Channel is considered to be of biostratigraphic significance. This species is known from rare specimens in the Early or Middle Devensian at Upton Warren (Coope *et al.* 1961) and from a single individual each in Ipswichian deposits at Coston and in presumed Hoxnian deposits at Trysull (Coope, in de Rouffignac *et al.* 1995). However, during Stage 7, this species apparently became extremely abundant, to the extent that it is the dominant species in the coleopteran assemblages from Aveley (6.1), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Strensham (6.17). Correlation of the Stoke Goldington Lower Channel with these localities (and consequently with a post-Hoxnian/pre-Ipswichian Stage 7 temperate episode) is therefore suggested (Green *et al.* 1996). This is supported by the presence of *Stomodes gryosicollis* and *Heterhelus scutellaris*, the only other known occurrences of which are in the Lower Channel at Marsworth (Green *et al.* *ibid*).
Palynological studies

Although palynological evidence has to date been unable to identify a diagnostic Stage 7 flora, nevertheless, similarity between the flora from Stoke Goldington and that from Lower Channel at Marsworth (6.10) and Strensham (6.17) was noted, on the basis of the predominance at all three sites of open-ground temperate plant communities (Green et al. 1996). At Marsworth and Strensham, other environmental and stratigraphic evidence strongly indicates that they should be correlated with the Stage 7 interglacial. An equivalent age for the Stoke Goldington deposits is therefore inferred. The Stoke Goldington flora also compares closely with that from the Saalian Hoogeveen temperate episode of the northern Netherlands, in terms of the arboreal and shrub taxa represented (Green et al. ibid). Although slight differences are present, for example the occurrence of Abies at Stoke Goldington (possibly due to long-distance transport of this species), the accumulated evidence favours a Stage 7 age for the Lower Channel at Stoke Goldington, on the basis of its similarity to other localities where a Stage 7 age has been securely established on both stratigraphic and mammalian biostratigraphic grounds.

6.16.7. Discussion and conclusions

In conclusion, the combination of evidence from multiple sources is strongly indicative of a Stage 7 age for the Stoke Goldington Lower Channel. The mammalian evidence is consistent with this interpretation, although the assemblage is extremely small. The presence of M. oeconomus is the most significant aspect of the fauna and suggests correlation with the later, rather than earlier, part of the Stage 7 interglacial. The occurrence of this species, taken together with the evidence from the coleopteran assemblage in particular (especially the abundant presence of Oxytelus gibbulus), strongly implies age-equivalence with sites such as the Lower Channel at Marsworth (6.10). A Substage 7a correlation is therefore tentatively proposed. The pollen evidence also compares closely to sites of this age, while the presence of Corbicula fluminalis is a good indication that the Lower Channel pre-dates the Ipswichian Interglacial. A Stage 7 correlation is also consistent with terrace stratigraphy in the Great Ouse, since the Stoke Goldington terrace occupies an intermediate position between the low terraces at Radwell, Bedford and Galley Hill (all containing faunal assemblages of Ipswichian age) and the Third Terrace at Biddenham (considered to contain interglacial deposits of
possible Stage 9 age, D.R. Bridgland pers. comm.). Amino acid ratios on molluscs from the Lower Channel of $0.146 \pm 0.014$ (Green et al. 1996) fall within one standard deviation of the range established for Stage 7 at Stanton Harcourt ($0.16 \pm 0.016$, Bowen et al. 1989). The Lower Gravel is therefore interpreted as a cold-climate aggradation prior to deposition of the Lower Channel (7 Substage 7b), whereas the Upper Gravel is considered here to represent the post-taureate episode (possibly the onset of Stage 6). The occurrence of *Equus ferus* and *Mammuthus primigenius* in the latter is paralleled at a range of other sites where cold-climate deposits overlie channel-infills of Stage 7 age, such as Marsworth (7.4) and Stanton Harcourt (7.5).
6.17 UPPER STRENSHAM, WORCESTERSHIRE (SO 904397)

6.17.1. **Location of the site**

The site is in the grounds of a water pumping station at Upper Strensham in the lower Avon valley, approximately 8.5km NNE of Tewkesbury (Figure 6.40).

![Location of Strensham and the distribution of Pleistocene deposits in the Avon valley](image)

Figure 6.40 Location of Strensham and the distribution of Pleistocene deposits in the Avon valley (modified from de Rouffignac et al. 1995).

6.17.2. **History of research**

During excavations for a pumping station at Upper Strensham in July 1990, a 3.9m sequence of Pleistocene fluvial and colluvial sediments was exposed, overlying Lias Clay bedrock. An organic horizon at the base of the sequence yielded rich faunal and floral remains, including a disarticulated skeleton of a mammoth, which was recorded and sampled by the Hereford and Worcester County Archaeological Service and G.R. Coope (de Rouffignac et al. 1995).
The Strensham site lies within the lower valley of the River Avon, beneath a well-defined terrace surface at 43m O.D. The Avon valley has been the focus of numerous investigations since the early part of the 19th century, the most significant early work being by Tomlinson (1925), who identified the presence of five altitudinally distinct terraces, which she numbered from one (the lowest) to five (the highest) (see Pershore 5.5, Twynning 7.8). Recent re-investigation of this sequence by Bridgland et al. (1989), Maddy (1989) and Maddy et al. (1991) has confirmed the units identified by Tomlinson and proposed a model of river terrace development, incorporating the sediments underlying the five terraces as members of an Avon Valley Formation (Maddy et al. 1991, see Figure 2.9).

The following description of the Strensham deposits is from de Rouffignac et al. (1995):

<table>
<thead>
<tr>
<th>Bed</th>
<th>Description</th>
<th>Thickness (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Sands, gravelly sands and silts and clays</td>
<td>3.9</td>
</tr>
<tr>
<td>4</td>
<td>Fossiliferous blue-grey clay (7.5YR 5/0), with occasional gravel stringers</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>Grey, medium, clayey gravels</td>
<td>0.15</td>
</tr>
<tr>
<td>2</td>
<td>Medium to fine orange sandy gravels</td>
<td>0.28</td>
</tr>
<tr>
<td>1</td>
<td>Lias Clay</td>
<td></td>
</tr>
</tbody>
</table>

The gravels of Bed 2 have a composition typical of Avon valley gravels, being dominated by quartz (38%), quartzite (22%) and flint (24%).

The terrace under which the Strensham fossiliferous deposits lie unfortunately cannot be attributed directly to any of those identified by Tomlinson (1925). This is because the altitude of the terrace surface lies 7m below the projected Terrace No. 5 surface and 7m above the projected surface of Terrace No. 4 in this area of the valley. Furthermore, the
Strensham deposits are separated from the sediments underlying Terrace No. 4 by a bedrock step, and thus form a morphostratigraphically separate sediment body (de Rouffignac et al. 1995).

However, despite the poor quality of the sedimentological information, it seems unlikely that the Strensham deposits form part of the Pershore Member, considered by Maddy et al. (1991) to span isotope stages 9-8 (5.5). The fact that the sediments of the Ailstone Member, which are assumed to underlie Terrace No. 4, were also observed to be distinct from those at Strensham, suggests that the latter constitute a previously unrecognised lithostratigraphic unit. However, Stage 7 interglacial sediments are known from the Ailstone Fossil Bed at the base of the Ailstone Member some 50km upstream (Bridgland et al. 1989), thus suggesting a broad time-equivalence between the fossiliferous deposits at Strensham and at least part of the Ailstone Member. Accordingly, it is suggested that the new lithostratigraphic unit, the Strensham Member, should be correlated (at least in part) with the Ailstone Member. Time-equivalence with oxygen isotope Stage 7 is therefore implied.

6.17.4. Palaeontology

The mammalian remains from this site were not seen in the present study and the following species list has thus been compiled from material published by de Rouffignac et al. (1995). Only two species are recorded, *Mammuthus primigenius* and *Cervus elaphus*. The former is represented by a partial associated skeleton, together with 5 additional specimens that do not belong to the skeleton, while the latter is represented by a single antler.

**Species List (Mammalia) from Upper Strensham, Worcestershire**

**Proboscidea**

*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Artiodactyla**

*Cervus elaphus* L., red deer
6.17.5. Palaeoenvironmental and palaeoclimatic interpretation

Pollen spectra from the Strensham sequence are suggestive of primarily open habitats, although sufficient quantities of arboreal pollen suggest the presence of stands of both coniferous and deciduous trees in the vicinity. The prevailing climate is considered to be temperate, with abundant *Sagittaria* pollen suggesting conditions as warm as present-day England. Plant macrofossil remains are exclusively from aquatic or semi-aquatic species which characterise ponds or slow-moving streams.

Mollusca from Bed 4 (fossiliferous clay) are indicative of a pond on a river floodplain, which maintained an occasional fluvial link, probably during floods. Of the 28 species represented, 4 are typical river species (the shells of these being almost all broken and/or juvenile), 4 are characteristic of small, muddy, poorly-oxygenated ponds, 4 are marsh and land species and the remaining majority (75% of the assemblage) are found in ponds or very slow-moving streams. Quiet water sedimentation is also indicated by the almost complete absence of land taxa, since these would normally be incorporated into the sediments by overbank flooding, a mechanism which seems to have been of minor importance here (de Rouffignac et al. 1995). The presence of a standing or very slow-moving water body is also indicated by the ostracod fauna, which is dominated by *Candona* spp. (de Rouffignac et al. *ibid*). In terms of the palaeoclimate, the molluscs are broadly indicative of temperate conditions (*Pisidium moitessierianum*, *P. amnicum* and *P. henslowanum* being known only from temperate contexts in the British Pleistocene). The presence of *Discus ruderatus*, today an inhabitant of coniferous forest in central Europe and Scandinavia, may indicate a degree of continentality in the climate. Conditions as warm as those of the English Midlands today are therefore inferred (de Rouffignac et al.*ibid*).

The Coleoptera from Bed 4 are also characteristic of a pond with standing water and rich vegetation, on the basis of large numbers of the aquatic weevil *Eubrychius velutus*. Few inhabitants of running water are present, thereby confirming that the pond was for the most part isolated from the main river channel. The presence of marshland and water meadows in the immediate vicinity of the pond is indicated by *Donacia semicuprea* and *Notaris acridulus*, which feed on sweetgrass (*Glyceria*) and by various species of scavenging Carabidae. Drier ground with sparser vegetation is suggested
further from the water's edge, although indicators of dry-ground habitats are few. An important feature of the Strensham coleopteran assemblage is the abundance of dung beetles, particularly *Oxytelus gibbulus*. This implies that large herbivorous mammals were common in the neighbourhood, perhaps explaining the rarity of trees at this time (Coope *et al.* 1961; de Rouffignac *et al.* 1995). Fully temperate climatic conditions, similar to those in Britain today, are suggested by the beetle assemblage, although the presence of *O. gibbulus* and *Aploderus caesus* (both central European species at the present day), implies an element of continentality.

The mammalian assemblage is entirely consistent with the evidence from other sources, as presented above. *Mammuthus primigenius* and *Cervus elaphus* indicate the availability of substantial areas of rich grazing. Both species are known from cold and temperate episodes.

6.17.6. Biostratigraphy and correlation

**Mammalian studies**

No firm biostratigraphic conclusions can be gleaned from the Strensham mammals, since the assemblage is too small to determine whether the mammoths are of 'Ilford type', the primitive form that is characteristic of the Stage 7 interglacial. The single molar from Strensham (unrelated to the partial skeleton) has a rather high lamellar frequency, above the range of the Ilford sample (Lister, in de Rouffignac *et al.* 1995), although this does not in itself preclude correlation with Stage 7. The 'Ilford type' is frequently, but not exclusively, encountered in deposits assigned to the Stage 7 interglacial and the Strensham sample is thus too small to give an accurate picture of the contemporary mammoth population. Furthermore, if the single tooth is of small size, the lamellar frequency may have been enhanced, due to a compression effect unrelated to its evolutionary grade (Lister and Joysey 1992). This cannot be known as the tooth in question is incomplete. Finally, the poor state of preservation of the tooth suggests that it may have been reworked. However, the very presence of *M. primigenius*, represented by the un-reworked skeleton, in deposits containing evidence of fully temperate conditions is extremely significant, since this species is not known from any other interglacial other than Stage 7 (this study).
Coleopteran studies

The abundant presence of *Oxytelus gibbulus* in the Strensham deposits is considered to be of biostratigraphic significance. This species is known from rare specimens in the Early or Middle Devensian at Upton Warren (Coope *et al.* 1961) and from a single individual each in Ipswichian deposits at Coston and in presumed Hoxnian deposits at Tresull (Coope, in de Rouffignac *et al.* 1995). In contrast, at Strensham, *O. gibbulus* occurs in abundance (90 specimens compared with 51 of the next most numerous species, *Platystethus nitens*). This compares well with the evidence from other sites now widely regarded as being of Stage 7 age. At all of the following sites, *O. gibbulus* is the dominant species in the coleopteran assemblage: Aveley (6.1), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Stoke Goldington (6.16). Correlation of the Strensham deposits with these localities (and consequently with a post-Hoxnian/pre-Ipswichian Stage 7 temperate episode) is therefore suggested (de Rouffignac *et al.* 1995).

No species of biostratigraphic significance were noted in either the pollen or molluscan assemblages.

6.17.7. Discussion and conclusions

In conclusion, the mammalian evidence is consistent with a Stage 7 age for the Strensham deposits and particularly a Substage 7a correlation. The combination of *Mammuthus primigenius* and *Cervus elaphus* is known from both the Stage 7 interglacial (see 6.1) and the Devensian, but it is the occurrence of these species at Strensham in deposits containing palaeobotanical, molluscan and coleopteran evidence of fully temperate conditions that strongly suggests a Stage 7 age for the deposits. This conclusion has also received support from coleopteran biostratigraphy, namely the abundance of the staphilinid beetle *Oxytelus gibbulus*, which has also been noted in substantial numbers at other sites (also assigned to Substage 7a in the present study), such as the upper part of the sequence at Aveley (6.1), the Lower Channel at Marsworth (6.10), Stanton Harcourt (6.11) and Stoke Goldington (6.16). The combined biostratigraphic evidence is upheld by terrace stratigraphy, since the Strensham Member (although considered a distinct lithostratigraphic unit) is thought to equate with other
interglacial sediments at the base of Avon Terrace No. 4 at Ailstone (Bridgland et al. 1989; Maddy et al. 1991). Amino acid ratios on Bithynia tentaculata from Bed 4, in the order of 0.166, are also consistent with a Stage 7 attribution (de Rouffignac et al. 1995).
6.18. THE CRAYFORD BRICKEARTHS, centred on CRAYFORD, SLADE GREEN and ERITH, KENT and comprising the sites of STONEHAM'S PIT (TQ 517758), RUTTER'S PIT (TQ 514765), NORRIS' PIT (TQ 514768), FURNER'S OLD PIT (TQ 519768), FURNER'S NEW PIT (TQ 520766) and TALBOT'S PIT (TQ 520763)

6.18.1. Location of the sites

The Crayford brickearths cover an extensive area on the south bank of the Thames, extending from Erith in the north through Slade Green (formerly known as Slades Green), to Crayford in the south (Figure 6.41). The A206 from North End towards Dartford follows the line of the old workings, although these are now difficult to discern because of modern landscaping and cultivation. Six pits have yielded faunal material (Stoneham’s Pit, Rutter’s Pit, Norris’s Pit (also known as the ‘North End Pit’), Furner’s Old Pit, Furner’s New Pit and Talbot’s Pit), although relating individual specimens to the pit of their discovery is usually impossible. Changes in pit ownership and the extending, closing or merging of the different pits over time has led to understandable difficulties in provenancing material and many visitors to the area appear just as likely to have recorded the name of the railway station where they disembarked for their day’s collecting as the locality. However, since the stratigraphic sequence is the same in all the pits, this is of minimal importance.

6.18.2. History of research

The earliest workings in the area were opened in the first half of the nineteenth century. The first published reference to the deposits is by Morris (1838), who recorded four sections and described their fossiliferous content. Morris referred to ‘Francis and White’s Pit’ at Erith (later called ‘White’s Pit’ by Dawkins (1867a)), to a Crayford pit, which is certainly Stoneham’s, and to two other pits (‘Hutchinson’s’ and ‘Mr Clarke’s’) which cannot be traced, although they were probably at Slade Green. Lydekker’s Catalogue of Fossil Mammalia in the British Museum (1885-7) notes the purchase of bones from Slade Green as early as 1846 and from Erith in 1849, although the earliest date for Crayford appears to be 1862. The abundance of fossils soon attracted the attention of local collectors, who obtained numerous specimens (unfortunately usually
lacking in stratigraphic data) from the workmen at the brickpits. It seems likely though that the majority of specimens came from Stoneham’s Pit at Crayford (Kennard 1944). Important faunal collections were made in the early years, in particular, by Mr Grantham of Crayford and by Dr F. Spurrell (father of F.C.J. Spurrell) of Belvedere and these were examined and commented on by (amongst others) Dawkins (Dawkins and Sanford 1866; Dawkins 1867a, b, c), Falconer (Falconer and Cautley 1845-9; Murchison 1868), Morris (Morris 1843), Prestwich, Woodward and Cheadle (Cheadle 1876a, b).

The first Palaeolithic flake was found by in 1872 by the Rev. Fisher, in situ, six feet above the base of the brickearth in Stoneham’s Pit (although Fisher mistakenly referred
to it as 'Slades Green') (Fisher 1872) and a second by R.W. Cheadle at a higher level (Cheadle and Woodward 1876). Shortly afterwards, F.C.J. Spurrell made his famous discovery of an in situ ‘working floor’ at the base of the brickearth in Stoneham’s Pit, where the products of a Levallois industry lay mingled with the bones of butchered animals. In one particular case, a flake was actually found resting on the jaw of a woolly rhinoceros (Spurrell 1880a). One of Spurrell’s most remarkable achievements was recovering all the flakes from a worked flint nodule and refitting them around the original prepared core, which had broken in the final stages of knapping. This and other accounts of his discoveries, together with comments on the palaeogeographical evolution of the area were reported by Spurrell (1880a, b 1883a, b, 1886). A second ‘working floor’ with more refitting flakes was later discovered at the same level by R.H. Chandler in Rutter’s Pit (Chandler 1914, 1916). Rutter’s and Stoneham’s Pits were also collected from by A.S. Kennard between 1892 and 1900 (Kennard 1944). The spread of brickearth was largely worked out at some point prior to 1944 (Kennard 1944) and houses or arable land now cover the bottoms of the former pits (Wymer 1968).

Summaries of the archaeological material from Crayford are provided by Wymer (1968) and Roe (1981).

6.18.3. Geological background and provenance of mammalian remains

The geological sequence follows a phase of deep erosion, which cut a bench in the Chalk/Thanet Sand at around zero O.D. The Pleistocene deposits are banked against this steep cliff, being sometimes separated from the underlying bedrock by a bed of sand containing rolled shells (Morris 1838). Three well-marked divisions in the Crayford series are recognised Morris 1838; Dawkins 1867a; Tylor 1869; Whitaker 1889; Leach 1905; Chandler and Leach 1912b; Chandler 1914; Kennard 1944) (Figure 6.42):

3. The Upper Brickearth (including the ‘trail’), up to 6m
2. The Lower Brickearth (including the Corbicula Bed), the former up to 9m thick, the latter up to 1.5m

.................................................................hiatus (development of land surface)

1. The Crayford Gravel, up to 4.5m
The Crayford Gravel consists of sand and coarse gravel, containing some derived artefacts and vertebrate remains. The gravel rises slightly to the east and the brickearths correspondingly thin out and disappear, so that at Slade Green, only the basal gravel is present (Whitaker 1889). The Crayford Gravel clearly pre-dates the brickearths and was probably deposited soon after the cutting of the bench (Kennard 1944). The inferred environment of deposition for this unit is in a fast-flowing river of considerable size.

Figure 6.42 Section through the Crayford brickearth and gravel pits (modified from Chandler 1914). Asterisk denotes *Corbicula* Bed.

The principal, *in situ* artefact accumulations are present on top of the gravel (Chandler 1914). The overlying Lower Brickearth aggraded to approximately 9m O.D. and has yielded the majority of organic remains for which Crayford is known (Kennard 1944). Lenticular patches of sand and pebbles, thought to represent transient currents, have been observed within this unit, although the brickearth itself is clearly the product of slow-moving water. Large mammalian remains are scattered throughout, usually as single bones, although a few articulated specimens do occur (Kennard 1944). Mollusca are uncommon, although it is noteworthy that the larger bivalves (*Anodonta, Corbicula* and *Unio*) are often in life-position, thereby suggesting that deposition of the Lower Brickearth occurred rather rapidly.

The Lower Brickearth is overlain by the ‘*Corbicula Bed’*, a bed composed of fine yellow sand and pebbles, with a little clay in places and varying from 0.15m to approximately 1.5m in thickness, although it is found at a constant horizon (around 10.5m O.D.) across a large area (Chandler 1914, 1916; Kennard 1944). As the name
suggests, it contains numerous molluscan remains (especially *Corbicula*), together with abundant remains of small mammals, including lemmings. Bull (1942) suggested that the small mammals may have existed at a much later period and burrowed down into the top of the shell bed, although this was refuted by Hinton (1910b) and Kennard (1944), who both considered the remains to be contemporary with the shell bed on account of their fragmentary and rolled state. Walker (1876) also recorded the finding by Cheadle of a 7ft long mammoth tusk within this unit. The nature and contents of the *Corbicula* Bed led Kennard (1944) to interpret it as the product of a free-flowing stream, citing species of molluscs that are characteristic of moving water.

The Upper Brickearth, which overlies the *Corbicula* Bed, is present only on the higher ground to the west (Bull 1942) and is more thinly-bedded and clayey than the Lower Brickearth (Leach 1905; Chandler 1914). It has yielded a few mammalian fossils and remains of *Pisidium* sp. (Kennard 1944). Many of the mammalian remains form nuclei for the race nodules which are present in the more clayey parts of this unit (Chandler 1914). A different depositional origin for the Upper Brickearth was first suggested by Tylor (1869), who proposed that it was the result of sludging from higher ground during a period of heavy rainfall. This was supported by Bull (1942) who also invoked a possible loessic component. Chandler (1914) recorded the presence of deposits of ‘trail’ up to 2.1m deep, present above the Upper Brickearth. The ‘trail’ is composed of clayey gravel with large flints and other locally-derived materials. It rests unevenly upon the underlying beds and is involuted in contortions with the brickearth where the two come into contact (Chandler 1914).

6.18.4. Palaeontology

The following species lists have been compiled from material in the Natural History Museum, London, the British Geological Survey Museum at Keyworth, the University Museum, Oxford, the Yorkshire Museum, Manchester Museum, Buxton Museum, the Lapworth Museum of Birmingham University, the Sedgwick Museum of Geology, Cambridge and Dartford Museum. The largest collections were made by F.C.J. Spurrell, W.B. Dawkins and J.W. Flower with occasional specimens collected by W. Ball, J. Morris, J. Prestwich, M.A.C. Hinton, R.H. Chandler, A.S. Kennard, R.W.
The species are listed separately from Crayford, Erith and Slade Green, although since the stratigraphy is the same in all areas, this does not have any particular bearing on the possible relative ages of the three localities. The presence of 21 species at Crayford was confirmed by the present study (to which may be added Homo on the basis of artefacts), and 12 species each at Erith and Slade Green. The species lists are similar to those given by Kennard (1944), although his records of Vulpes vulpes (red fox) and Lepus sp. (hare) were not relocated. However, a previously unpublished record of Sorex cf. araneus (common shrew) from Crayford was identified and one important re-identification was made, dismissing the record of alpine dhole (Cuon priscus) (Stuart 1982; Sutcliffe 1985) (see below). 1381 specimens were examined.

Species List (Mammalia) from Crayford

**Insectivora**

Sorex cf. araneus L., common shrew

**Primates**

Homo sp., indet. hominid (artefacts)

**Rodentia**

Citellus citellus L. (=Spermophilus primigenius Kormos), ground squirrel

Dicrostonyx cf. torquatus (Pallas), collared lemming

Lemmus lemmus (L.), Norwegian lemming

Microtus oeconomus (Pallas), northern vole

Microtus sp., indet. vole

**Carnivora**

Canis lupus L., wolf

Canis sp., small canid

Ursus arctos L., brown bear

Crocuta crocuta Erxleben, spotted hyaena

Panthera leo (L.), lion

**Proboscidea**

Palaeoloxodon antiquus (Falconer and Cautley), straight-tusked elephant
Mammuthus primigenius (Blumenbach), mammoth
Elephantidae sp., indet. elephant

Perissodactyla
Equus ferus Boddaert, horse
Stephanorhinus hemitoechus (Falconer), narrow-nosed rhinoceros
Stephanorhinus kirchbergensis (Jäger), Merck's rhinoceros
Coelodonta antiquitatis (Blumenbach), woolly rhinoceros
Rhinocerotidae sp., indet. rhinoceros

Artiodactyla
Megaloceros giganteus (Blumenbach), giant deer
Cervus elaphus L., red deer
Bos primigenius Bojanus, aurochs
Bison priscus Bojanus, bison
Bovidae sp., indet. large bovid (Bos or Bison)
Ovibos moschatus Zimmerman, musk ox

Species List (Mammalia) from Erith, Kent

Rodentia
Citellus citellus L. (=Spermophilus primigenius Kormos), ground squirrel
Dicrostonyx cf. torquatus (Pallas), collared lemming
Lemmus lemmus (L.), Norwegian lemming
Microtus oeconomus (Pallas), northern vole
Microtus sp., indet. vole

Carnivora
Panthera leo (L.), lion

Proboscidea
Mammuthus primigenius (Blumenbach), mammoth
Elephantidae sp., indet. elephant

Perissodactyla
Equus ferus Boddaert, horse
Coelodonta antiquitatis (Blumenbach), woolly rhinoceros

Artiodactyla
Cervus elaphus L., red deer
Species List (Mammalia) from Slade Green, Kent

**Carnivora**

*Canis cf. lupus* L., wolf
*Ursus arctos* L., brown bear
*Panthera leo* (L.), lion

**Proboscidia**

*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant
*Mammuthus primigenius* (Blumenbach), mammoth

**Perissodactyla**

*Equus ferus* Boddaert, horse
*Stephanorhinus cf. hemitoechus* (Falconer), narrow-nosed rhinoceros
*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros

**Artiodactyla**

*Megaloceros giganteus* (Blumenbach), giant deer
*Cervus elaphus* L., red deer
*Bos primigenius* Bojanus, aurochs
*Bison priscus* Bojanus, bison
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 6.15 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insectivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. cf. araneus</em></td>
<td>1</td>
<td>0.07</td>
<td>1</td>
</tr>
<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. citellus</em></td>
<td>229</td>
<td>16.59</td>
<td>20</td>
</tr>
<tr>
<td><em>D. torquatus</em></td>
<td>4</td>
<td>0.28</td>
<td>1</td>
</tr>
</tbody>
</table>

cont’d.../...
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. lemmus</td>
<td>5</td>
<td>0.36</td>
<td>1</td>
</tr>
<tr>
<td>M. oeconomus</td>
<td>79</td>
<td>5.72</td>
<td>50</td>
</tr>
<tr>
<td>Microtus sp.</td>
<td>187</td>
<td>13.55</td>
<td>17</td>
</tr>
<tr>
<td><strong>Carnivora</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. lupus</td>
<td>18</td>
<td>1.3</td>
<td>3</td>
</tr>
<tr>
<td>Canis sp.</td>
<td>11</td>
<td>0.79</td>
<td>1</td>
</tr>
<tr>
<td>U. arctos</td>
<td>12</td>
<td>0.86</td>
<td>2</td>
</tr>
<tr>
<td>C. crocata</td>
<td>2</td>
<td>0.14</td>
<td>1</td>
</tr>
<tr>
<td>P. leo</td>
<td>36</td>
<td>2.6</td>
<td>4</td>
</tr>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. antiquus</td>
<td>6</td>
<td>0.43</td>
<td>4 (1 juv., 3 adults)</td>
</tr>
<tr>
<td>M. primigenius</td>
<td>146</td>
<td>10.57</td>
<td>26 (11 juv., 15 adults)</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>3</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferox</td>
<td>301</td>
<td>21.81</td>
<td>12</td>
</tr>
<tr>
<td>S. hemitoechus</td>
<td>14</td>
<td>1.01</td>
<td>2</td>
</tr>
<tr>
<td>S. kirchbergensis</td>
<td>5</td>
<td>0.36</td>
<td>1</td>
</tr>
<tr>
<td>C. antiquitatis</td>
<td>66</td>
<td>4.78</td>
<td>10 (3 juv., 7 adults)</td>
</tr>
<tr>
<td>Rhinocerotidae sp.</td>
<td>17</td>
<td>1.23</td>
<td>2</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. giganteus</td>
<td>3</td>
<td>0.21</td>
<td>1</td>
</tr>
<tr>
<td>C. elaphus</td>
<td>42</td>
<td>3.04</td>
<td>5</td>
</tr>
<tr>
<td>B. primigenius</td>
<td>72</td>
<td>5.21</td>
<td>4</td>
</tr>
<tr>
<td>B. priscus</td>
<td>34</td>
<td>2.46</td>
<td>7</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>83</td>
<td>6.01</td>
<td>5</td>
</tr>
<tr>
<td>O. moschatus</td>
<td>4</td>
<td>0.28</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.15 Breakdown of the mammalian species list from the Crayford brickearths (Crayford, Erith and Slade Green), showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

### 6.18.5. Palaeoenvironmental and palaeoclimatic interpretation

A major problem in the palaeoenvironmental interpretation of the Crayford sites is the provenancing of the faunal material, since most specimens are lacking in stratigraphic data. However, if the account of Whitaker (1889) is followed, the Crayford Gravel (which was exposed notably at Slade Green) contains the following mammalian species: *Canis cf. lupus, Ursus arctos, Panthera leo, Palaeoloxodon antiquus, Mammutthus primigenius, Equus ferox, Stephanorhinus cf. hemitoechus, Coelodonta antiquitatis, Megaloceros giganteus, Cervus elaphus, Bos primigenius and Bison priscus*. Kennard
(1944, 126) corroborates the presence of straight-tusked elephant in the basal gravel, stating "It is almost certain that all the teeth of Elephas antiquus Falc. came from this gravel and not from the overlying brickearth". Kennard (1944, 160) also suggests that "although there is insufficient evidence to fix the climate...it was probably warm". The mammalian evidence is broadly supportive of this but has little to add to the matter. Although P. antiquus is considered an indicator of temperate woodland, the specimens are few and may be derived from an earlier source. However, the presence of B. primigenius would appear to confirm the temperate nature of the deposit, since this species is restricted to interglacial occurrences in the British late Middle Pleistocene (Stuart 1982). In terms of the palaeoenvironment, the mammalian assemblage from the gravel is indicative of open conditions (presence of M. primigenius, E. ferus, two species of grazing rhinoceros and M. giganteus).

Palaeoenvironmental and palaeoclimatic data from the Lower Brickearth is substantially richer. Mollusca from the Lower Brickearth are indicative of the presence of a slow-moving fresh water (probably a sluggish stream with little aquatic vegetation) and include Bithynia tentaculata, Valvata piscinalis, Lymnaea peregra, L. palustris, L. truncatula, Planorbis corneus, P. planorbis, P. leucostoma, Sphaerium corneum, S. dickinii, Corbicula fluminalis, Pisidium amnicurn, P. subtruncatum, Anodonta spp. and Unio littoralis. Terrestrial species include Pupilla muscorum and Cepaea nemoralis, both inhabitants of open grassland (Kennard 1944). The sole record of palaeobotanical remains from Crayford is of Castanea sativa (sweet chestnut), which was found in the Lower Brickearth and is today common in the Mediterranean (Kennard ibid). Most of the large mammalian remains came from the Lower Brickearth and include P. leo, M. primigenius, E. ferus, S. kirchbergensis, C. antiquitatis, C. elaphus, B. primigenius and O. moschatus. Although Kennard (ibid, 161) states that "From the vertebrate and invertebrate evidence the summers were much warmer than those of today and the winters milder", it seems more likely that rather continental conditions prevailed, with hot summers and cold winters. This would explain the superficially 'disharmonious' co-occurrences of 'warm' and 'cold' mammal species within the Lower Brickearth, for example S. kirchbergensis and B. primigenius with C. antiquitatis and O. moschatus. The pattern is equally marked within the Corbicula Bed, where temperate Mollusca apparently co-existed with ground squirrel, lemmings and northern vole. The overall
picture suggested by the mammalian assemblage from the Lower Brickearth is therefore of an interglacial, continental climate with an open, steppe-like environment.

Mammalian remains from the Upper Brickearth reportedly include *M. primigenius*, *E. ferus* and *C. antiquitatis* (Kennard 1944), although the absence of stratigraphic data on most of the specimens makes it impossible to verify this. As stated above, the Upper Brickearth is considered to be the result of sludging from higher ground during a period of greatly increased rainfall. Remains of *Pisidium* sp. reveal that there was at least one interval during the deposition when a landsurface was established with a small pool containing molluscs and vegetation (Kennard 1944). Kennard (*ibid*) stated that the climate does not appear to have been particularly cold during deposition of the Upper Brickearth, although it was more likely cooler than during deposition of the Lower Brickearth. Kennard (*ibid*) also emphasised the absence of reindeer, as an indicator of cold climate, from this unit. Visibly colder conditions, in the form of festooning and contortions, are apparent in the ‘trail’, which probably marks the end of the interglacial.

6.18.6. Biostratigraphy and correlation

The mammalian evidence was reviewed by Stuart (1976, 1982) and the assemblage from the Lower Brickearth assigned to the terminal phase of the Ipswichian Interglacial (Ip ?IV). This correlation was largely based on comparison of the height of the Crayford brickearth with other localities, such as Aveley (6.1) and Uphall Pit, Ilford (6.2), which were also thought to be of Ipswichian age and to post-date zone Ip IIb. The Upper Brickearth at Crayford was thus considered to be Devensian in age (Stuart 1976). However, Currant (1986) has proposed that the Crayford brickearths be regarded as representative of a pre-Ipswichian cold stage, on account of the presence of a typically ‘cold’ fauna, including *Mammuthus*, *Coelodonta*, *Ovibos*, *Spermophilus*, *Lemmus* and *Dicrostonyx*. This idea has been developed most recently by Sutcliffe (1996), who has suggested that the Crayford deposits be assigned to OIS 6. However, reappraisal of the mammalian evidence in the present study suggests that the Crayford brickearths may relate to a pre-Last Interglacial temperate stage, correlated with OIS 7.
The mammalian assemblage from the Crayford brickearths is characterised by a predominantly grassland fauna, a feature which is clearly illustrated in all groups of mammals at the site, from microtine rodents to elephants.

The rodent assemblage is dominated by the grassland-dwelling ground squirrel *Citellus citellus* (referred by Mayhew (1976) to the living Siberian species, *Spermophilus undulatus*, as opposed to *S. primigenius* by Sutcliffe and Kowalski (1976)). The Crayford deposits mark the first post-Anglian occurrence of this species in Britain, considered here to reflect a general influx of species from central and eastern Europe at this time. *C. citellus* is recorded at Crayford in considerable abundance (16.59% of the assemblage) and many crania, complete dentitions and partial skeletons are preserved from this period (Figures 6.43 below and 3.10). The presence of *D. torquatus* and *L. lemmus* is also significant in demonstrating the continental nature of the assemblage. Hinton (1926b) assigned the *Dicrostonyx* remains from Erith to *D. gulielmi*, a lemming of *D. torquatus* type but bigger and with broader teeth with slight dental differences (see Chapter 3). However, it is now generally accepted that there is no real basis for this distinction and that all remains should be treated as *D. torquatus*.

![Figure 6.43 Cranium of *Citellus citellus*, Erith (left lateral view, M26572, N.H.M.L.).](image)

The grassland influence is also apparent in the abundance of *Microtus* spp., including the northern vole *Microtus oeconomus*. An important point concerning the Crayford rodent assemblage is the re-identification of specimens formerly attributed to the snow vole *Microtus nivalis* or to *Microtus malei* as northern vole *Microtus oeconomus* (see
Chapter 3). Re-examination of the specimens reveals that only the latter species is present and that variations exhibited by the first lower molars should consequently be interpreted as individual expressions along the range of *M. oeconomus* variability. The Crayford *M. oeconomus* are particularly distinguished by their large size, which is consistent with the progressive increase in size documented throughout the later Middle Pleistocene, reaching a maximum in the cold stage immediately preceding the Last Interglacial (see Figure 3.24; Tables 3.5 and 3.6). The mean length of the first lower molars from Crayford is slightly larger than that from the Lower Channel at Marsworth (6.10) (2.87 ± 0.041, n = 12 at Crayford, 2.78 ± 0.067, n = 6 at Marsworth), thereby suggesting that the Crayford sample is the slightly younger of the two sites. However, the biggest difference is observed between Crayford and sites attributed in the present study to Stage 6, which show the *M. oeconomus* from the former to be significantly smaller than the *M. oeconomus* from the latter. The accumulated evidence therefore implies that Crayford is older than Stage 6 but slightly younger than the fully-interglacial deposits in the Lower Channel at Marsworth.

The Carnivora are particularly well-represented at Crayford, with a large form of *Panthera leo* being the most abundant predator (making up almost half of the carnivore remains). Remains of *Crocuta crocuta* are also recorded, although these are not as common as those of *Canis lupus* and *Ursus arctos*. As part of the present study, a detailed re-assessment of the Crayford canids was made, in particular the record of alpine dhole, *Cuon alpinus*. As noted by Kennard (1944), there appear to be two distinct size classes of canid. The larger specimens (for example M5047b and 5112a) are probably referable to *Canis lupus*. They are smaller than the biggest Devensian *C. lupus* from Kent's Cavern (Devon), Banwell Cave and Lime Kiln Hill Quarry (Somerset) and are most comparable with the smaller Devensian wolves and medium-sized wolves from late Middle Pleistocene localities such as the Lower Channel at Marsworth (6.10), Bleadon Cave (6.22) and Hutton Cave (6.23). The smaller Crayford canids are closest in size to specimens from the early Middle Pleistocene *C. lupus mosbachensis*, present at Sidestrand, Westbury-sub-Mendip and Boxgrove (see Figure 3.28).

The identity of the smaller species of canid at Crayford has been complicated by previous misidentifications. Kurtén first identified the specimen M48380 (a right
mandible with virtually complete dentition) as the asiatic dhole *Cuon alpinus* (A.P. Currant pers. comm.), a fairly large 'dog-like' canid whose distribution is now restricted to montane forest areas of the Indian peninsula, south-east Asia, China and eastern parts of the former Soviet Union (Clutton-Brock *et al.* 1976). This identification became absorbed into the literature by later authors, for example Stuart (1982) and Sutcliffe (1985) as the sole occurrence of this species in the British Isles. However, re-examination of the mandible in question reveals that neither the dental formula nor the morphology of the teeth agrees with an identification as *Cuon*. In *Cuon*, the m3 is absent, whereas the Crayford mandible clearly possesses a root socket for an m3, although the tooth itself has since been lost (Figure 6.44a).

![Figure 6.44a](image)

**Figure 6.44a** Right mandible of small canid, previously identified as *Cuon* (occlusal view, M48380, N. H.M.L.), Crayford, showing alveolus for lower third molar.

Furthermore, the morphology of the m1 in the Crayford specimen is different to that found in *Cuon*. In *Cuon*, the talonid of the m1 has only one blade, a highly-diagnostic trait also shared by the African wild dog (*Lycaon pictus*) and the South-American bush dog (*Speothos venaticus*). All other canids have two cusps on the talonid, comprising of a shearing blade at the front and a semi-circular 'basin' to the rear for grinding (Figure 6.44b).
Figure 6.44b Right mandible of small canid, previously identified as *Cuon* (right lateral view, M48380, N.H.M.L.), Crayford, showing two cusps on the talonid of the first lower molar.

The dhole, African wild dog and South-American bush dog are more exclusively carnivorous than other canids. They also hunt in large packs and are adapted for swift pursuit, preying on medium-sized, fast-running herbivores. The development of a second rearward blade and the subsequent loss of the grinding capacity in the back teeth in the dhole is a 'cat-like' trait and probably evolved as the canid solution to the problem of fleet prey that cats solved with the evolution of the pantherines (Macdonald 1992). The m1 of the Crayford mandible has two cusps on the talonid and clearly displays the 'basined' morphology of a grinding tooth (Figure 6.44a). These lines of evidence would therefore appear to suggest that the Crayford animal is not a dhole but another type of canid, most closely resembling a small wolf (*Canis lupus*). Examination of the m1 in the Crayford ‘*Cuon*’ mandible reveals that it is relatively shorter and broader than any other Middle Pleistocene *Canis* m1 seen during the present study, although the significance of this is not yet understood (see Figure 3.28).

The Crayford Proboscidea are dominated by remains of *Mammuthus primigenius* (almost 95% of the elephant assemblage). Molars of ‘Ilford type’ have been identified among these remains, although more ‘advanced’ molars are also present. Certain teeth also display a pronounced degree of annulation, a trait which may also be of biostratigraphic significance. The presence of *Palaeoloxodon antiquus* in conjunction with *M. primigenius* is an important feature and one that is characteristic of Stage 7, although it is possible that the *P. antiquus* teeth may have been derived from an earlier source (see above).
Other important elements of the Crayford assemblage include a large *Equus ferus* and three species of rhinoceros. Despite suggestions that the remains of *Stephanorhinus kirchbergensis* in the Natural History Museum, London, are of doubtful provenance (Hinton 1926a; Kennard 1944) on account of their apparently darker preservation type, there does not appear sufficient reason to exclude these specimens from the Crayford assemblage. An upper third molar of this species in the Manchester Museum (No. 1422) is also regarded as a *bona fide* record, being lighter in colour than the four aforementioned specimens and a perfectly good match with other Crayford specimens. The presence of *S. kirchbergensis* in sites now widely regarded as of Stage 7 age (Sutcliffe 1976, 1995a) was dismissed by Stuart (1976). However, re-examination of the material in the present study has demonstrated the unquestionable presence of this species at Ilford (Uphall Pit (6.2) and its presence at Crayford is therefore not unexpected. During the Stage 7 interglacial, *S. kirchbergensis* was apparently present in much smaller numbers than the narrow-nosed rhinoceros *Stephanorhinus hemitoechus*, probably as a result of the decrease in woodland and the increase in open grassland.

However, at Crayford, although *S. hemitoechus* is indeed more abundant than *S. kirchbergensis* (14 identified specimens as opposed to 5), the most numerous rhinoceros remains are referrable to the woolly rhinoceros *Coelodonta antiquitatis* (66 specimens, 64.7% of the rhinoceros assemblage). The presence of this species at Crayford is most important, since it is not known from any British interglacial fauna other than Stage 7. The presence of *C. antiquitatis* at Crayford also indicates the steppe-grassland character of this part of the interglacial and emphasises the prevalence of rather continental conditions. This is confirmed by the record of musk ox (Figure 3.57). Kennard (1944) regarded the Crayford *Ovibos* as a separate species *Ovibos spurrelli*, although in the present study, no basis was found for regarding it as anything other than *O. moschatus*.

The remaining Artiodactyla from the Crayford brickearths are of large size, comparable to specimens from Ilford (Uphall Pit) (6.2), but otherwise do not show any traits of biostratigraphic significance.
**Malacological studies**

A full species list is given in Kennard (1944). Kennard notes that Crayford marks the last appearance in Britain of *Corbicula fluminalis*, *Paludilhia radigueli*, *Unio littoralis*, *Candidula radigueli* and *Pisidium sulcatum*. In particular, the presence of *C. fluminalis* presents a strong case against correlation of the Crayford deposits with the Last (Ipswichian) Interglacial (Keen 1990; Meijer and Preece 1995). Kennard accordingly placed Crayford as the latest deposits in the Middle Terrace of the Thames, postdating the Ilford brickearths (6.2).

**Palynological studies**

Although the Crayford brickearths were non-polliniferous, they have been previously assigned to the Ipswichian Interglacial (zone Ip ?IV), on the basis of their similarity in height to other brickearths, such as at Aveley (6.1) and Ilford (Uphall Pit) (6.2), which were believed to postdate zone Ip IIb (Stuart 1976). However, these other sites have subsequently been reassigned to an earlier interglacial, equivalent to OIS 7 (Sutcliffe and Bowen 1973; Sutcliffe 1975, 1976; Sutcliffe and Kowalski 1976; Shotton 1983c; Wymer 1985; Bowen *et al* 1989; Bridgland 1994; Bridgland *et al*. 1995b), thereby casting doubt on an Ipswichian age.

**6.18.7. Discussion and conclusions**

Evidence for the age of the Crayford deposits comes primarily from two sources. First, the stratigraphic relationships of the Lower Brickearth are closely comparable with the heights of the brickearth deposits at Aveley (6.1), Ilford (Uphall Pit) (6.2) and Northfleet (6.5). This strongly suggests contemporaneity of Crayford with these sites, all of which have been attributed to Stage 7 in the present study (see also Sutcliffe 1976, 1995a; Bridgland 1994).

Second, the mammalian biostratigraphic evidence, which supports the correlation of Crayford with Stage 7, on the basis of the presence of a distinctive suite of mammals. Comparison of the evidence from the Crayford Lower Gravel with that from the upper part of the sequence at Aveley (the elected 'type-sequence' for this time period, 6.1)
reveals the presence of an almost identical suite of mammals, including important indicators such as the ‘Ilford type’ mammoth, in association with abundant *E. ferus* and a large *P. leo*. It is possible that the Lower Gravel contains a derived component and *P. antiquus* and *S. kirchbergensis* have been cited as possible ‘intrusions’ (Kennard 1944). However, examination of a range of sites from this time period during the present study indicates that these two species regularly occur as part of the Stage 7 fauna, albeit in relatively small numbers. Their presence in the Crayford deposits is therefore not called into question. The presence of *E. ferus* and *Homo* sp. would also appear to contradict an Ipswichian age. Correlation of the Crayford Lower Gravel with the second temperate peak of Stage 7 (Substage 7a) is consequently proposed.

The Lower Brickearth and *Corbicula* Bed also contain a range of biostratigraphically significant species and are not considered to be widely separated in time from the underlying Lower Gravel. Important species include *C. citellus* and a large form of *M. oeconomus*. The presence of *C. citellus* is significant in that the Crayford interglacial marks the first post-Anglian occurrence of this species in Britain, while the prevalence of a large form of *M. oeconomus* in the rodent fauna is considered characteristic of the Stage 7 interglacial (Currant, in Green et al. 1996, see Chapter 3). The presence of *E. ferus*, *S. kirchbergensis* and *Corbicula* in these deposits argues very strongly against correlation with the Ipswichian Interglacial. The Lower Brickearth and *Corbicula* Bed are therefore assigned to the terminal phases of Substage 7a. The occurrence of *C. citellus*, *D. torquatus*, *L. lemmus*, *C. antiquitatis* and *O. moschatus* clearly indicates the existence of a continental climate as the end of the interglacial approached. Support for a Stage 7 correlation has also come from amino acid ratios on *Bithynia tentaculata* of 0.170 ± 0.02 (Bowen et al. 1989).

*M. primigenius*, *E. ferus* and *C. antiquitatis* are reported from the Upper Brickearth (Kennard 1944). The presence of these species, in conjunction with lithological evidence of mass movement of sediment, festooning and contortions, is considered to reflect the transition into the ensuing cold stage, OIS 6.
6.19. GREAT YELDHAM, ESSEX (TL 757379)

6.19.1. **Location of the site.**

The site is located in an old brickyard, approximately 180m west of Great Yeldham station (Wymer 1985), on the west bank of the River Colne (see Figure 6.21).

6.19.2. **History of research**

The first published report of the site is by Whitaker (in Whitaker *et al.* 1878) who described the stratigraphic sequence in the pit and mentioned the occurrence of bones in brickearth deposits. A later account by Holmes (1896) referred to bones in the collection of a Mr Wade of Spaynes Hall, Great Yeldham, including bear teeth, a fragment of an elephant tooth, rhinoceros bones, fragments of red deer antler and remains of roe deer and ox. No Palaeolithic artefacts have been reported, although when Whitaker visited the site with F.J. Bennett, the latter considered the bones to have been deliberately split open (Whitaker, in Whitaker *et al.* 1878). However, none of the material examined in the present study showed evidence of butchery, and given that E.T. Newton, in a note to Holmes (1896), commented on the rough process of extraction of the bones, it seems beyond question that their fragmentary condition is the result of the latter. The site is also mentioned in Wymer (1985).

6.19.3. **Geological background and provenance of mammalian remains**

Whitaker (in Whitaker *et al.* 1878) described the following section:

3. Brickearth and gravel, up to 8-9ft (2.4-2.7m)
2. Lighter coloured brickearth with bones, 2 ft (0.6m)
1. Black, sandy peaty earth, with land and freshwater shells, said to be 6 ft (1.8m)

Holmes (1896) noted that the deposits rested in a slight hollow in the surface of a chalky boulder clay and that they were unrelated to the modern drainage system.
6.19.4. Palaeontology

The following species list has been compiled from material in the British Geological Survey Museum, Keyworth. The presence of 7 mammalian species was confirmed in the present study, from 24 specimens. The bones are grey in colour, with orange mottling from the brick earth.

Species list (Mammalia) from Great Yeldham, Essex

Carnivora

*Ursus arctos* L., brown bear

Proboscidea

cf. *Mammuthus primigenius* (Blumenbach), woolly mammoth

Perissodactyla

*Equus ferus* Boddart, horse

*Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros

Artiodactyla

*Cervus elaphus* L., red deer

*Capreolus capreolus* (L.), roe deer

Cervidae sp., indet. deer

*Bos primigenius* Bojanus, aurochs

Bovidae sp., indet. large bovid (*Bos or Bison*)

Table 6.16 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>U. arctos</em></td>
<td>3</td>
<td>12.5</td>
<td>1</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cf. <em>M. primigenius</em></td>
<td>1</td>
<td>4.16</td>
<td>1</td>
</tr>
</tbody>
</table>

cont’d.../...
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>1</td>
<td>4.16</td>
<td>1</td>
</tr>
<tr>
<td><em>S. hemitoechus</em></td>
<td>4</td>
<td>16.66</td>
<td>1</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. elaphus</em></td>
<td>2</td>
<td>8.33</td>
<td>1</td>
</tr>
<tr>
<td><em>C. capreolus</em></td>
<td>1</td>
<td>4.16</td>
<td>1</td>
</tr>
<tr>
<td>Cervidae sp.</td>
<td>3</td>
<td>12.5</td>
<td>1</td>
</tr>
<tr>
<td><em>B. primigenius</em></td>
<td>7</td>
<td>29.16</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>2</td>
<td>8.33</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6.16 Breakdown of the mammalian species list from Great Yeldham, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.19.5. Palaeoenvironmental and palaeoclimatic interpretation

The mammalian assemblage from Great Yeldham is extremely small but some conclusions may nevertheless be drawn as to the prevailing environmental and climatic conditions at the time of deposition of the fossiliferous deposits. The proximity of areas of open grassland is attested to by various species of large herbivore, including *B. primigenius*, *C. elaphus*, *E. ferus*, *S. hemitoechus* and cf. *M. primigenius*, while *U. arctos* and *C. capreolus* indicate the presence of nearby deciduous or mixed woodland. Fully temperate climatic conditions are inferred, on the basis of the presence of *S. hemitoechus*, *C. capreolus* and *B. primigenius*.

6.19.6. Biostratigraphy and correlation

Mammalian studies

The age of the Great Yeldham deposits has apparently never been discussed in the literature until the present study. Although the mammalian assemblage is small, the composition of the assemblage can provide some indication of its relative age. The presence of *U. arctos*, as opposed to *U. spelaeus*, indicates that the assemblage must post-date the Hoxnian interglacial, while the presence of *E. ferus* argues against an...
Ipswichian age. The elephant remains are tentatively assigned to *M. primigenius*, a species which, in a temperate context, would suggest a post-Stage 9 age. In terms of overall composition, the assemblage is most closely comparable with faunas assigned to the second temperate peak of the Stage 7 interglacial, such as from the upper part of the sequence at Aveley (6.1) and Uphall Pit, Ilford (6.2). Critical species therefore include cf. *M. primigenius*, in association with *E. ferus*, *S. hemitoechus* and a large form of *B. primigenius*.

6.19.7. **Discussion and conclusions**

In summary, despite the relatively limited assemblage, it is concluded here that the most appropriate correlation for the mammalian assemblage from Great Yeldham is with the Stage 7 interglacial. The general composition of the assemblage also suggests that the deposits may relate to the later part of the interglacial (possibly Substage 7a), on the basis of cf. *M. primigenius*, in conjunction with *E. ferus*, *S. hemitoechus* and a large form of *B. primigenius*. 
6.20. SIBLE HEDDINGHAM, ESSEX (TL 7834)

6.20.1. Location of the site

Various cuttings were mentioned by Bennett (in Whitaker et al. 1878) in the vicinity of the village of Sible Heddingham, on the west bank of the River Colne, (see Figure 6.21), including one about 0.6km SSW of Heddingham station, from where the specimens in question were collected.

6.20.2. History of research

Virtually nothing is known about the history of the assemblage or the site itself. The bones bear the name of the well-known local collector, John Brown of Stanway, and were therefore probably collected between 1850 and 1870. The only known published reference to the site is by Whitaker et al. (1878), who described the geological sequence and mentioned the presence of animal remains. By the time of writing, the site was already described as overgrown. Remains of *Mammuthus primigenius* from Sible Heddingham were also mentioned in Adams (1877-81).

6.20.3. Geological background and provenance of mammalian remains

The Heddingham deposits are probably part of Terrace No. 3 of the River Colne, which extends to a maximum of 13.5m above the floor of the present-day valley (Ellison and Lake 1986). At the station cutting, Bennett (in Whitaker et al. 1878) recorded a 4.5-9m thick section of laminated, light-coloured brickearth overlying false-bedded sands and gravels. On account of their preservation, the bones are considered to have come from the brickearth.

6.20.4. Palaeontology

The following species list has been compiled from material collected by J. Brown and now housed in the Natural History Museum, London. The presence of 3 mammalian species was confirmed in the present study, on the basis of 12 specimens. No species
list has been published from this site before. The bones are grey in colour, with orange mottling.

Species list (Mammalia) from Sible Hedingham, Essex

**Proboscidea**

*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Perissodactyla**

*Equus ferus* Boddaert, horse

**Artiodactyla**

*Bos primigenius* Bojanus, aurochs

Table 6.17 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>6</td>
<td>50</td>
<td>4 (1 juv., 3 adults)</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>5</td>
<td>41.66</td>
<td>1</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>B. primigenius</em></td>
<td>1</td>
<td>8.33</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6.17 Breakdown of the mammalian species list from Sible Hedingham, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.20.5. *Palaeoenvironmental and palaeoclimatic interpretation*

The mammalian assemblage from Sible Hedingham is extremely small and contains only species that are indicative of open grassland. Temperate climatic conditions are inferred on the basis of the presence of *Bos primigenius.*
6.20.6. Biostratigraphy and correlation

Mammalian studies

As at Great Yeldham (6.19), the age of the Sible Heddingham assemblage has apparently never been discussed in the literature until the present study. Although the mammalian assemblage is small, the composition of the assemblage is nevertheless supportive of a Stage 7 correlation. Of importance is the presence of *M. primigenius* in association with *Equus ferus*. Although these two species commonly occurred together in the Devensian, two factors suggest that the Sible Heddingham deposits were not only laid down during temperate, as opposed to cold-climate conditions, but also relate to a considerably older period. The first is the occurrence of *Bos primigenius*, which indicates that the mammalian assemblage is of fully temperate affinities and therefore unlikely to be of Devensian age. The second is the presence of the ‘Ilford type’ mammoth, a primitive form that is diagnostic of the Stage 7 interglacial. The combination of small teeth with a low plate count that characterises the ‘Ilford type’ is well-illustrated in a second lower molar (27911), also described by Adams (1877-81). The presence of *M. primigenius* argues against correlation of the assemblage with any interglacial other than Stage 7, while the presence of *E. ferus* is inconsistent with an Ipswichian age. In terms of overall composition, the assemblage is most closely comparable with faunas assigned to the second temperate peak of the Stage 7 interglacial, such as from the upper part of the sequence at Aveley (6.1) and Uphall Pit, Ilford (6.2).

6.20.7. Discussion and conclusions

Despite the recovery of only three taxa, it is concluded here that the biostratigraphic evidence is sufficient to demonstrate correlation of the mammalian assemblage from Sible Heddingham with the Stage 7 interglacial, and more precisely with Substage 7a. This is based upon the presence of *M. primigenius* (including specimens of ‘Ilford type’), in conjunction with *E. ferus* and a large form of *B. primigenius*. A Stage 7 correlation is also supported on altitudinal grounds, since the Sible Heddingham deposits are situated on the same terrace as those at Lexden, a site also assigned to Substage 7a in the present study (6.12).
6.21. OTTER STRATUM, TORNEWTON CAVE, BUCKFASTLEIGH, DEVON (SX 8172 6737)

6.21.1. Location of the site

Tornewton Cave in the Torbryan valley, is located midway between Dartmoor and the Devon coast. The Am Brook, a tributary of the river Dart, runs to the west of the site (Figure 6.45).

Figure 6.45 Location of Tornewton Cave in relation to other caves in the Torbryan Valley (modified from Sutcliffe 1974).
6.2 History of research

Eleven caves are known in the Torbryan valley, all of which have been excavated to varying degrees since the mid-19th century, when they were discovered by James Lyon Widger, a local man of limited means and no scientific training. Despite the contemporaneity of his investigations with those of more renowned local antiquarians, such as William Pengelly, Widger’s work failed to attract the interest of his peers and he spent much of his life digging alone in four of the caves between 1865 and 1890 (Walker and Sutcliffe 1968). The lack of acknowledgement for his work may have stemmed from Widger’s Creationist beliefs; indeed, in the one published account of his excavations, he claimed that the main purpose of his work in the Torbryan caves was to prove the existence of the Biblical deluge (Widger 1892).

Excavation of Tornewton Cave by Widger began in around 1877. He died, impoverished, in 1892, leaving much of the information concerning the caves sadly unrecorded. Further references to Widger’s work are provided by Lee (1880) and Lowe (1918) and part of his collection is figured in Reynolds (1902, 1906, 1909, 1922). In 1924, the Torquay Natural History Society commissioned Dorothy Garrod to evaluate several caves in the valley, with a view to continuing further excavation. It was thus that Tornewton Cave was selected as one of the study areas (Garrod 1924) and summer excavations were carried out there by the Society between 1924-1926 and 1936-1939. These unrecorded investigations largely obscured the original extent of Widger’s efforts (Currant in Roberts 1996) and little progress was apparently made in understanding the nature of the cave and its contents. From 1944 until the early 1960s, the first systematic excavations were carried out in Tornewton Cave by Dr. A. Sutcliffe (Sutcliffe 1957; Sutcliffe and Zeuner 1962). Sutcliffe’s findings elevated the site to international fame, through his recovery of a series of mammalian assemblages in apparent stratigraphic superposition, which were believed to span intervals now correlated with oxygen isotope stages 6 to 2 inclusive. Sedimentological work was also carried out in the cave by Dr. S.N. Colcutt in the 1970’s (Colcutt 1984). Between 1989 and 1992, new excavations were directed in Tornewton Cave by Mr A.P. Currant of the Natural History Museum, as part of a programme of reinvestigation on behalf of the British Museum (Roberts 1996).
6.21.3. **Geological background and provenance of mammalian remains**

Tornewton Cave is located on the eastern side of a steep limestone gorge. The Cave comprises two sub-vertical phreatic rifts, with associated horizontal passages (Figures 6.46 and 6.47). The larger of the two rifts is referred to as the Main Chamber, with Upper, Middle and Lower Entrances. The Middle entrance was Widger’s original access to the cave. The Middle Entrance connects with the Main Chamber via a narrow passage known as the Middle Tunnel. The enlarged Lower Entrance gives access to the Lower Tunnel, an extension of the Main Chamber in its lower part. The smaller of the two rifts is known as Vivian’s Vault and is reached through a hole high in the wall of the Main Chamber (Currant 1996).

![Figure 6.46 Plan of Tornewton Cave (modified from Proctor 1994)](image)

(for key, see Figure 6.47).
The stratigraphic succession in the cave is as follows, from the base upwards (numbering according to Sutcliffe and Zeuner 1962; Currant, in Roberts 1996):

1. Laminated clay. Unfossiliferous, water-laid clays and silts; the upper part of this unit is much disturbed and deeply incised by the overlying deposit.

2. Stalagmite formation. Broken stalagmite clasts in the overlying Unit 3 were interpreted as representing a floor which had previously sealed Unit 1.

3. ‘Glutton Stratum’. A heavily-disturbed, compact cave earth, containing abundant mammalian remains (primarily of brown bear, *Ursus arctos*). This deposit was interpreted by Sutcliffe and Zeuner (1962) as accumulating under periglacial conditions. The Glutton Stratum is thickest at the back of the cave, thinning out towards the Lower Entrance. Remains of wolf (*Canis lupus*), lion (*Panthera leo*) and fox (*Vulpes vulpes*) were also common, with other species, such as glutton (*Gulo gulo*), reindeer (*Rangifer tarandus*) and hare (*Lepus sp.*) reported to be much rarer.

4. ‘Bear Stratum’. This unit overlies the Glutton Stratum and extends for the full length of the Main Chamber and Lower Tunnel. Sutcliffe and Zeuner (*ibid*) maintained that there was no faunal distinction between the Glutton and Bear Strata, although the
nature of the deposits in the latter was apparently different, showing signs of internal stratigraphy and containing rock clasts of limestone, as opposed to stalagmite.

5. Stalagmite floor, forming a thin but continuous sheet across the Main Chamber and individual stalagmites in the Lower Tunnel.

6. ‘Hyena Stratum’. This deposit is interpreted as the product of a prolonged period of denning by the spotted hyaena (*Crocuta crocuta*). Much of this extensive unit (which is present throughout the Main Chamber and the Lower Tunnel) consists of teeth, bones and bone debris, hyaena coprolites and fragmented coprolitic material. Abundant hyaena remains of all ages are represented, mostly by teeth and footbones. Species other than hyaena are quite rare but include a wide range of species: *C. lupus*, *P. leo*, *V. vulpes*, *Ursus* sp., narrow-nosed rhinoceros *Stephanorhinus hemitoechus*, hippopotamus *Hippopotamus amphibius*, fallow deer *Dama dama*, red deer *Cervus elaphus*, a large bovid, *Lepus* sp., water vole *Arvicola* sp. and numerous birds. These taxa are also represented by teeth, footbones or very heavily gnawed limb fragments and it is apparent that the hyaenas consumed all but the least digestible parts, even of their own kind.

7. Stalagmite floor, capping the Hyaena Stratum. This was almost entirely removed by Widger (1892). Although Widger (*ibid*) reported this floor to be two feet thick (0.6m), re-examination of a small remaining part of this stalagmite by Sutcliffe and Zeuner (1962) suggested that Widger’s figure should probably have read two inches thick (5cm).

8. ‘Head’ (apparently absent within the cave). This talus deposit accumulated outside the Lower Entrance and was considered to post-date the Hyaena Stratum (Sutcliffe and Zeuner 1962). Near the mouth of the cave, the ‘head’ rested directly on top of Unit 1 (the water-laid clays), with the intervening units apparently missing. Rare finds of reindeer (*Rangifer tarandus*) were present in the talus.

9. ‘Elk Stratum’. This thin deposit lay immediately on top of the talus, outside the Middle Entrance. A rich faunal assemblage was present, including *C. crocuta*, *R. tarandus*, horse (*Equus ferus*) and woolly rhinoceros (*Coelodonta antiquitatis*). The ‘elk’ has since been re-identified as *C. elaphus* (Lister 1984a).

10. Grey Loam. This thin deposit overlay the ‘Elk Stratum’ outside the Middle Entrance. It was in turn overlain by the ‘Reindeer Stratum’, containing an assemblage attributed to an interstadial phase within the Last Glaciation.
Widger (1892) also described further deposits of stalagmite, interspersed with 'Diluvium' and 'Eboulis', the ages of which are as yet uncertain but which probably date from the Late Pleistocene-early Holocene (Sutcliffe and Zeuner 1962).

Sutcliffe and Zeuner (1962) assigned the Hyaena Stratum to the Ipswichian Interglacial. The Glutton Stratum and Bear Stratum were consequently assigned to the penultimate cold stage (Stage 6), on the basis of their position below the Hyaena Stratum (Sutcliffe and Zeuner ibid).

Subsequent excavations by Sutcliffe in Vivian's Vault discovered a previously-unrecognised deposit, containing abundant microvertebrate remains, including white-toothed shrew (Crocidura sp.) (Rzebik 1968), numerous bird bones and the remains of clawless otter (Cyrenaonyx antiqua) (Figure 3.34). This deposit was named the 'Otter Stratum' (Sutcliffe and Kowalski 1976). These authors also listed remains of hamster (Cricetus cricetus), steppe lemming (Lagurus lagurus), collared lemming (Dicrostonyx torquatus), Norway lemming (Lemmus lemmus), snow vole (Microtus nivalis), northern vole (Microtus oeconomus), wood mouse (Apodemus sylvaticus) and water vole (Arvicola sp.). The authors noted that the assemblage appeared to contain a mixture of temperate elements, which they attributed to the Ipswichian Interglacial, and cold elements, which they attributed to the penultimate cold stage (Stage 6).

Reappraisal of the collections from Sutcliffe's excavations have led to the partial reinterpretation of the Tomewton Cave sequence (Currant, in Roberts 1996).

Collections from the Glutton Stratum have in fact, been found to contain a much wider range of species than that originally reported by Sutcliffe and Zeuner (1962), adding a strongly 'temperate' aspect to what is supposedly a cold, Stage 6 assemblage (Currant, in Roberts 1996). The fauna may therefore be described as an admixture of temperate and boreal indicators. A jaw of Gulo gulo from this deposit was submitted for radiocarbon dating, yielding an age-estimate of 22 160 ± 460 years B.P. (OxA-4587). The Glutton Stratum would therefore appear to have been emplaced as a debris flow beneath the older Bear Stratum, at some time around the Devensian glacial maximum (oxygen isotope Stage 2), thereby refuting the attribution of this deposit by Sutcliffe and Zeuner (1962) to Stage 6 (Currant, in Roberts 1996).
It seems likely that a major part of the cave became filled during the early part of the Devensian (Stage 4) and that the cave remained closed during the Middle Devensian (Stage 3). During this period, access appears to have been restricted to the Middle Tunnel, where the ‘Elk Stratum’ and its associated deposits contain the only characteristically Middle Devensian assemblage from the cave. Only after material filling the upper part of the cave had collapsed down the back of the Main Chamber, was access to the main cavern space re-opened. The dated glutton jaw may therefore have belonged to an animal that was occupying the cave at the time of the debris flow (Currant ibid).

Re-examination of in situ Bear and Hyaena Stratum deposits in a small cavern space at the back of the Main Chamber (the Main Chamber Extension) revealed large numbers of Microtus oeconomus in the Hyaena Stratum (Currant ibid). This species is considered an unusual find in an assemblage originally attributed to the Ipswichian by Sutcliffe and Zeuner (1962), since M. oeconomus is absent from most deposits representing the warmest part of the Last Interglacial. At Bacon Hole, West Glamorgan (7.1), an extensive series of mammal faunas recovered from Stage 5 sediments show that M. oeconomus was apparently absent during the early part of this stage but was quite common during subsequent substages of Stage 5 (Sutcliffe et al. 1987). Seen in the light of this evidence, attribution of the Hyaena Stratum to Substage 5e of the Ipswichian no longer seems so certain.

Furthermore, re-assessment of the underlying Bear Stratum fauna has demonstrated that, contrary to the findings of Sutcliffe and Zeuner (1962), this unit contains a microvertebrate fauna of clear interglacial character (Cornish, in Roberts 1996). It is therefore possible that the Bear Stratum represents Substage 5e of the Ipswichian Interglacial, so that the overlying Hyaena Stratum might represent Substage 5c (Currant, in Roberts 1996). Attribution of the Bear Stratum to Substage 5e is further supported by closer examination of the Hippopotamus specimens from Tornewton Cave. Most are poorly stratified, one is derived into the Glutton Stratum, and the remainder have clear signs that their original field data has been erased or altered. Little faith can therefore be placed in the provenance of a number of biostratigraphically significant specimens which were attributed to the Hyaena Stratum by Sutcliffe and Zeuner (1962) (Currant ibid). It therefore seems possible that the Hippopotamus remains originally came from
the fully temperate Bear Stratum, but given the then prevailing belief that this unit represented a non-temperate environment, it is easy to understand the collectors’ doubts about the provenance of these temperate indicators.

The revised interpretation inside the cave, according to Currant (ibid) is therefore as follows:
1. Deposition of the Bear Stratum during Substage 5e (Ipswichian).
2. Deposition of the Hyaena Stratum during Substage 5c.
3. Deposition of the Glutton Stratum as a debris flow beneath the Bear Stratum during Stage 2 (Late Devensian).

Excavations in the entrance to Vivian’s Vault during 1991 and 1992 proved a small remnant of in situ Hyaena Stratum, overlying a large fragment of in situ Bear Stratum against the wall of the Vault (Currant ibid). Immediately beneath the Bear Stratum, a thin unit of barren clay was observed to overlie a partly broken stalagmite floor. This stalagmite floor contained pockets of sediment, rich in Crocidura remains (Figure 6.48), and had bones of C. antiqua adhering to some of its broken surfaces (the Otter Stratum). The stratigraphic relationship of the Otter Stratum to the Bear Stratum indicates that the former must represent an earlier temperate episode (Currant ibid). Evidence of the age of the Otter Stratum can be deduced from its mammalian assemblage. Crocidura is not know from any Ipswichian deposits in Britain but has been recorded from both Stage 9, at Purfleet (5.1), Grays (5.2) and Cudmore Grove (5.3) and Stage 7, at Aveley (6.1) and Itteringham (6.3). Immediately beneath the entrance to Vivian’s Vault, a pipe of sediment runs down into the disturbed sediments of the Otter Stratum, apparently associated with the broken edge of the stalagmite floor mentioned above. A palate and dentary of C. cricetus were recovered from this deposit, which is tentatively interpreted as a small-scale debris flow (Currant ibid).

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The deposits of interest to the present study are those of the Otter Stratum and the associated intrusive debris flow containing the remains of *C. cricetus*.

6.2.1.4. Palaeontology

The following species list has been compiled from material housed in the Natural History Museum, collected by A.J. Sutcliffe and A.P. Currant of the same institution. Although processing of material from the most recent excavations has not been completed, the presence of 7 species has been identified to date in the Otter Stratum.

**Species List (Mammalia) from the Otter Stratum, Tornewton Cave, Devon**

**Insectivora**

*Erinaceus europaeus* L., hedgehog
*Sorex araneus* L., common shrew
*Crocidura cf. russula* Hermann, greater white-toothed shrew
*Crocidura* sp., indet. white-toothed shrew

**Rodentia**

*Apodemus sylvaticus* (L.), wood mouse

**Carnivora**
Vulpes vulpes L., fox
Meles meles (L.), badger
Cyrnaonyx antiqua (Blainville), extinct clawless otter

The material from the most recent excavations is currently under analysis by Mr A.P. Currant and the list must therefore be regarded as provisional, pending completion of processing of bulk samples. Comprehensive counts of numbers of specimens and calculation of minimum numbers of individuals has therefore not been possible.

6.21.5. Palaeoenvironmental and palaeoclimatic interpretation

The mammalian assemblage from the Otter Stratum is indicative of fully interglacial conditions, as attested to by the small mammal fauna. In particular, the presence of a white-toothed shrew (*Crocidura cf. russula*), which today has a predominantly southern European distribution, is considered to indicate a climate slightly warmer than at the present day. The occurrence of *A. sylvaticus* and *M. meles* indicate the proximity of deciduous or mixed woodland, while *S. araneus*, *C. cf. russula* and *E. europaeus* (the only occurrence of this species in the British late Middle Pleistocene) suggest the presence of areas of grassland with low vegetation cover or scrub. A nearby body of water is indicated by the presence of shelduck (*Tadorna tadorna*) (Stewart, in Roberts 1996) and *C. antiqua*. Sparse remains of *Bufo* and *Rana* were also recovered from this stratum (Gleed-Owen, in Roberts 1996).

The mammalian assemblage from the Otter Stratum contains an unusually high representation of rare insectivores and carnivores and is therefore unlikely to be an accurate reflection of the surrounding environment of the cave. This peculiar over-representation of a limited number of species is paralleled in the avian remains from this deposit, which are represented almost exclusively by shelduck. A hypothesis of avian botulism has been put forward for this accumulation (N. Hildegard pers. comm). Outbreaks of this disease have been documented in East Anglia in recent years (for example in the Bury Free Press of August 16\textsuperscript{th} 1991), as a consequence of summer drought. The lowering of water levels in already shallow lakes enables the organism responsible for botulism to thrive in the exposed mud, resulting in the deaths of waterbirds which ingest the toxin. Mass mortality of ducks and other waterbirds is the
outcome, with hundreds dying in a single outbreak. Up to 5 million waterbirds are estimated to die every autumn in the United States, as a result of avian botulism during the migration period (N. Hildegard pers. comm.). The disease affects the sight of the dying birds and drives them to seek dark places in which to shelter. An outbreak of avian botulism might therefore explain the strange accumulation of shelduck in the Tornewton Cave Otter Stratum. Thereafter, a chain of mortality would have been set up, with shrews consuming toxic maggots on the carcasses and themselves becoming fatally poisoned, and larger carnivores consuming the carcasses of the waterbirds and shrews and also perishing. The presence of articulated skeletons of shrews in the deposits suggests that died in situ.

The single record of *C. cricetus* from the later intrusive breccia is indicative of more continental conditions and the presence of steppe grasslands or meadows.


**Mammalian studies**

The mammalian assemblage from the Otter Stratum in Tornewton Cave contains two species of potential biostratigraphic significance. White-toothed shrews are known from sites attributed to the Stage 9 interglacial, at Purfleet (5.1), Grays (5.2) and Cudmore Grove (5.3), and from certain sites attributed to Stage 7 in the present study, such as at Aveley (6.1) and Itteringham (6.3). The Stage 9 *Crocidura* have tentatively been assigned to *C. cf. leucodon*, the bicoloured white-toothed shrew. However, the morphology of the fourth upper premolar in the *Crocidura* from the Otter Stratum sample is more consistent with an attribution to *C. cf. russula*, the greater white-toothed shrew. This might consequently suggest that the Otter Stratum is not of the same age as the Stage 9 *C. cf. leucodon* fauna. Upper fourth premolars are unfortunately not present in the *Crocidura* material from Aveley and Itteringham.

The presence of *C. antiqua* may also be of biostratigraphic significance. This is the only known record of this species in the British late Middle Pleistocene, although it was apparently widely distributed throughout Europe during between the Holsteinian and the end of the Saalian (Willemsen 1990). The occurrence of *C. antiqua* in Britain may
therefore be a biostratigraphic marker in the late Middle Pleistocene, but further remains would be required to confirm this.

6.21.7. Discussion and conclusions

The age of the Otter Stratum has been established on the basis of its stratigraphic position below deposits now recognised to be of Ipswichian age (the Bear Stratum) and on the basis of its mammal fauna. A temperate-climate episode is clearly indicated by the fauna and the presence of a white-toothed shrew suggests correlation of the Otter Stratum with either the Stage 9 or Stage 7 interglacials. However, the particular morphology of the Crocidura remains from Tornewton Cave is considered here to be a closer match with C. russula than with the C. cf. leucodon identified in deposits relating to the Stage 9 interglacial. Although it is perfectly possible that two species of Crocidura co-existed in Britain, the presence of a different species at Tornewton is believed to be a positive indication that the Otter Stratum is not of Stage 9 age. Correlation of the Otter Stratum with the Stage 7 interglacial is therefore favoured. Deposits containing indeterminate Crocidura at Aveley (6.1) and Itteringham (6.3) have been attributed to the early part of the Stage 7 interglacial, when woodland conditions appear to have prevailed. This corresponds well with the palaeoenvironmental evidence from the Otter Stratum, which also suggests the predominance of temperate woodland habitats at this time. Correlation with Substage 7c is therefore tentatively proposed. The presence of C. antiqua may also prove to be of biostratigraphic significance, since this species is so far recorded in Britain on only one occasion during the late Middle Pleistocene.

A Stage 7 correlation has also been upheld by recent dating evidence (A.P. Currant pers. comm.). Uranium-series dating of stalagmite deposits above and below the Otter Stratum have yielded age-estimates of 224 000 and 298 000 years B.P. respectively. These are close to the Stage 7 correlation proposed on the basis of biostratigraphy.

The age of the intrusive debris flow is hard to ascertain, since no other record of C. cricetus is known from the British late Middle Pleistocene. However, the observation that this deposit post-dates the Otter Stratum, but apparently pre-dates the Ipswichian deposits of the Bear Stratum, suggests that the debris flow took place during the
intervening period of cold conditions, corresponding with Stage 6 of the oxygen isotope record. The occurrence of *C. cricetus* would be consistent with such an interpretation, since the presence of more continental climatic conditions and the development of steppe-like habitats has been documented at other sites containing deposits related to the end of Stage 7, such as Crayford (6.18) and Hutton Cave (6.23).
6.22. BLEADON CAVE, SOMERSET (ST 36065813)

6.22.1. Location of the site

Bleadon Cave is located on the north side of the Mendip Hills, approximately 800m south-east of the village of Hutton and 2.5km south of Weston-super-Mare. The cave lies at approximately 100m O.D (Figure 6.49).

![Location map of Bleadon Cave](modified from Ordnance Survey map).

6.22.2. History of research

The rich collections of mammalian remains from Bleadon Cave are mainly the work of two local men, the Reverend David Williams, Rector of Bleadon and Kingston Seymour, and William Beard, a farmer of Winthill, Bleadon. Williams was elected a Fellow of the Geological Society in 1828 and maintained a life-long interest in the exploration of the caverns and fissures in the Bleadon and Hutton area, during which time he collected a vast amount of material. Beard was also an extremely active collector and by the 1830s was already noted for his substantial collections of bones which he kept in his home, the aptly-named 'Bone Cottage'.
In January 1833, according to Beard’s manuscript books (in the Somerset County Record Office), Beard began work on Bleadon Hill, which resulted in the discovery of the bone cave on the 4th day of that month. Beard’s work at the cave ended on 22nd March 1834, although he kept the site open for the numerous visitors (including such notables as Richard Owen, Henry de la Beche, Adam Sedgwick, William Pengelly, Thomas Huxley and Hugh Falconer) until 1865 (Taylor 1908-9). Remains of bear, straight-tusked elephant, mammoth (the most common of the elephants), horse, wild boar, giant deer, roe deer and bison from Bleadon are mentioned by Dawkins (Dawkins 1865). After his death in 1852, the Somersetshire Archaeological and Natural History Society purchased Williams’s collection and donated it to the Somerset County Museum at Taunton Castle. To this was added the Beard Collection in 1864. W.A. Sanford began cataloguing these remains, although only the Felidae were ever completed (Dawkins and Sanford 1866; Sanford 1867).

The Taunton Castle fossil mammal collection was one of the major research resources for the palaeontologists of the latter part of the 19th Century and formed the basis for many of the Palaeontographical Society monographs, on account of the superb preservation of the specimens and the remarkable completeness of the material. However, following the death of the curator W. Bidgood at the end of the last century, the collections were abandoned and gradually displaced as the interests of the Somersetshire Archaeological and Natural History Society changed. The nadir was reached in the 1960s when the bones from at least five well-known Mendip cave sites (including Bleadon) were taken out of the Castle Museum and dumped in a coalhouse in the grounds. They remained untouched for the best part of three decades. Since 1993, the author has been involved in a program of provenancing, restoring and identifying this material, in conjunction with A.P. Currant (Natural History Museum, London) and Somerset County Museum.

6.22.3. Geological background and provenance of mammalian remains

No published sections or geological descriptions are known from Bleadon Cave. However, the site was visited in 1982 by A.P. Currant, who recorded the following plan and section (Figures 6.50 and 6.51).
The bones are recorded from an ochreous cave earth, interpreted as a debris flow, an observation that fits well with the matrix, which can be seen adhering to some of the specimens. The distinctive preservation type has enabled some of the material lacking locality details (particularly that collected by Williams) to be correctly provenanced.
6.22.4. Palaeontology

The following species list has been compiled from material in the Somerset County Museum, Taunton, and the Natural History Museum, London. The presence of 20 mammalian species in the Bleadon Cave assemblage has been confirmed by the present study, including previously unpublished records of *Microtus oeconomus*, *Crocuta crocuta* and an indeterminate rhinoceros. Remains of steppe pike (*Ochotona pusilla*) from Bleadon Cave were recorded by Jackson (in Parry 1930), and of *Arvicola* by Dawkins (1865), although these were not traced during the present study. Dawkins (*ibid*) also recorded giant deer and *Hippopotamus*, the presence of which was also not verified in collections. It seems most likely that some of the extremely large red deer specimens contributed to a mistaken record of giant deer, likewise the huge canines of wild boar, which may have been misidentified as hippopotamus. A total of 2847 specimens was examined.

Species List (Mammalia) from Bleadon Cave, Somerset

**Lagomorpha**

*Lepus timidus* L., mountain hare

**Rodentia**

*Citellus cf. citellus* L., ground squirrel

*Microtus oeconomus* (Pallas), northern vole

*Microtus* sp., indet. vole

**Carnivora**

*Canis lupus* L., wolf

*Vulpes vulpes* L., red fox

*Ursus arctos* L., brown bear

*Mustela putorius* L., polecat

*Crocuta crocuta* Erxleben, spotted hyaena

*Felis silvestris* Schreber, wild cat

*Panthera leo* (L.), lion

*Panthera pardus*, leopard

**Proboscidea**

*Palaeoloxodon antiquus* (Falconer and Cautley), straight-tusked elephant
Mammuthus primigenius (Blumenbach), mammoth
Elephantidae sp., indet. elephant
Perissodactyla
Equus ferus Boddaert, horse
Rhinocerotidae sp., indet. rhinoceros
Artiodactyla
Sus scrofa L., wild boar
Cervus elaphus L., red deer
Capreolus capreolus L., roe deer
Bos primigenius Bojanus, aurochs
Bison cf. priscus Bojanus, bison
Bovidae sp., indet. large bovid (Bos or Bison)

Table 6.18 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagomorpha</td>
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<td></td>
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<tr>
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<tr>
<td>Rodentia</td>
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<td>C. citellus</td>
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<tr>
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</tr>
<tr>
<td>C. lupus</td>
<td>35</td>
<td>1.22</td>
<td>3 (1 juv., 2 adults)</td>
</tr>
<tr>
<td>V. vulpes</td>
<td>18</td>
<td>0.63</td>
<td>3</td>
</tr>
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<td>U. arctos</td>
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<td>0.77</td>
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<td>P. pardus</td>
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<td>2 (1 juv., 1 adult)</td>
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<td>1</td>
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<tr>
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</tr>
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<td>2.63</td>
<td>1</td>
</tr>
<tr>
<td>M. primigenius</td>
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<td>1</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>61</td>
<td>2.14</td>
<td>2 (1 juv., 1 adult)</td>
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<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
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</thead>
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<tr>
<td>Proboscidea</td>
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<tr>
<td>P. antiquus</td>
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<tr>
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<td>1</td>
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<tr>
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<td>61</td>
<td>2.14</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
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<td>31.08</td>
<td>65 (8 juv., 57 adults)</td>
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<td>10.92</td>
<td>21 (7 juv., 14 adults)</td>
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<td>C. elaphus</td>
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<td>18.68</td>
<td>39 (14 juv., 25 adults)</td>
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<td>C. capreolus</td>
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<td>6 (1 juv., 5 adults)</td>
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<td>0.14</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>373</td>
<td>13.1</td>
<td>16 (4 juv., 12 adults)</td>
</tr>
</tbody>
</table>

Table 6.18 Breakdown of the mammalian species list from Bleadon Cave, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.22.5. Palaeoenvironmental and palaeoclimatic interpretation

As one would expect in a cave site, the Carnivora are particularly well-represented in the Bleadon assemblage, with 8 species identified. Although the entire assemblage is from a debris flow, it nonetheless contains a coherent mammal fauna that may be taken as accurately reflecting the immediate environment of the cave. The predominance of remains of *P. leo*, including remains of juveniles (Figure 6.52), is a strong indication that the cave was being used as a lion den and it is therefore likely that a substantial proportion of the mammalian remains was brought in as prey, or that the cave acted as a natural trap to which lions were drawn. This latter scenario seems most plausible as an explanation for the presence of elephant remains, since it seems unlikely that lions were bringing carcasses of this size into the cave. The absence of gnawing on most of the bones is also characteristic of the behaviour of lions, unlike that of many other predators. The presence of other carnivore species (including a rare record of *Mustela putorius*, see Figure 3.32) suggests that they may also have been using the cave periodically, or may have also fallen victim to a natural trap.
Figure 6.52 Left and right dentaries of juvenile *Panthera leo* (buccal view and lingual view respectively, TTNCM:41/1995/Cat.45 and TTNCM:41/1995/Cat.46, Taunton Museum), Bleadon Cave.

*E. ferus* is the most abundantly represented of the large herbivores, with 885 specimens recorded (31.08% of the assemblage). This suggests the presence of large areas of open grassland in the vicinity of the cave, an inference supported by the remains of other large grazers and grazer/browsers (rhinoceroses, *C. elaphus* and large bovids) and grassland rodents such as *C. citellus* and *M. oeconomus*. However, the unusually abundant presence of *S. scrofa* (311 specimens) and *C. capreolus* (101 specimens), which are both relatively rare in the fossil record, may be taken as reflecting extensive tracts of deciduous or mixed woodland on top of the Mendips. This is supported by the presence of *U. arctos*. Remains of *P. pardus* (Figure 3.39) are known only from cave sites in upland areas during the British late Middle Pleistocene, although modern leopards today inhabit a wide range of environments.

The presence of *P. antiquus*, *S. scrofa*, *C. capreolus* and *B. primigenius* indicates a temperate climate.
6.22.6. Biostratigraphy and correlation

Mammalian studies

The findings of the present study place the mammalian assemblage from Bleadon Cave in the Stage 7 interglacial (probably Substage 7a), based upon a number of important diagnostic features, which unite assemblages of this age.

The presence of *C. citellus* may be significant, since this species is so far unknown from any other interglacial in the post-Anglian Middle Pleistocene, but is also recorded from the Crayford brickearths (6.18). The presence of *M. oeconomus* is also important, since this species is common at other sites attributed to Stage 7 in the present study and appears to have enjoyed a period of dominance of the small mammal fauna during this period (Currant, in *Green et al.* 1996). It has also been recorded from the Ipswichian, for example at Swanton Morley (Coxon *et al.* 1980), but not as the dominant microtine species.

A further important feature is the presence of *P. antiquus* and *M. primigenius*, although it cannot be established whether the latter is of ‘Ilford type’. However, the co-existence of these two species is characteristic of the Stage 7 interglacial and can be documented at numerous other sites, including Ilford (Uphall Pit) (6.2), Northfleet (6.5), Brundon (6.6), the Lower Channel at Marsworth (6.10) and Stanton Harcourt (6.11). Other diagnostic characters of the Stage 7 interglacial, found in the Bleadon assemblage, include the presence of a large form of *P. leo* as the most abundant predator, followed by *U. arctos*, *C. lupus* and *C. crocuta*. The latter species has been recovered in small numbers from both cave and open sites attributed in the present study to Stage 7 sites, including and Stanton Harcourt, Crayford and Hutton Cave (6.23), but was apparently less abundant in Britain at that time than during the succeeding Ipswichian Interglacial. The presence of *P. pardus* is also of potential biostratigraphic significance, since this species is known only from one other late Middle Pleistocene locality in Britain, the Stage 7 cave site of Pontnewydd (Clwyd) (6.25).
The Bleadon assemblage is also notable for the presence of abundant large *E. ferus*, large *C. elaphus* and large bovids. The unusually large size of most of the herbivores in the Stage 7 interglacial attests to the richness of the environment during that time period. This is also reflected in the extremely large size of the *S. scrofa* remains.

**6.22.8. Discussion and conclusions**

Examination of the mammalian assemblage from Bleadon Cave reveals that it is a very close match with those from the upper part of the sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2), Brundon (6.6), and Stanton Harcourt (6.11). Important features of the assemblage include the presence of *C. citellus* and *M. oeconomus*, the co-existence of *P. antiquus* and *M. primigenius* and the presence of a very large forms of *P. leo*, *E. ferus*, *C. elaphus* and large bovids. The assemblage is clearly interglacial in character, on the basis of the presence of thermophilous species, such as *P. antiquus*, *S. scrofa*, *C. capreolus* and *B. primigenius* and the association of remains of *M. primigenius* and *E. ferus* with these temperate indicator species is clearly established by matrix blocks containing remains of more than one species, for example a block containing molar plate of *M. primigenius*, together with a right dentary fragment of a juvenile *S. scrofa* (TTNCM:41/1995/(G649), Somerset County Museum). On the basis of the mammalian biostratigraphic evidence, the assemblage from Bleadon Cave is therefore correlated with Stage 7 and most probably with Substage 7a.

This is the first time that the Bleadon Cave assemblage has been attributed to any particular stage in the British Pleistocene and the recognition of an important Stage 7 assemblage from this cave site is of great significance.
6.23. HUTTON CAVE, SOMERSET

6.23.1. Location of the site

The precise location of Hutton Cave is unknown. Recent investigation has revealed that the cave marked as ‘Hutton Cavern’ on the Ordnance Survey maps is really Bleadon Cave (6.22) (D. Irwin pers. comm.). All that is known of Hutton Cave is that it was located on the north side of the Mendip Hills, in the vicinity of the village of Hutton, approximately 2.5km south of Weston-super-Mare.

6.23.2. History of research

The cave system at Hutton was discovered in about 1756 by ochre miners and is first mentioned in Catcott’s Treatise on the Deluge of 1768. Shortly afterwards however, the cave became inaccessible through collapse of the roof and walls, thus denying any further investigation. Buckland’s Reliquiae Diluvianae of 1823 recalled the abandoned ochre pits near the summit of the Mendips, which had been worked during the mid-eighteenth century and mentioned one cavern in particular, the floor of which ‘consisted of good ochre, strewed on the surface of which were multitudes of white bones, which were also found dispersed through the interior of the ochreous mass’ (Buckland ibid, 53). Buckland also recorded the presence of a wide variety of species, which he believed had been accumulated by diluvial forces and estimated the deepest part of the workings to be thirty-five yards below the surface of the hill. Armed with this knowledge and spurred on by the discovery of fragments of fossil bone in the rubbish of adjacent pits, the Reverend David Williams and Mr Henry Beard sank a shaft into the hill and succeeded in rediscovering the cave system on 19th September 1828 (Williams 1831; Taylor 1908).

Further references to the site are in Rutter (1829a, b), Sanford (1865, 1870) and Davies (1926). Wild boar remains were figured by Buckland (1823), elephant remains by Leith-Adams (1877-81), lion remains by Dawkins and Sanford (1868), rodent remains by Sanford (1870) and Hinton (1926b) and the canid remains by Reynolds (1909).

The Hutton Cave mammalian remains suffered the same fate as those from Bleadon.
Cave, being abandoned and left in a state of neglect for many years in the Somerset County Museum (see 6.22). Since 1993, the author has been involved in a program of provenancing, restoring and identifying this material, in conjunction with A.P. Currant (Natural History Museum, London) and Somerset County Museum.

6.23.3. Geological background and provenance of mammalian remains

Original descriptions of the cave (for example Catcott, 1768) describe three open chambers, some 6m from the ground surface. The chambers lay one above the other and were separated from each other by suspended floors of jammed boulders and ochreous earth. The bones are recorded from these ochre deposits (interpreted as a debris flow, an observation which fits well with the matrix which can be seen adhering to some of the specimens) in the floors and elsewhere in the fissure between 4.5 and 15m depth. The distinctive preservation type has enabled some of the material lacking locality details (particularly that collected by Williams) to be correctly provenanced.

6.23.4. Palaeontology

The present study has confirmed the presence of 11 mammalian species from Hutton Cave, based upon material housed in Somerset County Museum and the Natural History Museum, London and collected by D. Williams, H. Beard and B. Bright. 831 specimens were examined.

A number of records were unable to be verified during the present study. Sanford (1870) listed remains of *Arvicola, Clethrionomys glareolus, Ochotona pusilla* and *Citellus citellus (Spermophilus erythrogenoides)* from Hutton Cave, although these have not been relocated in the collections. Sanford (1865) also documented the presence of leopard at Hutton, although the apparent absence of these specimens from the Hutton collections at the Somerset County Museum leads one to suspect that they in fact originated from Bleadon Cave, from where several specimens are known.
Species List (Mammalia) from Hutton Cave, Somerset

**Lagomorpha**
*Lepus* sp., indet. hare

**Rodentia**
*Allocricetus (Cricetulus) bursae* Schaub, dwarf hamster
*Dicrostonyx torquatus* (Pallas), collared lemming

**Carnivora**
*Canis lupus* L., wolf
*Vulpes vulpes* L., red fox
*Crocuta crocuta* Erxleben, spotted hyaena
*Felis silvestris* Schreber, wild cat
*Panthera leo* (L.), lion

**Proboscidea**
*Mammuthus primigenius* (Blumenbach), mammoth
Elephantidae sp., indet. elephant

**Perissodactyla**
*Equus ferus* Boddaert, horse

**Artiodactyla**
*Sus scrofa* L., wild boar
*Cervus elaphus* L., red deer

Table 6.19 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lagomorpha</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>L. timidus</em></td>
<td>29</td>
<td>3.48</td>
<td>5</td>
</tr>
<tr>
<td><strong>Rodentia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. bursae</em></td>
<td>4</td>
<td>0.48</td>
<td>2</td>
</tr>
<tr>
<td><em>D. torquatus</em></td>
<td>7</td>
<td>0.84</td>
<td>3</td>
</tr>
<tr>
<td><strong>Carnivora</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lupus</em></td>
<td>188</td>
<td>22.62</td>
<td>5</td>
</tr>
<tr>
<td><em>V. vulpes</em></td>
<td>6</td>
<td>0.72</td>
<td>3</td>
</tr>
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</table>

cont’d.../...
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. crocuta</td>
<td>93</td>
<td>11.19</td>
<td>2</td>
</tr>
<tr>
<td>F. silvestris</td>
<td>4</td>
<td>0.48</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>P. leo</td>
<td>4</td>
<td>0.48</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. primigenius</td>
<td>8</td>
<td>0.96</td>
<td>3 (2 juv., 1 adult)</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>22</td>
<td>2.64</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>462</td>
<td>55.59</td>
<td>14 (6 juv., 8 adults)</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. scrofa</td>
<td>2</td>
<td>0.24</td>
<td>1</td>
</tr>
<tr>
<td>C. elaphus</td>
<td>2</td>
<td>0.24</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.19 Breakdown of the mammalian species list from Hutton Cave, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.23.5. Palaeoenvironmental and palaeoclimatic interpretation

As with the neighbouring site of Bleadon Cave (6.22), the Carnivora are particularly well-represented in the Hutton assemblage, with 5 species identified. However, unlike Bleadon Cave, which is dominated by P. leo, remains of C. lupus (Figures 6.53) and C. crocuta are the most commonly represented of the Hutton carnivores, suggesting that these two species were probably inhabiting the cave (possibly at different floor levels). It is therefore likely that a substantial proportion of the mammalian remains were brought in as prey, or that the cave acted as a natural trap to which predators were attracted.

Although the entire assemblage is from a debris flow, it nonetheless contains a coherent mammal fauna that may be taken as accurately reflecting the immediate environment of the cave. E. ferus is the most abundantly represented of the large herbivores, with 462 specimens recorded (55.86% of the assemblage). This suggests the presence of large areas of open grassland in the vicinity of the cave, an inference supported by the remains of other large grazers and grazer/browsers (M. primigenius and C. elaphus).
Although woodland indicator species are well-represented at nearby Bleadon Cave (6.22), these are virtually absent from Hutton (only 2 specimens of *S. scrofa*, 0.24% of the assemblage), possibly due to different prey-selection by the carnivore occupants of the cave or because the two sites represent slightly different time periods.

The presence of *S. scrofa* indicates a temperate climate, although the occurrence of *D. torquatus* (as at Crayford, 6.18) and *A. bursae* suggests a continental, steppe environment or the onset of colder conditions (Bishop 1982).

### 6.23.6. Biostratigraphy and correlation

#### Mammalian studies

Examination of the *M. primigenius* remains from Hutton Cave has revealed that they are of the primitive 'Ilford type', based upon the small size of the teeth and the low plate count (exemplified in a left and right first lower molar, 44736, Natural History Museum). The primitive 'Ilford type' mammoth is considered to be of biostratigraphic importance in demonstrating a Stage 7 age. The degree of annulation in these molars is also particularly pronounced, a feature which also may be of biostratigraphic significance (see Chapter 3).

Hinton (1926b) designated the lemming remains from Hutton Cave as the syntype of *Dicrostonyx guielmi*, a lemming of *D. torquatus* type but bigger and with broader teeth.
with slight dental differences (see Chapter 3). However, it is now generally accepted that there is no real basis for this distinction and that all remains should be treated as *D. torquatus*.

The Hutton Cave equids are represented by a large form of *E. ferus*, although no further features are present which might be of biostratigraphic significance.

**6.23.7. Discussion and conclusions**

Sutcliffe (1995) assigned the Hutton Cave assemblage to Stage 6, due to the presence of the small hamster *A. bursae* and the primitive ‘Ilford type’ *M. primigenius*. However, examination of the material in the present study places the Hutton Cave assemblage at the end of the preceding interglacial, Stage 7. A Stage 6 correlation is refuted for several reasons. First, the horse represented at Hutton Cave is a large caballine form, which contrasts markedly with the very small horse identified at Stage 6 sites by the present study (see Chapter 7). Second, the presence of the ‘Ilford type’ mammoth is strongly indicative of a Stage 7 age. This is supported by the presence (albeit in small numbers) of *S. scrofa*, a species which is unknown from cold stage deposits.

However, the presence of *A. bursae* and *D. torquatus* suggest that a continental climate prevailed with a predominantly open grassland environment. This possibly indicates the onset of colder conditions and suggests that the Hutton Cave assemblage may be slightly later in time than the fully-interglacial assemblage from nearby Bleadon Cave (6.22). The Hutton Cave assemblage includes various key species such as the ‘Ilford type’ mammoth and a large *E. ferus*, which would place the site with other Stage 7 mammoth-horse faunas but the greatest similarity is with the fauna from the Crayford brickearths (6.18), which contain a high proportion of continental, steppic indicators. Although the location of the specimens of *Ochotona pusilla* and *Citellus citellus*, described by Sanford (1870), could not be verified, their presence in the Hutton assemblage would not be inconsistent. It is therefore concluded that the most appropriate position for the Hutton Cave assemblage is in the terminal stages of the OIS 7 interglacial (Substage 7a) but before the development of truly cold conditions in OIS 6. As with the neighbouring site of Bleadon Cave (6.22), the recognition of an important late Stage 7 cave assemblage is of great significance.
6.24. ORESTON CAVES, PLYMOUTH, DEVON (lower caves centred on SX 501538 and Upper Cave probably at SX 503537)

6.24.1. Location of the site

The village of Oreston is located on the left bank of the River Plym, near to the point where it enters Plymouth Sound. Directly behind the village are limestone quarries, from which stone for the Plymouth breakwater was extracted and where the Oreston Caves were discovered.

6.24.2. History of research

The removal of a limestone hill in order to construct the breakwater at Plymouth revealed a high cliff face, perforated by sections of infilled fissures and caverns (Buckland 1823) (Figure 6.54). Seven main caverns and numerous smaller fissures, at differing heights, were ultimately exposed by the quarrying and proved to be the source of remarkable quantities of fossil material. In 1812, Joseph Whidbey (seen also as Whidby and Whitby), superintendent of quarrying operations at the breakwater, was requested by Sir Joseph Banks to examine any caves that might come to light and to preserve any fossil material from these caves (Jackson 1937). In 1816, the first cavern was exposed by blasting and was examined by Banks at Whidbey's request. The cave lay at approximately 1.2m O.D. and was 21m below the ground surface and 49m into the hill from the original cliff face (Worth 1879). It yielded the remains of three individuals of rhinoceros and was the first bone cave in Britain to be scientifically investigated (Home 1817; Owen 1842). The rhinoceroses were later identified as *S. hemitoechus* (Buckland 1823; Busk 1870) and the specimens were sent to the Royal College of Surgeons in London, where they were destroyed (presumably during an air raid) in World War II.

A second cave at 2.4m O.D., located 110m away from the first, 17m below the ground surface and 160m from the original quarry face, was found in 1820 and yielded further remains of rhinoceros, deer and bear (Whidbey 1821; Owen 1842), which were also unfortunately destroyed during the war. In 1822, the third and most extensive cavern came to light, 165m west of the first cave. This cave was located at approximately 9m...
O.D. and was the lowest of a series of five chambers, connected by galleries and fissures. Substantial collections of mammalian fossils, including hyaena, wolf, fox, horse, deer and aurochs, were made by Whidbey from this cave in the same year (Worth 1879). Buckland (1823) reported that Whidbey removed ‘fifteen large maund baskets full’ of bones, which were sent to the College and from there distributed amongst various public collections. It was noted that the faunal remains from this cave were disarticulated but that the carnivore remains were separate and at some distance from the herbivore remains (Buckland 1823).

In 1823, a fourth cave (also known as ‘Oreston Great Cave’) was discovered at approximately 12.7m O.D and with an entrance 9m below the ground surface. This cave, together with a smaller and slightly lower adjacent cave (at 9m O.D.), contained enormous quantities of wolf bones, which were collected by Mr Cottle of Bristol (Cottle 1829; Reynolds 1909). In just two days, Cottle collected forty wolf jaws but was told that workmen at the site had already thrown away two cartloads of bones from the caves, not realising that they were of importance (Worth 1879). The discovery of these fossil remains aroused considerable interest among antiquarians, both at home and abroad, with references made to the site by Cottle (1829), who ascribed the faunal remains to the Biblical Flood, Cuvier (1834) and Owen (1846).

The cave of interest to the present study (henceforth referred to as the ‘Upper Cave’) was discovered in 1858 and was investigated by William Pengelly (Pengelly 1897). Lying at only 2.4m from the top of the cliff, this cave was the highest and deepest recorded. The bottom of the cave was never reached during quarrying but was known to be at least 16m down (Worth 1879). Remains of wolf, bear, lion, woolly mammoth, horse, extinct ass, deer and aurochs were recovered, which Pengelly interpreted as the casualties of the Biblical Deluge. Brief notices of the work up to that point and of the mammalian fauna were also provided by Dawkins and Sanford (1866). The final cave was breached in 1878, 6m from the ground surface, and contained remains of bison, aurochs, bear and birds (Worth 1879). The limestone cliff was finally entirely quarried away and little further work seems to have been carried out on the faunal material, although the caves are mentioned by Reynolds (1902), who states that the hyaena remains were amongst the earliest discovered in England.
Faunal material from the first two caves is no longer available for study, since it was part of the ill-fated collections in the Royal College of Surgeons, but of the remaining specimens from the other caves at Oreston, it may be seen that each cave possesses its own distinctive preservation type. Given the obvious potential for confusion between the various caves, it was determined that only material in the Natural History Museum, London, could be unequivocally regarded as from the Upper Cave on the basis of its distinctive preservation. This material is here referred to as ‘Oreston preservation type 1’ and has a pinkish preservation type. A second collection, also housed in the N.H.M., is here referred to as ‘Oreston preservation type 2’ and has a dark brown-grey preservation. This latter assemblage almost certainly comes from either Oreston Great Cave, or its smaller neighbour, discovered in 1823, since it contains an assemblage dominated by wolf. It comprises the following species: Canis lupus, Crocuta crocuta, Equus ferus, Coelodonta antiquitatis, Rangifer tarandus and a large bovid. Other material, also labelled Oreston, was seen in the British Geological Survey Museum, Keyworth, in the Yorkshire Museum and in the Oxford University Museum. These latter specimens are whitish in colour with a strong pink-red stain, but it is not known from which of the caves they were collected. Only material that can be definitely provenanced to the Upper Cave will be considered here.

No complete skeletons or articulated remains were recovered and many of the bones are in perfect condition, although most are slightly broken. It therefore seems most probable that the bone accumulation is a natural one and not the result of carnivore activity.
Figure 6.54 Section through the Oreston quarries, showing the relative positions of some of the caves (modified from Buckland 1823). It should be noted that there appears to be some discrepancy in the literature between the number of caves recorded up to 1823 and the number shown in this figure. The Upper Cave is unfortunately not shown, since the figure was produced before it was discovered.

6.24.3. **Geological background and provenance of mammalian remains**

The limestone cliff is approximately 800m wide and 28m high (Worth 1879).

The Upper Cave at Oreston was 0.6-3m wide, at least 16m high and 27m long, trending in a NNE-SSW direction. The faunal remains were found in a tough, very dense “dark, unctuous clay” (Worth 1879, 95), which formed a layer 3.7m deep and was overlain by
limestone gravel and sand. Jeffery's (n.d.) (see Worth *ibid*) section indicates four levels:

4. Angular cemented blocks of limestone, 2.4m
3. Angular limestone fragments and sand, 2.4m
2. West wall of cave: tough, dark clay and sand with limestone fragments, uncemented and containing bones, 10m.
1. East wall of cave: stalagmite deposit with pockets of breccia, containing bones, 0.5-1m thick.

The lower caves contain material of probable Devensian and/or Last Interglacial age. The Upper Cave, on the other hand, is considered by the present study to contain material relating to a pre-Ipswichian temperate stage.

6.24.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London, collected by W. Pengelly. 262 specimens were examined and the presence of 12 species confirmed, including previously unpublished records of spotted hyaena *Crocuta crocuta*, woolly rhinoceros *Coelodonta antiquitatis* and roe deer *Capreolus capreolus*.

Species list (Mammalia) from the Upper Cave deposits at Oreston, Plymouth, Devon

**Carnivora**

*Canis lupus* L., wolf
*Ursus arctos* L., brown bear
*Crocuta crocuta* Erxleben, spotted hyaena
*Panthera leo* (L.), lion

**Proboscidea**

*Mammuthus primigenius* (Blumenbach), mammoth

**Perissodactyla**

*Equus ferus* Boddaert, horse
*Equus hydruntinus* Regalia, stenonid “ass”
*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros

**Artiodactyla**
Sus scrofa L., wild boar
Cervus elaphus L., red deer
Capreolus capreolus (L.), roe deer
Bos primigenius Bojanus, aurochs
Bovidae sp., indet. large bovid (Bos or Bison)

Table 6.20 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. lupus</td>
<td>1</td>
<td>0.38</td>
<td>1</td>
</tr>
<tr>
<td>U. arctos</td>
<td>18</td>
<td>6.87</td>
<td>2</td>
</tr>
<tr>
<td>C. crocuta</td>
<td>1</td>
<td>0.38</td>
<td>1</td>
</tr>
<tr>
<td>P. leo</td>
<td>24</td>
<td>9.16</td>
<td>2</td>
</tr>
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<td>Proboscidea</td>
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<tr>
<td>M. primigenius</td>
<td>12</td>
<td>4.58</td>
<td>3 (2 juv., 1 adult)</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. ferus</td>
<td>90</td>
<td>34.35</td>
<td>2</td>
</tr>
<tr>
<td>E. hydruntinus</td>
<td>4</td>
<td>1.52</td>
<td>1</td>
</tr>
<tr>
<td>C. antiquitatis</td>
<td>2</td>
<td>0.76</td>
<td>1</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. scrofa</td>
<td>17</td>
<td>6.48</td>
<td>3 (1 juv., 2 adults)</td>
</tr>
<tr>
<td>C. elaphus</td>
<td>39</td>
<td>14.88</td>
<td>3 (1 juv., 2 adults)</td>
</tr>
<tr>
<td>C. capreolus</td>
<td>3</td>
<td>1.14</td>
<td>2 (1 juv., 1 adult)</td>
</tr>
<tr>
<td>B. primigenius</td>
<td>20</td>
<td>7.63</td>
<td>2</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>31</td>
<td>11.83</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 6.20 Breakdown of the mammalian species list from the Upper Cave at Oreston, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.24.5. Palaeoenvironmental and palaeoclimatic interpretation

E. ferus is the most abundantly represented of the large herbivores, with 90 specimens recorded (34.35% of the assemblage). This suggests the presence of large areas of open grassland in the vicinity of the cave and is supported by the remains of other large grazers and grazer/browsers (M. primigenius, C. antiquitatis, C. elaphus and large bovids). However, the presence of U. arctos, S. scrofa and C. capreolus is considered
to reflect the proximity of deciduous or mixed woodland.

The mammalian assemblage is fully interglacial in character, as indicated by the occurrence of *C. capreolus* and *B. primigenius*, which are known only from temperate episodes in the Pleistocene. This would appear to be confirmed by the rare record of *E. hydrunlinus* (see Figure 3.44), which was predominantly distributed in southern Europe during the Pleistocene. Its presence might therefore suggest temperate conditions, in contrast to the presence of *C. antiquitatis*, which is usually recognised as a cold-climate indicator. The admixture of ‘temperate’ and ‘cold’ indicators is a commonly encountered feature of the Stage 7 interglacial and most probably relates to the development of more continental climatic conditions at this time, with warm summers and cold winters. The presence of extensive areas of open, steppe-like grassland would thus have permitted the co-existence of such species, since their distribution was probably more closely linked to a vegetation type than to temperature.

6.24.6. Biostratigraphy and correlation

Mammalian studies

The Oreston Cave site assemblages have been very much ignored in terms of their possible ages and no work either this century or last has attempted to place them within the British Quaternary scheme. The present study is therefore the first to attribute an age to the Upper Cave assemblage.

Following analysis of the mammalian remains during the present study, it is proposed here that the assemblage from the Upper Cave at Oreston should be correlated with the Stage 7 interglacial, based upon its great similarity to the distinctive ‘mammoth-horse’ faunal grouping from sites such as the upper part of the sequence at Aveley (6.1), Ilford (Uphall Pit) (6.2) and Brundon (6.6).

The Oreston assemblage is dominated by abundant remains of a large form of *Equus ferus* and by *Mammuthus primigenius*. Unfortunately, no complete adult teeth are present in the collection so it cannot be ascertained whether the *Mammuthus* sample contains specimens of ‘Ilford type’. However, the general composition of the
assemblage is in close agreement with a Stage 7 fauna. Accordingly, *Panthera leo* was apparently the most abundant predator, followed by *Ursus arctos* and *Canis lupus*. The presence of *C. crocuta* is significant, although (as at all Stage 7 sites examined in the present study), it does not appear to have been particularly abundant. Other typical late Stage 7 elements found in the Oreston assemblage include a large from of *C. elaphus*, large *B. primigenius* and *C. antiquitatis*. The presence of the extinct ass *E. hydruntinus* is also noteworthy, in that this is the only known occurrence of this species in Britain after Swanscombe (see 4.2). The occurrence of *S. scrofa* and *C. capreolus* (both relatively rare in the fossil record) compares well with the evidence from Bleadon Cave (Somerset), also attributed to Stage 7 in the present study (see 6.22), thereby suggesting that these two species were common in upland areas of the West Country at this time.

6.24.7. Discussion and conclusions

On the basis of the overall composition of the mammalian assemblage, the present study attributes the assemblage from the Upper Cave at Oreston to the Stage 7 interglacial, and more specifically to Substage 7a. This is on the basis of the co-occurrence of *M. primigenius* and *E. ferus* with a large form of *P. leo* and large herbivores, including *C. elaphus* and *B. primigenius*. This is the first time that an age has been attributed to the Oreston Upper Cave and the recognition of a new Stage 7 cave assemblage is of particular importance.
6.25. PONTNEWYDD CAVE, CLWYD, WALES (30153710)

6.25.1. Location of the site

Pontnewydd Cave lies in the valley of the River Elwy, approximately 10km to the south of the coastal resort of Rhyl (Figure 6.55).

Figure 6.55 Location of Pontnewydd Cave (from Green 1984).
6.25.2. History of research

The first published reference to the cave is by the Reverend E. Stanley in 1832, who both mapped and described Pontnewydd as part of a general investigation of the caves in the area. The cave was later referred to by Dawkins (1874, 1880), who recorded an excavation undertaken in 1870 by a Mrs Williams-Wynn, the Reverend D. Thomas and himself, during which mammalian remains were recovered. Sketch sections drawn by Hughes and the Reverend Thomas (1874) revealed that earlier investigations had already removed a substantial amount of the deposits. Hughes and Thomas (ibid) recognised the three main units in the cave, namely yellow cave earth, breccia and gravel. Dawkins (1874, 1880) professed not to have found any artefacts, although later investigations of his spoil dump outside the cave revealed the presence of abundant artefacts that he had apparently overlooked (Green 1984). The excavations by Hughes were considerably more rigorous and yielded not only artefacts and fauna, but also an ancient human tooth (now sadly lost) (Hughes and Thomas 1874; Hughes 1887).

In 1940, a guard chamber was constructed at the entrance to the cave and Pontnewydd became a store for land mines and depth charges (Green 1984). In 1966 or 1967, amateur excavations were undertaken at the back of the cave by the Birkenhead YMCA Speleological Club and a small number of mammalian bones were recovered (Kelly 1967). This regrettable operation was in fact illegal, since the cave had been designated a Scheduled Ancient Monument since 1933 (Green 1984).

Between 1978 and 1996, systematic excavations were undertaken at the cave by H.S. Green, on behalf of the National Museum of Wales. These investigations established the stratigraphic sequence within the cave, confirming the descriptions of Hughes and Thomas (1874), and recovered abundant lithic and faunal material (Green et al. 1981; Green 1984, 1990, 1992; Campbell 1990). Most significantly, at the time of writing, 23 remains of Homo sapiens neanderthalensis had been recovered, 19 of which were in situ (H.S. Green pers. comm.). Traces of butchery have also been noted on remains of horse and bear from the Lower Breccia (Green 1992). Thermoluminescence dating of burnt flints from within the Lower Breccia and Uranium-series dating of stalagmitic floors on top of this deposit suggest an age of around 200 000 years B.P. (see below) (Huxtable 1984; Schwarcz 1984c).
6.25.3. **Geological background and provenance of mammalian remains**

The entrance of the cave is situated at 89.5m O.D., in Carboniferous Limestone in the valley of the River Elwy (Green *et al*. 1981). The cave consists of one major east-west trending chamber, with a number of subsidiary, generally north-south trending passages (Green 1984). The complete sequence of deposits is not visible in any one area, but the composite stratigraphy can be constructed from descriptions given by Collcutt (1984), Green *et al*. (1981), Green (1984) and Green (1990) (Figure 6.56). At least seven debris flows are known from the cave, spanning a period well in excess of 250 000 years. The only beds formed *in situ* are the stalagmite found in some areas of the cave on the surface of the Lower Breccia, the silt (Bed 6) which overlies the stalagmite and the sediments of Beds 8-11, which cap the Upper Breccia (Green 1990).

The lowest units in the cave are Beds 1 and 2 (the Upper and Lower Sands and Gravels). These collectively make up the ‘Siliceous Member’ and consist of a complex series of deposits, containing well-rounded siliceous particles, frequently up to 150mm in diameter. The jumbled orientation of these pebbles suggests that they are the product of a debris flow. Discrete lenses of generally matrix-poor, finer-grained material (coarse sands and fine gravels) and laminated clayey silts are common throughout the deposits. Periodic streamflow, ponding and gentle slumping as a result of mudflow processes are indicated (Green *et al*. 1981; Green 1992). These basal deposits are assigned to Stage 8 or earlier (Green 1992).
The deposits overlying the 'Siliceous Member' make up the 'Calcareous Member'. The lowest of these is the Intermediate Complex, which comprises a group of deposits that are lithologically transitional between the Lower Sands and Gravels below and the Breccias above. These buff, orange and yellow sediments are composed of siliceous pebbles, badly sorted coarse sand and highly altered limestone clasts. Internal stratigraphic relationships are unclear, due to the discontinuous nature of individual lenses and extreme lateral variation (Green et al. ibid). The Intermediate Complex has yielded an interglacial fauna of distinctive preservation type, henceforth known as 'Preservation Type I' (Currant 1984). These specimens are characterised by an orange base colour, frequently with dark, irregular mottlings (Currant pers. comm.)

Above the Intermediate deposits lies the Lower Breccia, a debris flow which contains the bulk of the faunal and artefactual remains. The Lower Breccia consists of angular coarse particles, predominantly of limestone, with medium to strong carbonate cement, and is interpreted as the result of a mudflow on a major scale (Green et al. 1981).
contains a mixture of interglacial faunal elements, probably reworked from the Intermediate Complex, and cold elements. The sequence of events in the cave showing reworking of faunal elements is shown in Figure 6.57. Although a separate preservation type ('Type II') was originally assigned to the material in the Lower Breccia (Currant 1984), better exposures of the Intermediate Complex in subsequent years has meant that the distinction between Preservation Types I and II, as originally defined, is now considered to be meaningless (A.P. Currant pers. comm.). Material from the Intermediate Complex and Lower Breccia (with the exception of a very few specimens, see below) are therefore undifferentiated on preservation type, and are referred to as Type I. A very small number of specimens from the Lower Breccia appear to be genuinely distinct from Type I material and have subsequently been referred to a modified 'Preservation Type II' (A.P. Currant pers. comm.). These have a white base colour, often with faint dark grey mottling, and where the original surface is still visible, the detail is clear and sharp.

Figure 6.57  Schematic section of Pontnewydd Cave, showing the principal lithostratigraphic units and the derivation series of faunal preservation types I, II and III (from Currant 1984).
Immediately capping the Lower Breccia are localised areas of stalagomite floor or individual bosses. Dating of these speleothems has shown their formation to have been episodic and to span a considerable period of time with formation beginning in Stage 7 (Green 1992). Separating the stalagmite, which had formed locally on the Lower Breccia, from the Upper Breccia, is a laminated silt deposit (Bed 6, also known as the ‘Pond Deposit’), the product of low-energy fluval or lacustrine deposition. Scanning Electron Microscopy of the sediments indicates a cold context for the origin of this bed (Green 1992). Specimens from the Pond Deposit and from the overlying Upper Breccia are designated ‘Preservation Type III’ (Currant 1984) and have a base colour ranging from white to greys and brown. Tooth enamel from these horizons is stained a characteristic blue-grey. The Upper Breccia debris flow is of Late Pleistocene age. It consists of angular coarse particles, mainly of limestone, but with more silt and fine sand than the Lower Breccia. This unit appears to have been emplaced with some force, since it channelled into underlying deposits, reworking artefacts and bones and removing and rafting large slabs of stalagmite from their original in situ position on top of the Lower Breccia (Green ibid). A thick stalagmite boss, found rafted within the Upper Breccia, yielded Uranium-series age estimations of 130 - 100 000 years B.P. (Green ibid). In a small part of the cave, the Breccias are overlain by a small, un-cemented remnant of silty Red Cave Earth, with abundant limestone clasts. The sequence is capped by a later of water-lain clay and sand, itself overlain by a stalagmite of Holocene age (Green ibid).

Only mammalian remains from the Intermediate Complex and from the Lower Breccia are of interest to the present study, since these can be demonstrated to pre-date the stalagmite on top of the Lower Breccia, dated at circa 220 000 years B.P. (Green 1990; 1992). The remaining upper part of sequence is of Late Pleistocene age and therefore outside the remit of the present investigation.

6.25.4. Palaeontology

The following species lists have been compiled from material in the National Museum of Wales in Cardiff, collected by that institution. The present study has confirmed the presence of 11 taxa in the Intermediate Complex and 25 taxa in the Lower Breccia. A previously unpublished record of common shrew (Sorex araneus) was identified in the
Lower Breccia. The putative record of Russian desman (Desmana moschata), listed by Green (1992) from the Lower Breccia, was re-identified as a fragment of bird. A record of reindeer (Rangifer tarandus), listed by Green (ibid) from the Lower Breccia, was not seen during the present study. A total of 1009 specimens was examined, although because of time constraints, this did not include hundreds of additional specimens of cranial fragments, deciduous canines, deciduous incisors, canines, incisors and miscellaneous tooth fragments of Ursus. For the same reason, only a representative sample of the small mammals was examined. A breakdown of the species list into total numbers of specimens and minimum numbers of individuals has therefore not been attempted.

Species List (Mammalia) from the Intermediate Complex, Pontnewydd Cave, Clwyd.

**Lagomorpha**

*Lepus timidus* L., mountain hare

**Primates**

*Homo sapiens neanderthalensis*, Neanderthal (fossils and artefacts)

**Rodentia**

*Castor fiber* L., European beaver

*Microtus agrestis* (L.) or *Microtus arvalis* (Pallas), field or common vole

*Microtus oeconomus* (Pallas), northern vole

*Apodemus cf. sylvaticus* (L.), wood mouse

**Carnivora**

*Canis lupus* L., wolf

*Vulpes vulpes* L., fox

*Ursus* sp., indet. bear

*Panthera pardus* L., leopard

**Perissodactyla**

*Equus ferus* Boddaert, horse

**Artiodactyla**

*Cervus elaphus* L., red deer

*Capreolus capreolus* (L.), roe deer
Species List (Mammalia) from the Lower Breccia, Pontnewydd Cave, Clwyd.

**Insectivora**
*Sorex araneus* L., common shrew

**Lagomorpha**
*Ochotona pusilla* (Pallas), steppe pika
*Lepus timidus* L., mountain hare

**Primates**
*Homo sapiens neanderthalensis*, Neanderthal (fossils and artefacts)

**Rodentia**
*Castor fiber* L., European beaver
*Dicrostonyx torquatus* (Pallas), collared lemming
*Lemmus lemmus* (L.), Norway lemming
*Arvicola terrestris cantiana* (= *Arvicola cantiana* Hinton), water vole
*Microtus agrestis* (L.) or *Microtus arvalis* (Pallas), field or common vole
*Microtus gregalis* (Pallas), narrow-skulled vole
*Microtus oeconomus* (Pallas), northern vole
*Microtus* sp., indet. vole

**Carnivora**
*Canis lupus* L., wolf
*Vulpes vulpes* L., fox
*Ursus* sp., indet. bear

? *Crocuta crocuta* Erxleben, spotted hyaena
*Felis silvestris* Schreber, wild cat
*Panthera leo* (Goldfuss), lion
*Panthera pardus* L., leopard
*Panthera* sp., indet. big cat

**Perissodactyla**
*Equus ferus* Boddaert, horse
*Stephanorhinus hemitoechus* (Falconer), narrow-nosed rhinoceros
*Stephanorhinus kirchbergensis* (Jäger), Merck’s rhinoceros
*Stephanorhinus* sp., indet. rhinoceros
Rhinocerotidae sp., indet. rhinoceros
Artiodactyla

Megaloceros giganteus (Blumenbach), giant deer
Cervus elaphus L., red deer
Capreolus capreolus (L.), roe deer
Cervidae sp., indet. deer
Bovidae sp., indet. large bovid (Bos or Bison)

6.25.5. Palaeoenvironmental and palaeoclimatic interpretation

The mammalian assemblages from the Intermediate Complex and the Lower Breccia were originally interpreted separately, with the former being regarded as an interglacial woodland assemblage (attested to by the presence of A. sylvaticus, C. fiber and C. capreolus) and the latter as a palimpsest of woodland and open indicators, representing a wide climatic and chronological range (Currant 1984; Green 1992). However, given the fact that an unknown proportion of the Lower Breccia assemblage is derived from the Intermediate Complex, there appears to be little value in continuing to assess these assemblages separately. The following observations therefore treat both assemblages as a single entity, although the possibility that certain suites of mammals within the assemblage may relate to different climatic episodes is also discussed. Despite the origins of the assemblage as a debris flow, a coherent mammal fauna is nonetheless present, that may be taken as accurately reflecting the immediate environment of the cave.

The Carnivora are extremely well-represented in the Pontnewydd assemblage, with 7 species identified. The overwhelming predominance of remains of Ursus, including remains of many juveniles, is a strong indication that the cave was being used as a bear den and that these animals perished during the debris flows that swept through the cave. The presence of other large carnivores, such as Canis lupus, Panthera leo and Panthera pardus, suggests that they might also have been using the cave periodically, whereas the smaller species (V. vulpes and F. sylvestris) were probably incorporated as part of the debris flow.

Equus ferus is the most abundantly represented of the large herbivores. This suggests the presence of large areas of open grassland in the vicinity of the cave, an inference
supported by the remains of other large grazers and part-grazers, including *Stephanorhinus hemitoechus, Cervus elaphus, Megaloceros giganteus* and large bovids. However, the proximity of areas of deciduous or mixed woodland is also indicated by the presence of *Castor fiber, Stephanorhinus kirchbergensis* and *Capreolus capreolus*. Remains of *P. pardus* are known only from cave sites in upland areas during the British late Middle Pleistocene, although modern leopards today inhabit a wide range of environments.

The small mammals are indicative of a range of environments. *Apodemus sylvaticus* is characteristic of deciduous woodland, *Sorex araneus* is found wherever low vegetation cover is afforded, for example in thick grass or scrubby habitats, and the cricetids, *Ochotona pusilla* and *Lepus timidus* are generally indicative of open grassland. The presence of a nearby body of still or slowly-moving water is attested to by the remains of *C. fiber* and *Arvicola terrestris cantiana*. Interpretation of the palaeoclimate at the time of deposition is extremely difficult due to the derived nature of the assemblage. However, at least two climatic episodes appear to be represented in the Lower Breccia. Temperate conditions are indicated by the presence of *S. araneus, C. fiber, A. sylvaticus, S. hemitoechus, S. kirchbergensis* and *C. capreolus*, whereas the combined occurrence of *Ochotona pusilla, Dicrostonyx torquatus, Lemmus lemmus, Microtus gregalis* and *Microtus oeconomus* (all of which are absent from Britain at the present day and have much more northerly and/or continental distributions) are diagnostic of a cold steppic conditions.

6.25.6. Biostratigraphy and correlation

Mammalian studies

The Pontnewydd assemblage contains a number of species of biostratigraphic significance. The presence of *S. kirchbergensis* indicates that the assemblage from the Lower Breccia must pre-date the Ipswichian Interglacial. This is supported by the abundant presence, in a temperate-climate context, of *E. ferus* and also of *H. s. neanderthalensis*, since neither horses nor humans form a part of the British Last Interglacial fauna. The fact that the hominid remains can be referred to an early *H. s. neanderthalensis* is also significant, since this implies an age no younger than circa
250 000 years (Green 1990).

Overall, the general composition of the Pontnewydd fauna compares most favourably with Stage 7 assemblages from other upland areas, such as Bleadon Cave in the Mendip Hills (6.22). The two faunas are extremely similar in terms of the species represented and share the only known British late Middle Pleistocene occurrences of *P. pardinus*. The remains of *P. leo* are notable for their large size, again a feature consistent with a Stage 7 age. The bears from the Intermediate Complex and the Lower Breccia are peculiar in that they possess spelaeoid characteristics in their dentition (Currant 1984). This is apparent from the generally low-crowned aspect of the teeth, although this is by no means present in all the specimens. For example, two left first upper molars (D114 and F2375) present the typical high-crowned morphology of the brown bear, *Ursus arctos*. *U. arctos* had apparently replaced the cave bear *Ursus spelaeus* in the British Isles by the time of the Stage 9 interglacial (see Grays, 5.2) and the appearance of spelaeoid characters at Pontnewydd is therefore somewhat unusual. Specimens of *U. arctos* with spelaeoid features have, however, also been noted at Three Holes Cave, Devon in deposits post-dating a stalagmite floor, dated by Uranium-series to 319 000 years B.P., and pre-dating Ipswichian sediments (A.P. Currant pers. comm.). The Three Holes bears may therefore be of comparable age to the Pontnewydd specimens. The possibility that the Pontnewydd population became genetically isolated and 'rediscovered' spelaeoid features, or that the low-crowned tooth morphology was a dietary adaptation (cave bears being considered to be less carnivorous than brown bears), are just two potential explanations for this character. All the bears from the Late Pleistocene Silt Pond Deposit and the Upper Breccia are of typical high-crowned *U. arctos* morphology.

The Intermediate Complex and Lower Breccia have also yielded abundant remains of a large *E. ferus*, visually comparable in size to horses from sites such as Ilford (6.2) and Crayford (6.18).

The Pontnewydd assemblage marks the only known occurrences of *O. pusilla* and *M. gregalis* in the British late Middle Pleistocene, although both species are known from Devensian deposits. *O. pusilla* is presently restricted to the central part of the Palaeartctic steppe, whereas *M. gregalis* is found in northern tundra and in the wooded
steppes of central Asia (Stuart 1982). It is possible that their restricted occurrence in Britain at this time relates to the exceptional availability of a particular set of climatic and environmental conditions. The presence of *M. oeconomus* in the Pontnewydd assemblage is also important, since this species is frequently encountered at other sites attributed to Stage 7 in the present study, such as Stoke Tunnel (6.7), the Lower Channel at Marsworth (6.10), Stoke Goldington (6.16), Crayford (6.18) and Bleadon Cave (6.22). The remains of *Arvicola* from the Lower Breccia are of more advanced morphology than those from Stage 9 localities, such as Grays (5.2), with enamel equally distributed on both sides of the salient angles. The Pontnewydd specimens are also larger than those from Stage 9 sites, in accordance with the observed increase in size through time noted in Chapter 3. Measurements of the length of the first lower molar in the Pontnewydd sample (n = 3) yielded a mean figure of 3.69mm (s.e. = 0.121, s.d. = 0.210). This compares well with measurements from Itteringham (also attributed to Stage 7, 6.3). Specimens from the Stage 9 localities of Grays (5.2) and Cudmore Grove (5.3) were demonstrated to be significantly smaller than those from Stage 7 (Figure 3.20; Tables 3.3 and 3.4).

6.25.7. Discussion and conclusions

The Pontnewydd mammalian assemblage is a complex one, since it clearly includes elements from more than one climatic episode. Understanding the age of these deposits is somewhat facilitated by the available dating evidence, which provides important chronological markers for the different sedimentary events. Minimum Uranium-series dates on the stalagmite overlying the Lower Breccia indicate that the Intermediate Complex and the Lower Breccia were in place by approximately 220 000 years B.P. (Schwarcz 1984c). This is supported by thermoluminescence dates on burnt flint from the Lower Breccia of 200 000 ± 25 000 years B.P. (Huxtable 1984). Both the Intermediate Complex and the Lower Breccia may therefore be correlated with parts of the Stage 7 interglacial. This is consistent with the presence of *S. kirchbergensis* in the Lower Breccia assemblage, which suggests an age no later than Stage 7. Corroborating evidence for a pre-Last Interglacial age comes from the presence of abundant remains of *H. s. neanderthalensis* and *Equus ferus*. The identification of the hominid remains as Neanderthal, and the presence of an archaeological assemblage showing evidence of the Levallois technique, places the Lower Breccia in a position no earlier than Stage 8 (the
earliest stage when artefacts of this type have been recognised in Britain, see Purfleet, 5.1 and the Lion Pit tramway cutting, 6.4). A post-Stage 8, pre-Substage 5e age is therefore inferred for the deposits of the Intermediate Complex and Lower Breccia, a correlation which is very much in keeping with the evidence from absolute dating at the site.

The faunas contained in the successive deposits have been interpreted as representing open woodland and steppe environments respectively, possibly representing deposition over millennia (Green 1992). Two interpretations are considered plausible here. The most straightforward would be to correlate the Intermediate Complex with the early part of the Stage 7 interglacial, possibly Substage 7c, and the Lower Breccia with the later part of the interglacial, incorporating cold elements from Substage 7b, together with temperate elements reworked from Substage 7c and contemporaneous material from Substage 7a. Human occupation of the cave would appear not to be contemporary with the phase represented by the Intermediate Complex (Green 1992). However, despite the important presence of temperate woodland indicators in the Intermediate Complex, which might suggest correspondence with other possible Substage 7c assemblages from the lower part of the sequence at Aveley (6.1), Itteringham (6.3) and Stone Point (6.14), there is nothing in the Intermediate Complex that has not been found in assemblages attributed in the present study to the later part of the interglacial (Substage 7a ?). It is therefore equally possible that the Intermediate Complex was deposited during the later part of the Stage 7 interglacial and that the overlying Lower Breccia contains a mixture of reworked temperate species from this episode and cold species from the beginnings of Stage 6. Nothing in the mammalian assemblage from Pontnewydd favours one interpretation or the other on biostratigraphic grounds, although the dating evidence corresponds most closely with the first scenario.

It is therefore tentatively suggested that the Intermediate Complex relates to an early woodland-dominated episode in the Stage 7 interglacial (possibly Substage 7c) and that the Lower Breccia relates to the later part of the same interglacial (possibly Substage 7a). The Lower Breccia incorporates material from both the earlier temperate episode and the intervening period of cold-climate conditions (Substage 7b) but also contains contemporary material. Thus, the assemblage from the Lower Breccia assemblage most closely resembles others, such as Bleadon Cave (6.22), which have also been assigned to
the later part of the Stage 7 interglacial. It must be stressed that these correlations are extremely tentative and hinge upon the reliability of the dating evidence. However, the attribution of these assemblages to successive temperate episodes in Stage 7, separated by a period of colder conditions, would appear to make some sense of what is an extremely complex sequence and would fit well with the sedimentological evidence.
6.26. HINDLOW QUARRY, HARTINGTON UPPER QUARTER, near BUXTON, DERBYSHIRE

6.26.1. Location of the site

The precise location of the cave is unknown, since no records were kept (see below).

6.26.2. History of research

In 1957, local cavers exploring a cave in a limestone quarry near Buxton, Derbyshire discovered fossilised bones on the cave floor (Buxton Museum archives). These bones were collected by D. Alsop and passed to J.W. Jackson for identification. The quarry proprietors had requested that there be no publicity about the finds and nothing more was heard about the site until the bones resurfaced in 1982 in Jackson’s collections at Buxton Museum. Only a small proportion of the material from the cave was ever excavated but the assemblage is remarkable for both the excellent quality of preservation and for the substantial portions of articulated leg bones of lion and horse, thereby suggesting that entire individual skeletons had probably been present in the cave.

6.26.3. Geological background and provenance of mammalian remains

Because of the circumstances of the discovery, no information (published or otherwise) on the geological context of the mammalian remains is available. The bones and teeth have a very characteristic creamy-white colouring and preservation is generally extremely fresh, with only one specimen (a left astragalus of a large bovid) showing signs of transport. Some of the material is coated with, or embedded within a dull orange-brown flowstone, whilst other specimens have traces of a dense, orange bone breccia adhering to them. Visible signs of carnivore gnawing was observed on some of the juvenile bovid bones. At least two adult lions are represented and, in one case, most of an articulated right hind leg. All the major body parts were recovered and the virtual completeness of some of the limbs suggests that entire individuals were present in the cave. A similar situation is observable in the equids, where the presence of at least one
juvenile and two adult animals is indicated. Again, a complete articulated left hind leg was recovered.

6.26.4. Palaeontology

The following species list has been compiled from material in Buxton Museum from the collections of J.W. Jackson. The present study has confirmed the identity of 5 species of mammals from the cave, all of which are previously unpublished. 183 specimens were examined.

Species list (Mammalia) from Hindlow Quarry, Derbyshire

Carnivora

*Canis lupus* L., wolf

*Panthera leo* (L.), lion

Proboscidea

*Mammuthus primigenius* (Blumenbach), mammoth

Perissodactyla

*Equus ferus* Boddaert, horse

Artiodactyla

*Bos primigenius* Bojanus, aurochs

Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 6.21 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lupus</em></td>
<td>1</td>
<td>0.54</td>
<td>1</td>
</tr>
<tr>
<td><em>P. leo</em></td>
<td>88</td>
<td>48.08</td>
<td>2</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>1</td>
<td>0.54</td>
<td>1</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>57</td>
<td>31.14</td>
<td>3 (1 juv., 2 adults)</td>
</tr>
</tbody>
</table>

cont'd.../...
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. primigenius</td>
<td>3</td>
<td>1.63</td>
<td>1</td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>33</td>
<td>18.03</td>
<td>4 (2 juv., 2 adults)</td>
</tr>
</tbody>
</table>

Table 6.21 Breakdown of the mammalian species list from Hindlow Cave, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

6.26.5. Palaeoenvironmental and palaeoclimatic interpretation

Reconstructions of the palaeoenvironment based on cave assemblages are fraught with problems, due to the selective nature of the material. The cave appears to have been occupied as a den by lions which were targeting horses and large bovids as prey. This suggests the presence of areas of open grazing in the vicinity of the cave. The presence of *Bos primigenius* suggests a temperate climate, since occurrences of this species in the Middle and Upper Pleistocene have been restricted to warm episodes.

6.26.6. Biostratigraphy and correlation

Mammalian studies

The Hindlow Cave assemblage has been interpreted as Devensian in age, on the basis of the presence of *P. leo, E. ferus* and *M. primigenius* (Buxton Museum display). However, the presence of remains of large *B. primigenius* (identified on the basis of a proximal radius, a distal femur and a calcaneum) strongly suggests that the assemblage relates to an interglacial, as opposed to a cold stage. This is supported by the extremely large size of the lion and horse remains, which are visually most comparable to Stage 7 localities, such as Aveley (6.1) and Ilford (Uphall Pit) (6.2) (and substantially larger than any Devensian lion or horse material seen by the author). An unusual feature of the Hindlow Cave horses is that the upper cheek teeth possess a double caballine fold, although the significance of this is unknown, since this character has not been identified in any other *E. ferus* material. *M. primigenius* is represented by a single cuneiform (differing from *P. antiquus* both in its smaller size and slightly different morphology). This specimen may have been part of a limb brought in by carnivores and it is therefore
not possible to determine whether the Hindlow woolly mammoth was of ‘Ilford type’ or not.

6.26.7. Discussion and conclusions

On the available evidence, the Hindlow Cave mammalian assemblage is tentatively attributed to the Stage 7 interglacial, probably Substage 7a). This is on the basis of the presence of B. primigenius (which would appear to contradict attribution of the material to a cold stage) and on the very large size of the lion, bovid and horse remains, which are most closely comparable with Stage 7 localities. As a whole, the assemblage is a good match with the upper sequence at Aveley (6.1) and Ilford (Uphall Pit) (6.2) in terms of species composition and correlation with these localities is consequently proposed. Cave assemblages that can be attributed to this period are very rare and the Hindlow Cave fauna is therefore of particular importance as a potential record.
The Stage 7 mammal fauna is differentiated from that of the preceding Stage 9 interglacial by the absence of *Macaca sylvanus* and by the presence of *Arvicola terrestris cantiana* with a more advanced enamel morphology (enamel equal on both sides of the salient angles, absence of the *Mimomys* fold). The Stage 7 fauna is also differentiated from that of the Ipswichian Interglacial by the presence of *Mammuthus primigenius*, *Equus ferus*, *Homo* sp. and *Stephanorhinus kirchbergensis*, none of which have been recorded from deposits of Substage 5e age. In addition to the presences and absences outlined above, the Stage 7 interglacial is further identified by the presence of two distinct faunal groupings, considered to correspond to the earlier and later parts of the Stage 7 interglacial and perhaps corresponding with Substages 7c and 7a respectively. Both faunas are apparently equally temperate in nature, although their ecologies are rather different.

The fauna from the earlier part of Stage 7 is characterised by the presence of *Crocidura cf. russula*, in association with *Palaeoloxodon antiquus* and *Dama dama*. *Equus ferus* is also recorded. *Cyrenaonyx antiqua* may also prove to be of biostratigraphic significance, since it has so far been recorded only from this period. The fauna from the later part of the Stage 7 interglacial is characterised by the presence, in a temperate context, of *Mammuthus primigenius* (often of 'Ilford type'), in association with *Equus ferus* and *Palaeoloxodon antiquus*. *Microtus oeconomus*, *Stephanorhinus kirchbergensis* and *Coelodonta antiquitatis* are frequently encountered, together with *Panthera leo*, *Bos primigenius* and *Bison priscus* of notably large body size. This part of the Stage 7 interglacial also witnesses the first post-Anglian occurrence in Britain of *Ochotona pusilla*, *Cricetus cricetus*, *Allocricetus bursae*, *Dicrostonyx torquatus*, *Microtus gregalis* and *Citellus citellus*, together with the only known British Middle Pleistocene occurrences of *Felis chaus* and *Panthera pardus*. 
CHAPTER 7. THE “STAGE 6 COLD EPISODE”

7.0. Introduction

This chapter will examine the mammals of the “Stage 6 cold episode”. Eight sites are reviewed here: Bacon Hole (West Glamorgan), Minchin Hole (West Glamorgan), Clevedon Cave (Somerset), Marsworth (Buckinghamshire), Stanton Harcourt (Oxfordshire), Balderton (Lincolnshire), Brighton (East Sussex) and Waterhall Farm (Hertfordshire). The location of these sites is shown in Figure 7.1.

Mammalian assemblages discussed in this chapter are from both cave sites and fluvial sites. The identification of deposits of Stage 6 age rests entirely on their stratigraphic position underlying deposits of known Ipswichian age, and in some cases, overlying interglacial deposits of established Stage 7 age. Only assemblages which can be convincingly demonstrated to post-date Stage 7 and/or to immediately pre-date Substage 5e have therefore been considered. The precise establishment of the stratigraphic position of these assemblages is absolutely critical, since Middle Pleistocene cold stage faunas have remained relatively stable in terms of their species composition and are therefore extremely difficult to tell apart. It is therefore essential to have a sound stratigraphic framework, in order for any patterns be discerned. In all cases, subsidiary information in the form of periglacial features, such as ice-wedge casts and involutions, supports the attribution of these assemblages to a period of cold-climate conditions. Further corroboration for the presence of a Stage 6 cold period has come from terrace studies in the Thames (Bridgland 1994) and Avon Rivers (Maddy et al. 1991), which have identified major gravel aggradations corresponding to this period. The “Stage 6 cold episode” is therefore taken to refer specifically to the un-named period of cold-climate conditions after the “Stage 7 interglacial” but before the Ipswichian. Stage 6 was apparently one of the most severe cold episodes of the Middle Pleistocene, coinciding with the most extensive glaciation in the Netherlands (Zagwijn 1985).

The following section will examine the evidence from the above sites to establish the nature of the mammal faunas of this cold period and to identify species of biostratigraphic significance.
Figure 7.1 Location of sites assigned to the “Stage 6 cold episode”.
7.1. BACON HOLE, PENNARD, GOWER PENINSULA, WEST GLAMORGAN (SS 559868)

7.1.1. Location of the site

Bacon Hole is a large terrestrial cave, located on the southern edge of the Gower Peninsula, approximately 11km WSW of Swansea.

7.1.2. History of research

Bacon Hole has a long history of palaeontological exploration, beginning with the discovery of fossil mammals in the 1830s, which led to a series of investigations by Lieutenant-Colonel E.R. Wood in the 1850s, as part of a generalised examination of the Gower caves (Benson 1852; Falconer 1860; Murchison 1868). Wood formed a partnership with Hugh Falconer, who examined the mammalian remains and took the initial steps towards establishing of a stratigraphic sequence for the cave. Most importantly, Falconer noted in both Bacon Hole and the adjacent site of Minchin Hole, the presence of marine sands with abundant shells of extant species, overlain by ossiferous interglacial deposits containing narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*) and straight-tusked elephant (*Palaeoloxodon antiquus*) (Falconer 1860; Murchison 1868). Although hippopotamus was not recorded from the interglacial deposits of either Minchin Hole or Bacon Hole, Falconer listed it as part of a similar *hemitoechus-antiquus* fauna in nearby Ravenscliff Cave.

Further work was carried out by J.G. Rutter in the 1940s and 1950s (Allen and Rutter 1946) and by the Natural History Museum between 1975 and 1981. References to the site, its stratigraphy and fauna are provided by Stringer (1975, 1977), Currant *et al.* (1984), Stringer *et al.* (1986) and Sutcliffe *et al.* (1987).

7.1.3. Geological background and provenance of mammalian remains

Bacon Hole is formed on a near-vertical fault in well-bedded Carboniferous limestone. It opens on to a sloping rock platform, which is dissected on the western side by a deep gully. Prior to the later part of the Devensian, the platform appears to have been roofed-
over, material entering the cave up-slope from the seaward end. The internal stratigraphy is notable for its regular, sub-horizontal disposition in all but the most seaward areas (Currant et al. 1984).

The following 20m thick sequence is described by Currant et al. (1984) and Stringer et al. (1986) (Figure 7.2):

J: Complex of upwardly-fining cyclothems, forming a pronounced talus cone in the present cave entrance and capped by a massive stalagmitic floor, dated to 13 ka B.P. by Uranium-series dating.

I: Upper Cave Earth. This horizon is indicative of a similar environment to the Sandy Cave Earth but with a minimal marine influence. At one point, this deposit blocked the entrance to the cave, thereby initiating stalagmite deposition (dated to 81 000 years B.P. by Uranium-series dating).

H: Upper Sands. These are well-bedded, medium sands containing much fine shell debris which were probably accumulated by wind action. The Foraminifera include the last occurrence in Britain of the extinct Rosalina sp., also known from continental Eemian sites.

G: Grey Clays, Silts and Sands. These deposits have undergone marked syn- and post-depositional modification by waterlogging and downslope creep. The extensive bone and coprolite accumulations are due to occupation by Crocuta crocuta. Remains of Microtus oeconomus, Apodemus sylvaticus, Palaeoloxodon antiquus, Mammutthus primigenius and Stephanorhinus hemitoechus are also present.

F: Shelly Sand composed primarily of shell debris from small littorinids.

E: Sandy Cave Earth. This deposit consists of coarse, angular and heavily shattered limestone clasts in a heterogenous matrix, with sandy and shelly lenses and pockets of lands snails. Vertebrate remains are characteristic of local temperate woodland and include Palaeoloxodon antiquus, Dama dama, Apodemus sylvaticus, Calonectris diomedea (Cory's shearwater), a species now found nesting on the coasts of southern Europe is also present.

D: Sandy Breccio-Conglomerate, comprising of pebbles, shingle and coarse sand with shell debris, probably representing a storm beach created at a time when sea
level was apparently marginally higher than at present. Remains of *Apodemus sylvaticus* and *Calonecritis diomedea* were recovered from this bed.

C: Coarse Orange Sand (not separated from Bed B in Figure 7.1), consisting of angular limestone debris in a fine/medium sand but with increased silts, colloids and compaction upwards. Mammalian and molluscan remains are present.

B: Coarse Grey Sand, consisting of a well-sorted fine/medium quartzite-rich sand without fine bedding and not well compacted. Mammalian and molluscan remains are present.

A: Basal pebble layer.

Base: Stalagmite floor.

Figure 7.2 Section through the Bacon Hole sequence
(modified from Jones and Keen 1993).

The Sandy-Breccio Conglomerate (Bed D), the Sandy Cave Earth (Bed E) and the Shelly Sand (Bed F) share a fauna indicative of a warm, temperate interglacial period. But for the absence of *Hippopotamus amphibius*, these assemblages are identical to those known from the Ipswichian Interglacial (Substage 5e), as represented at Trafalgar Square. Attribution of these deposits to this part of the Last Interglacial is therefore proposed (Stringer 1975, 1977; Currant *et al.* 1984; Stringer *et al.* 1986 and Sutcliffe *et*
al. 1987) and corroborated by Uranium series dates on fragments of a stalagmite floor (which once capped this part of the sequence) in Area VIII of the site of 125 000 years B.P. The stalagmite floor was subsequently broken up and incorporated into a succeeding level (Currant et al. 1984; Stringer et al. 1986).

The deposits of interest to the present discussion are Beds A-C, which underlie the Ipswichian deposits represented by Beds D-F. Bed A consists of cobbles and pebbles, interpreted as a possible coarse littoral lag deposit but no longer in situ. The overlying Coarse Grey Sand and Coarse Orange Sand are considered to have been deposited by wind action, with the inclusion of local rock debris in the latter (Currant et al. ibid; Stringer et al. ibid). The Coarse Sands have yielded a biostratigraphically diagnostic cold-climate mammalian fauna (see below). The stratigraphic position of these lower deposits, with their associated biotic evidence of cold-climate conditions, indicates that they pre-date the Ipswichian Interglacial. It is therefore proposed that they should be correlated with the immediately pre-Ipswichian cold episode, Stage 6.

7.1.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London. The presence of 3 mammalian species was confirmed in the basal deposits, on the basis of 104 specimens collected by the Natural History Museum. The material is well-preserved and of a pale creamy white colour.

Species List (Mammalia) from the basal deposits at Bacon Hole, West Glamorgan

**Rodentia**

*Microtus oeconomus* (Pallas), northern vole

*Microtus* sp., indet. vole

**Carnivora**

*Vulpes vulpes* L., red fox

**Perissodactyla**

*Equus ferus* Boddaert, horse
Table 7.1 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. oeconomus</em></td>
<td>65</td>
<td>62.5</td>
<td>13</td>
</tr>
<tr>
<td><em>Microtus sp.</em></td>
<td>28</td>
<td>26.92</td>
<td>10</td>
</tr>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>V. vulpes</em></td>
<td>3</td>
<td>2.88</td>
<td>1</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>8</td>
<td>7.69</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7.1 Breakdown of the mammalian species list from the basal deposits at Bacon Hole, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

7.1.5. Palaeoenvironmental and palaeoclimatic interpretation

The climate at the time of deposition of the pre-Ipswichian deposits at Bacon Hole is considered to be cold and dry (Currant et al. ibid; Stringer et al. ibid). The low-diversity molluscan assemblage recovered from the Coarse Sands is dominated by *Lauria cylindracea*, *Pyramidula rupestris* and *Pupilla muscorum*, with *Cochlicopa lubricella*, *Oxychilus* cf. *alliarius*, *Vitrina* sp. and *Cepaea* sp. These taxa are indicative of cool conditions and bare rock and scree slopes with little vegetation. The mammalian assemblage is supportive of this interpretation. The presence of *Equus ferus* indicates that open conditions prevailed, while the occurrence of *Microtus oeconomus* (which is today most widely distributed throughout the northern tundra and taiga zones of continental Europe) suggests that climatic conditions were more continental than at present in the British Isles. *V. vulpes* is known from both cold and temperate episodes.
7.1.6. **Biostratigraphy and correlation**

**Mammalian studies**

The Bacon Hole Coarse Sands assemblage contains two biostratigraphically significant species. The first of these is a large form of northern vole, *Microtus oeconomus*. Measurements undertaken during the present study of the length of the first molar of this species, from a range of Middle and Upper Pleistocene sites, has demonstrated that *M. oeconomus* reached its largest size in the cold episode immediately pre-dating the Ipswichian Interglacial (Figure 3.24; Tables 3.5 and 3.6). The Bacon Hole sample from the Coarse Sands (n = 3), although small, records the largest *M. oeconomus* of all the sites measured. Mean ml length in these specimens was measured at 3.08mm (s.e. = 0.107, s.d. = 0.186), substantially larger than *M. oeconomus* from Stage 7 localities such as the Lower Channel at Marsworth (see Table 3.6). The *M. oeconomus* sample from the basal deposits at Bacon Hole was also noticeably larger than that from the Ipswichian Interglacial deposits above (n = 93). Mean ml length in these latter specimens was measured at 2.65mm (s.e. = 0.012, s.d. = 0.119). Although the very small sample size from the lower deposits prevented tests of statistical significance, the ranges of the upper and lower samples barely overlap at two standard deviations, so that given the large sample size from the upper deposits, it is extremely likely that the *M. oeconomus* from this part of Stage 6 was significantly larger than in the Ipswichian.

During Stage 7, *M. oeconomus* appears to have enjoyed a period as the dominant species of *Microtus* in the British Isles, and as will be shown in this chapter, this was also apparently true of Stage 6. As outlined in Chapter 3, there was also increased intraspecific morphological variability during this period, leading to the erroneous recognition of two further species, *M. malei* and *M. nivalis*. It has since been demonstrated that all remains variously attributed to *M. malei* or *M. nivalis* are in fact variants of *M. oeconomus* (Stuart 1982). The specimens from Bacon Hole are all referable to *M. oeconomus* and slight variations are indeed exhibited between individuals.

The second species of biostratigraphic significance is *Equus ferus*. The presence of this species is in itself important, since it corroborates the pre-Last Interglacial age for the
Coarse Sands. However, the horse in question has undergone a noticeable reduction in size, compared to the large forms encountered in late Middle Pleistocene interglacials. The extent of this size decrease is shown clearly in Figure 7.3, in which an example of the small Stage 6 *E. ferus* from Bacon Hole is shown against a typical Stage 9 interglacial specimen from Grays (5.2). Size decrease is believed to occur in response to climatic warming in accordance with Bergmann's Rule (but cf. Lister 1992). However, the reverse seems true of the Middle Pleistocene true horses, which have tended to have been particularly large during temperate periods. The decrease in body size exhibited by the Stage 6 horse may have been an adaptation of horses to the climate and vegetational conditions of this period (cf. Forstén 1996). This compares well with the both the oxygen isotope curve and other lithological evidence, which suggests that the Stage 6 cold episode was extremely severe. The small horse represented at Bacon Hole is therefore considered to be of possible biostratigraphic significance in demonstrating a Stage 6 age in the late Middle Pleistocene.

![Figure 7.3](image)

**Figure 7.3** Comparison of right astragalus of *Equus ferus* (M33513, N.H.M.L.) from basal deposits at Bacon Hole (left) with a typical right astragalus of *Equus ferus* (21292a, N.M.H.L.) from Grays (right) (posterior view).
7.1.7. **Discussion and conclusions**

An immediately pre-Ipswichian age is implied for the Coarse Sands, on the basis of their position directly below deposits containing a Last Interglacial mammalian assemblage. Evidence of prevailing cold-climate conditions comes from the Sands themselves, which are interpreted as the product of aeolian deposition, with the addition of coarse rock debris (Currant *et al.* 1984). This is corroborated by the presence of a molluscan assemblage indicative of cold conditions and bare rock slopes with little vegetation and by the occurrence of *E. ferus* and *M. oeconomus*, both characteristic of open conditions. A Stage 6 age for the Coarse Sands is therefore inferred. A Stage 6 mammalian assemblage, as established in the basal deposits at Bacon Hole, may be characterised the presence of two species of biostratigraphic significance:

- a large form of *M. oeconomus*
- a small-bodied *E. ferus*

A range of sites attributed to the Stage 6 cold episode will now be examined and the evidence from these compared to the fauna established above.
7.2. LOWER RED CAVE EARTH, MINCHIN HOLE, PENNARD, WEST GLAMORGAN (SS 562868)

7.2.1. Location of the site

Minchin Hole is a large, single-chambered cave, formed along a minor fault in steeply sloping Carboniferous limestone on the southern edge of the Gower Peninsula, approximately 11km WSW of Swansea.

7.2.2. History of research

Little is known of the early history of Minchin Hole, although Dean Buckland is known to have been one of the first visitors (in 1831), following the discovery of fossil mammals in the cave. The first major excavations were conducted by Lieutenant-Colonel E.R. Wood in the 1850s (Benson 1852; Falconer 1860; Murchison 1868), the mammalian remains from which were examined by Hugh Falconer. As at the neighbouring site of Bacon Hole (7.1), Falconer noted the presence of marine sands at the base of the sequence, overlain by interglacial deposits containing narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*) and straight-tusked elephant (*Palaeoloxodon antiquus*) (Falconer 1860; Murchison 1868). Falconer further noted, at the top of the sequence, the presence of cold stage deposits, which contained a second distinct faunal assemblage of woolly mammoth and woolly rhinoceros. Although hippopotamus was not recorded from the interglacial deposits in Minchin Hole, Falconer listed this species as part of a similar *hemitoechus-antiquus* fauna in nearby Ravenscliff Cave.

Minchin Hole was later reinvestigated by T.N. George, who described the now-classic sequence of the basal 'Patella Beach', overlain by a breccia containing interglacial mammalian remains, the 'Neritoides beach' and finally by wind-blown sand (George 1932). George concluded that a substantial period of time had elapsed between the deposition of the *Patella* and *Neritoides* Beaches and observed that the mammalian fauna of the intervening breccia represented a temperate episode. Further studies in the cave were carried out in the 1940s by E.E. Allen and J.G. Rutter (Allen and Rutter 1946) and by Rutter and E.J. Mason in the 1950s on behalf of the Royal Institution of South Wales. These investigations exposed the 'Inner Beach', an earlier raised beach.
deposit that had not been encountered by George at the cave mouth, where the ‘Patella Beach’ rests directly on the limestone floor of the cave.

The most recent excavations in the cave were conducted by the Natural History Museum in conjunction with the University of Wales (Aberystwyth) between 1972 and 1984 (Sutcliffe and Bowen 1973; Sutcliffe 1981; Sutcliffe and Currant 1984; Sutcliffe et al. 1987).

7.2.3. Geological background and provenance of mammalian remains

The following sequence is from Sutcliffe (1981) and Sutcliffe and Currant (1984) (Figure 7.4):

9, 10 and 11. Uppermost cave deposits. These are preserved only at the back of the cave and as fragments adhering to the walls and ceiling. The inner talus is composed mainly of red cave earth and limestone breccias, overlain by a thick flowstone floor. The outer talus consists of sand rock and breccias. The two talus deposits interfinger in their uppermost parts.

7 and 8. George’s ‘Neritoides Beach’ and the interglacial Earthy Breccia Series. On the western side of the cave mouth, the ‘Patella Beach’ is directly overlain by the ‘Neritoides Beach’, composed largely of small littoral gastropods and containing mammalian remains. This deposit appears to merge with, and be a continuation of, a breccia that is present on the eastern side of the cave. Revision of the ‘Neritoides Beach’ has shown that contrary to George’s original interpretation (George 1932), this deposit represents not a discrete beach episode but a transition, at a time of falling sea level, from the fully marine ‘Patella Beach’ to the overlying terrestrial Earthy Breccia Series (Sutcliffe 1981; Sutcliffe and Currant 1984).

6. Fallen flowstone block, containing terrestrial molluscs and resting directly on top of the ‘Patella Beach’ near the cave entrance.

5. ‘Patella Beach’. Following the deposition of units 1–4 and the elapse of sufficient time for the partial lithification of the Inner Beach and for compaction of the Lower Red Cave Earth, the sea level rose once more, cutting a sloping cliff in the Pleistocene sediments. A storm beach with an observed vertical range of more than 6m (6.2-12.4m O.D.) was laid down at the foot of this cliff, resting on the limestone
surface of the cave at its mouth and upon the eroded surface of the ‘Inner Beach’ beyond. The storm beach consists of variable clasts, ranging from limestone boulders up to 1.3m long at the seaward limit, to smaller boulders, pebbles, shingle and shell fragments (especially of the limpet *Patella*) at its feather-edge inner limit. The beach thins rapidly inside the cave and feathers out entirely against a cliff in the earlier sediments approximately 10m beyond the entrance. At its seaward end, it is truncated by present-day wave erosion. The ‘*Patella Beach*’ is considered to represent a sea level about 2m higher than at present.

4. Flowstone floor with small fragments of bone.

3. Lower Red Cave Earth. Thick deposit of poorly-sorted angular limestone clasts in red clayey matrix, containing remains of northern vole, *Microtus oeconomus* and a large bovid. There is no visible stratification in this deposit, which is apparently derived from the back of the cave and is interpreted as the product of roof collapse, with some material possibly washed in from outside. A fall in sea level is inferred.

2. Thin white deposit resting upon the eroded surface of the ‘Inner Beach’, ?incipient stalagmite.

1. ‘Inner Beach’. 2 metres of bedded sand with marine shells, resting on the wave-smoothed limestone floor of the cave. The eroded surface of the sand lies at 11.6m O.D. This deposit is interpreted as an intertidal beach deposit, laid down when sea level was approximately 3m higher than at present.

The particular interest of Minchin Hole lies in the presence there of two distinct fossil beach deposits, both representing former sea levels higher than at the present day. George (1932) originally identified the *Patella* and *Neritoides* Beaches as two separate deposits. However, subsequent stratigraphic studies by Sutcliffe and Bowen (1973), Sutcliffe and Currant (1984) and Sutcliffe *et al.* (1987) have established that these two beaches are, in fact, part of a single feature, separated from the older, sandy Inner Beach by a terrestrial cave earth deposited under cold-climate conditions. Various ages have been assigned to the two periods of marine transgression. Bowen (1973a, b) has suggested that the Inner Beach could belong to either Stage 9 or 7 and the *Patella Beach* to Substage 5e. This has been corroborated by amino acid racemisation ratios that indicate different ages for the two beaches, the Inner Beach being the older (Davies 1983). Correlation of the *Patella Beach* with the Ipswichian Interglacial corresponds well with the evidence from mammalian remains which directly overlie it. Although
lacking in *Hippopotamus*, these include an otherwise typical Ipswichian fauna with *Palaeoloxodon antiquus* and *Stephanorhinus hemitoechus* (Sutcliffe and Bowen 1973; Sutcliffe and Currant 1984 and Sutcliffe et al. 1987). A fallen block of flowstone, resting on top of (and hence no younger than) the *Patella* Beach was dated by Uranium-series to around 120 000 years B.P. (Schwarcz 1984a), an age-estimate that would support correlation of the *Patella* Beach with Substage 5e.

The Inner Beach is therefore considered to be representative of a pre-Ipswichian high sea level. The most likely correlation for this deposit is with Stage 7, as the first immediately pre-Ipswichian interglacial. This has received support from thermoluminescence dates in the region of 190 000 years B.P. (Southgate 1985) and from amino acid racemisation (Bowen et al. 1985). The Lower Red Cave Earth is therefore interpreted as the product of an episode of lowered sea level, later in age than the Inner Beach, but earlier than the *Patella* Beach (Sutcliffe and Currant 1984). Correlation with Stage 6 is therefore proposed. No mammalian remains are known from the Stage 7 Inner Beach, although a small faunal assemblage has been recovered from the Lower Red Cave Earth.

Figure 7.4 Schematic section through the deposits in Minchin Hole (not to scale) (modified from Sutcliffe and Currant 1984).
7.2.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London, collected by that institution. The presence of 2 taxa has been ascertained, on the basis of 87 specimens.

Species List (Mammalia) from the Lower Red Cave Earth, Minchin Hole, West Glamorgan

**Rodentia**

*Microtus oeconomus* (Pallas), northern vole

**Artiodactyla**

Bovini indet. sp., large bovid

Table 7.2 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rodentia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. oeconomus</em></td>
<td>8</td>
<td>9.19</td>
<td>4</td>
</tr>
<tr>
<td><em>Microtus sp.</em></td>
<td>78</td>
<td>89.65</td>
<td>11</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bovinae sp.</td>
<td>1</td>
<td>1.14</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7.2 Breakdown of the mammalian species list from the Lower Red Cave Earth at Minchin Hole, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

7.2.5. Palaeoenvironmental and palaeoclimatic interpretation

The Lower Red Cave Earth was deposited at a time of lowered sea level (Sutcliffe and Currant 1984). Cold-climate conditions are therefore inferred. The presence of *Microtus oeconomus* is supportive of this interpretation, since this species is today most widely distributed throughout the northern tundra and taiga zones of continental Europe.
and is absent from the British Isles. The presence of a large bovid implies the availability of grazing in the vicinity.

7.2.6. Biostratigraphy and correlation

Mammalian studies

The presence of *Microtus oeconomus* in the Minchin Hole assemblage is of potential biostratigraphic significance. Measurements of the length of the first lower molar in a range of *M. oeconomus* from Middle and Upper Pleistocene cold and temperate-episode deposits, reveal that this species reached its maximum size in cold-climate deposits immediately preceding the Ipswichian Interglacial. The Minchin Hole sample (*n = 5*) falls well within the Stage 6 group, with mean m1 lengths of 3.05mm (s.e. = 0.083, s.d. = 0.186) (see Figure 3.24; Tables 3.5, 3.6). The presence of this large form of *M. oeconomus* in Minchin Hole implies correlation with the assemblage from the Coarse Sands at nearby Bacon Hole (7.1), also attributed to Stage 6.

7.2.7. Discussion and conclusions

The age of the Lower Red Cave Earth at Minchin Hole has been established on the basis of its stratigraphic position between the Inner Beach and the *Patella* Beach. These have been attributed to a pre-Ipswichian interglacial, probably Stage 7, and to Substage 5e respectively (Bowen 1973a, b; Sutcliffe and Currant 1984; Schwarcz 1984a; Sutcliffe et al. 1987; Bowen et al. 1985; Southgate 1985). Correlation of the *Patella* Beach and *Neritoides* Beach with the Ipswichian Interglacial has also been supported by amino-acid ratios (Davies 1983), thereby implying equivalence with Beds D-F at Bacon Hole (7.1). The Lower Red Cave Earth is therefore attributed to a cold-climate episode between these Stage 7 and the Ipswichian, considered to correspond to Stage 6 of the oxygen isotope record. This is corroborated by the fact that the Lower Red Cave Earth was deposited at a time of lowered sea level and by the presence of continental climatic indicators, such as *M. oeconomus*. The occurrence of a large form of northern vole in the Lower Red Cave Earth compares closely with evidence from the basal part of the sequence at Bacon Hole and is supportive of a Stage 6 age for the deposits.
7.3. CLEVEDON CAVE, SOMERSET (ST 418727)

7.3.1. Location of the site

Clevedon Cave (also known as Walton Cave) in Holly Lane Quarry is situated between the villages of East Clevedon and Walton, at the convergence of two ridges of carboniferous limestone, approximately 81m high, one running west from Bristol and the other running south-west from Portishead, that enclose the Vale of Gordano. The cave lies at the foot of a limestone cliff at approximately 18m O.D. (Figure 7.5).

Figure 7.5 Location of Holly Lane Quarry (modified from Greenly 1922).

7.3.2. History of research

The cave was discovered in 1905 by Mr G.E. Male of Clevedon in a limestone quarry. Together with his brother, Dr H.C. Male, he is reported to have collected hundreds of bones from the limestone breccias and cave-earth, with which the cave was infilled, and from the breccias outside the cave. Many specimens were unfortunately later discarded (Greenly 1922), although further excavations were undertaken by Professor S.H. Reynolds in 1906, who recorded remains of bear, wolf, arctic fox, a small horse and northern vole (Reynolds 1907). Further references to the cave and its fauna are provided by Davies (1907), Greenly (1922), Palmer and Hinton (1929), Gilbertson and Hawkins (1974) and Hawkins (1977). The remains of Microtus oeconomus from the cave are discussed in detail by Hinton (1907b). By 1929, quarrying in the area had ceased (Palmer and Hinton ibid).
7.3.3. **Geological background and provenance of mammalian remains**

The following section was described at Holly Lane Quarry, where the thickest exposures were located (Palmer and Hinton 1929). The breccias were observed to be thickest close to the limestone cliff face at the northern end of the quarry and to reach a maximum depth of 15m, where they abutted the cliff. A further 9m of breccia was proved through prospecting, resting on top of a limestone platform. The gravel beds concealed the entrance to the cave at the base of the cliff.

4. Recent humus and stony loam, 0.15-0.45m
3. Upper limestone breccia with lenticular seams of sand, 1.5-3.6m
2. Aeolian sand and loam, 0.3-3m
1. Lower limestone breccia, with occasional blocks of limestone and bands of coarser gravels, 4.5m +

A similar sequence was described by Davies (1907) (Figure 7.6):

![Figure 7.6 Section through the sequence at Holly Lane Quarry, showing Clevedon Cave at the base (modified from Davies 1907).](image)

The cave itself was filled almost completely to the roof with the same deposits (Davies *ibid*).

The breccias and sands are known to continue across the Vale of Gordano and further westwards for approximately 1.25km. They are present on the southern flanks of both
limestone ridges, although in the Vale itself and in the East Clevedon Gap, they also extend to the northern sides (Greenly 1922). Palmer and Hinton (1929) interpreted the limestone breccias as the product of extremely cold conditions and likened them to the Coombe Rock deposits of south-east England. Virtually all the large mammalian remains were stated to have come from the lower breccia, with only one tooth of Equus ferus reported from the upper breccia. Remains of Ursus arctos were apparently most common inside the cave, whereas remains of Canis lupus were most frequently encountered outside. Rodent and molluscan remains occurred in sandy seams in both lower and upper breccias but were most numerous in the former. No mammalian remains are known from the aeolian sands, although small shell fragments were present. A substantial number of mammalian specimens were apparently articulated, in particular bones of Equus ferus, which included a skull and partial skeleton and two complete lower legs. These were found at the foot of the limestone cliff, a fall from which was presumed to be the cause of death (Palmer and Hinton 1929).

7.3.4. Palaeontology

The following species list has been compiled from material in the British Geological Survey Museum, Keyworth. The presence of 5 species has been confirmed, on the basis of 79 specimens collected by G.E. Male, H.C. Male and S.H. Reynolds. No new species were identified during the present study. All the fox remains have been assigned to Vulpes vulpes. Reynolds (1907) listed a putative record of arctic fox (Alopex lagopus) based on some small vertebral material, but due to the difficulties of separating remains of Vulpes and Alopex, it was decided to refer all specimens here to Vulpes, in the absence of more complete material. A record of rabbit (Oryctolagus cuniculus), also listed by Reynolds (1907), seems likely to be a modern intrusion. A point of note is that certain of the bear remains display osteo-arthritic pathological deformities.

Species List (Mammalia) from Clevedon Cave, Somerset

Rodentia

Microtus oeconomus (Pallas), northern vole

Carnivora

Canis lupus L., wolf
Table 7.3 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated. The figures do not however correspond with published reports (for example Reynolds 1907), which state that *Equus ferus* was the most abundant mammal. It is therefore almost certain that other equid material exists, which was not seen by the author during the present study. The specimen numbers given below must therefore be taken as minimum counts. This is not thought to affect the interpretation of the assemblage greatly, since all the species listed in the published reports have been found in the collections at the British Geological Survey Museum.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rodentia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. oeconomus</em></td>
<td>31</td>
<td>39.24</td>
<td>23</td>
</tr>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lupus</em></td>
<td>7</td>
<td>8.86</td>
<td>1</td>
</tr>
<tr>
<td><em>V. vulpes</em></td>
<td>2</td>
<td>2.53</td>
<td>1</td>
</tr>
<tr>
<td><em>U. arctos</em></td>
<td>28</td>
<td>35.44</td>
<td>2</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>11</td>
<td>13.92</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7.3 Breakdown of the mammalian species list from Clevedon Cave, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

7.5.5. Palaeoenvironmental and palaeoclimatic interpretation

The nature of the deposits suggests that cold and dry climatic conditions prevailed at the time of deposition of the breccias and aeolian sands. Twelve species of terrestrial Mollusca and one marine shell were recorded from the breccias (Palmer and Hinton 1929). The land molluscan assemblage is characterised by species inhabiting open ground, such as *Hygromia hispida*, *Helix aspersa* and *Pupilla muscorum* (Reynolds...
1907; Greenly 1922), thereby corroborating the inference of cool and open climatic conditions. Fish vertebrae of an indeterminate species and 24 species of bird were also reported (Reynolds 1907; Greenly 1922), including osprey (*Pandion halieutus*), buzzard (*Buteo buteo*), Wheatear (*Oenanthe oenanthe*), skylark (*Alauda arvensis*), robin (*Erithacus rubecula*), redwing (*Turdus iliacus*), song thrush (*T. philomelus*), blackbird (*T. merula*), raven (*Corvus corax*), greenfinch (*Carduelis chloris*), swift (*Apus apus*), ringed plover (*Charadrius hiaticula*), golden plover (*Pluvialis apricaria*), turnstone (*Arenaria interpres*), dunlin or sandpiper (*Calidris or Tringa*), godwit or greenshank (*Limosa or Tringa*), whimbrel, heron (*Ardea cinerea*), common gull, cormorant, duck (*Anas sp.*), widgeon (*Anas penelope*), pintail (*Anas acuta*) and goose (*Anser sp.*).

The mammalian assemblage is also indicative of open conditions, as attested to by the presence of *Equus ferus*. The occurrence of *Microtus oeconomus* (which is today most widely distributed throughout the northern tundra and taiga zones of continental Europe) suggests that climatic conditions were more continental than at present in the British Isles. *Canis lupus*, *Vulpes vulpes* and *Ursus arctos* are known from both cold and temperate episodes.

7.3.6. Biostratigraphy and correlation

**Mammalian studies**

The mammalian assemblage from Clevedon Cave contains two species of biostratigraphic significance and compares closely with that from Bacon Hole (7.1). The presence of a large form of northern vole, *Microtus oeconomus*, at Clevedon Cave, is of particular importance. The Clevedon Cave sample (*n* = 13) has a mean length of 3.08mm in the first lower molar (s.e. = 0.080, s.d. 0.288), placing it firmly within the range established for *M. oeconomus* in Stage 6 deposits at Bacon Hole and Minchin Hole (7.2). The Clevedon Cave sample has been demonstrated to be significantly larger than an Ipswichian sample from Bacon Hole (Figure 3.24; Tables 3.5 and 3.6), which is therefore consistent with the finding that the *M. oeconomus* was larger in the cold period immediately preceding the Ipswichian, than at any time before or since.
As outlined in Chapter 3, the dominance of *M. oeconomus* in the British microtine fauna is associated with increased intraspecific morphological variability during Stages 7 and especially 6. This resulted in the erroneous creation of a new species, *M. malei*, which was believed to be closely related to the snow vole *M. nivalis* (Hinton 1907a, b). Accordingly, Hinton (*ibid*), who recognised the large form and morphological variability of the *Microtus* at Clevedon, assigned all remains to *M. malei*. It has since been demonstrated that all remains variously attributed to *M. malei* or *M. nivalis* are in fact variants of *M. oeconomus* (Stuart 1982) and that these species have never been part of the British fauna. The specimens from Clevedon Cave are therefore all referable to a large form of *M. oeconomus*.

The second species of biostratigraphic significance at Clevedon Cave is *Equus ferus*. The remains of this species from Clevedon Cave are all of the small variety noted at Bacon Hole (7.1), a feature considered to be of great importance in establishing a Stage 6 age for the deposits. As previously stated, this decrease in body size may have been an adaptation to the climatic and vegetational conditions of this period (cf. Forstén 1996).

**Malacological studies**

The molluscan assemblage was estimated to be closely comparable with that of Crayford (Woodward and Kennard, in Palmer and Hinton 1929).

**7.3.7. Discussion and conclusions**

The combination of a large form of *M. oeconomus* and a small-bodied *E. ferus* at Clevedon Cave demonstrates the close similarity of the assemblage to that from Bacon Hole (7.1). A Stage 6 age is therefore proposed. Corroborative evidence of cold-climate conditions has come from the lithological nature of the deposits themselves and from the molluscan remains.
7.4. COLLEGE FARM, PITSTONE QUARRY, MARSWORTH, BUCKINGHAMSHIRE (SP 932145-6)

7.4.1. Geological background and provenance of mammalian remains

The location and history of research at this locality are fully described in 6.10. The mammalian assemblage of interest in this section is that recovered from the cold-climate colluvial chalky muds (Layer 1), which overlie the interglacial deposits of the Lower Channel (see Figure 6.27). They are in turn overlain by the extensive deposits of Coombe Rock, 2-3m thick, described in Green et al. (1984). Evidence of cryoturbation within the Coombe Rock, in the form of frost polygons and festooning, was also observed (Evans and Oakley 1952). These deposits are attributed to the solifluction of chalk debris from the scarp slope of the Chilterns, which was subsequently exposed to arctic conditions. A severe periglacial climate is suggested (Green et al. 1984). The fossiliferous chalky muds are interpreted as the product of colluvial deposition under cold-climate conditions, following the end of the interglacial period represented in the Lower Channel (6.10). The Coombe Rock deposits are therefore considered to represent subsequent fully periglacial conditions.

Dating of the chalky muds and periglacial deposits is on the basis of their stratigraphic position, post-dating the temperate-climate deposits in the Lower Channel but pre-dating those of the Upper Channel. The interglacial represented by the Mammuthus- Equus-dominated assemblage in the Lower Channel has been correlated with Stage 7 (Green et al. 1984; 6.10), whereas the interglacial represented by the Hippopotamus assemblage in the Upper Channel has been correlated with the Ipswichian Interglacial (Substage 5e) (Green et al. ibid). Correlation of the intervening cold-climate deposits with Stage 6 is therefore implied.

7.4.2. Palaeontology

The following species list has been compiled from material in Aylesbury Museum, collected during rescue excavations co-ordinated by D. Parish. Only specimens marked from the cold-climate deposits (Layer 1) are considered here. The presence of 5 species was confirmed and one important re-identification was made. The record of extinct
‘ass’, *Equus hydruntinus* (Green *et al*. 1984), based upon very small dental and postcranial material, was re-identified as a small form of *Equus ferus*. It is now also known that all of the specimens described below are not part of the Stage 7 interglacial assemblage from Layers 2 and 3, but came from the colluvial cold-climate deposits of Layer 1. This is the first time that a separate cold stage fauna has been identified and described from the site. Preservation of the assemblage from Layer 1 is very different to that observed in the Lower Channel interglacial beds, the specimens being a creamy yellow colour and frequently broken and abraded. Ninety-seven specimens were examined.

**Species list (Mammalia) from the chalky solifluction deposits, overlying the Lower Channel, Marsworth, Buckinghamshire**

**Carnivora**

*Canis lupus* L., wolf

*Vulpes vulpes* (L.), fox

**Proboscidea**

*Mammuthus primigenius* (Blumenbach), woolly mammoth

Elephantidae sp., indet. elephant

**Perissodactyla**

*Equus ferus* Boddaert, horse

**Artiodactyla**

Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 7.4 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.
<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnivora</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. lupus</em></td>
<td>5</td>
<td>5.15</td>
<td>2</td>
</tr>
<tr>
<td><em>V. vulpes</em></td>
<td>2</td>
<td>2.06</td>
<td>1</td>
</tr>
<tr>
<td>Proboscidea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>4</td>
<td>4.12</td>
<td>1</td>
</tr>
<tr>
<td>Elephantidae sp.</td>
<td>1</td>
<td>1.03</td>
<td>1</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>84</td>
<td>86.59</td>
<td>5 (3 juv., 2 adults)</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>1</td>
<td>1.03</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7.4 Breakdown of the mammalian species list from the chalky muds (Layer 1) at Marsworth, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

7.4.3. Palaeoenvironmental and palaeoclimatic interpretation

The mammalian remains from the chalky muds at Marsworth are characteristic of open environments. This is illustrated by the dominance of *Equus ferus* in the assemblage and supported by the presence of other large grazing or part-grazing herbivores, *Mammuthus primigenius* and large bovids. No indication of climate is given by the mammalian assemblage, since all species are known from temperate and cold stages alike. However, the lithological nature of the deposits themselves and the supporting evidence from periglacial structures strongly suggests that the climate was cold.

7.4.4. Biostratigraphy and correlation

Mammalian studies

The mammalian assemblage from the cold-climate deposits overlying the Lower Channel is quite different to that from the Lower Channel itself, not only in terms of its preservation but also its character. As far as the small sample allows, the *M. primigenius* from this horizon is now apparently represented exclusively by a fully-evolved form, in contrast to the Lower Channel, where approximately 50% of the diagnostic molars are of the primitive ‘Ilford type’. Marked differences are also apparent in the equid remains. The large horse of the Lower Channel has been replaced.
in the overlying cold-climate deposits by a small-bodied form, which is also found in other deposits attributed to Stage 6 in the present study, at Bacon Hole (7.1), Clevedon Cave (7.3) and Brighton (7.7). This small horse (the origin of the misidentification of *Equus hydruntinus* by Green *et al*. 1984) is considered here to be of biostratigraphic significance, since its presence appears to be in response to worsening climatic conditions during this period (Forstén 1996). The Carnivora from the chalky solifluction deposits are represented by *Canis lupus* and *Vulpes vulpes*. The wolf in question is larger than those from the underlying Lower Channel (see Figure 3.28) and is most closely comparable in size to those from known Devensian localities. *V. vulpes* is also recorded from the pre-Ipwsichian deposits at Bacon Hole.

### 7.4.5. Discussion and conclusions

The fossiliferous chalky muds and solifluction deposits at Marsworth are clearly the product of deposition under cold-climatic conditions, as attested to by the presence of periglacial phenomena, such as ice-wedge casts. A severe periglacial climate is inferred. The stratigraphic position of the chalky muds and solifluction deposits, overlying the temperate-climate deposits of the Lower Channel (6.10) but underlying those of the Upper Channel, implies correlation of the cold-climate deposits with Stage 6. The complete Marsworth sequence therefore spans isotope stages 7, 6 and Substage 5e, and is the only locality where two interglacial episodes have been demonstrated in stratigraphic superposition in the same place. The mammalian assemblage from the intervening cold-climate deposits is wholly consistent with a Stage 6 correlation, on the basis of the presence of a particularly small caballine horse and fully-evolved *M. primigenius*. The biostratigraphically significant small *E. ferus* has also been noted at other sites attributed to Stage 6 in the present study, such as Bacon Hole (7.1), Clevedon Cave (7.3) and Brighton (7.7), while the presence of a fully-evolved morphotype of *M. primigenius* has been identified in deposits of equivalent age at Balderton (Lister and Brandon 1991; 7.6). This is the first time that a distinctive cold stage fauna has been identified in the Marsworth sequence and although small, the assemblage is extremely important in establishing the nature of this relatively poorly-known cold episode.
7.5. STANTON HARcourt GRAVEL

The location and history of research at this locality are fully described in 6.10. The mammalian assemblage of interest in this section is that recovered from the Stanton Harcourt Gravel Member, which overlies the interglacial deposits of the Stanton Harcourt Channel.

7.5.1. Geological background and provenance of mammalian remains

The Stanton Harcourt Gravel forms the main part of the Summertown-Radley aggradation and was first recognised by Sandford (1924, 1926), who proposed a bipartite division of the terrace, identifying both the Stanton Harcourt Gravel and the overlying Eynsham Gravel. Sandford (ibid) also reported the presence of cold-climate mammals in the former, contrasting them with the temperate Hippopotamus assemblage of the latter. The full sequence in the Stanton Harcourt area is described in Bridgland (1994) (see also 6.11, Figures 6.28 and 6.29).

Exposures of Stanton Harcourt Gravel have been described on various occasions by Briggs (1973, 1976), Goudie and Hart (1975), Gilbertson (1976), Briggs and Gilbertson (1980), Bryant (1983), Briggs et al. (1985) and Seddon and Holyoak (1985) and have been interpreted as being deposited under cold, periglacial conditions (Bryant 1983; Seddon and Holyoak 1985). This member usually overlies, unconformably, Jurassic Oxford Clay, except in parts of Dix’s Pit (SP 413054), where it overlies the Stanton Harcourt Channel Deposits. The Stanton Harcourt Gravel is interpreted as the product of deposition by a braided river (Goudie and Hart 1975; Bryant 1983) and consists of loose or cemented, limestone-dominated, sand and gravel units, containing frequent cobble-sized (> 6 cm) Gryphaea valves, derived from Oxford Clay (Buckingham et al. 1996). Two divisions are noted within the gravel (Briggs et al. 1985). The lower part is coarser and has a maximum thickness of 1.5m, whereas the upper part is finer and is separated from the lower by a well-defined zone of cryoturbation (Bridgland ibid). Signs of cryoturbation are present at the top of both divisions of the Stanton Harcourt Gravel, in the form of involutions, festooning, small-scale slumps and load structures, often associated with ice-wedge casts. These imply the periglacial conditions at the
Both divisions of the Stanton Harcourt Gravel Member contain thin, intermittent sand and silt beds, from which molluscan remains of cold-climate affinities have been obtained (Briggs et al. 1985; Seddon and Holyoak 1985). In addition to the Stanton Harcourt Channel Deposits, the Stanton Harcourt Gravel is locally underlain by a basal sand/silt unit, often with ripple drift or parallel laminations. Plant and molluscan remains indicating cold conditions have been obtained from this basal unit (Bridgland 1994). A single silt-filled channel, approximately 1m above the Oxford Clay, also yielding cold-climate pollen and molluscs, was recorded by Seddon and Holyoak (1985). Capping the sequence is a ‘coverloam’, thought to post-date the emplacement of the Summertown-Radley Formation (Briggs et al. 1985).

Current measurements for the Stanton Harcourt Gravel Member suggest that the main flow direction was to the east or south-east (Bryant 1983). This contrasts with the evidence from the underlying Channel deposits, which indicates flow towards the north or north-east, and suggests that during the time of deposition of the Stanton Harcourt Gravel, water entered the area from the valley of the River Windrush, a left-bank tributary of Thames (Seddon and Holyoak 1985).

The cold-climate Stanton Harcourt Gravel is the same deposit that overlies the temperate Stanton Harcourt Channel Deposits and underlies the Eynsham Gravel. The former interglacial deposits are now widely regarded as representing a pre-Ipswichian temperate episode, equated with Stage 7 (Briggs and Gilbertson 1980; Shotton 1983c; Briggs et al. 1985; Bowen et al. 1989; Bridgland 1994 and Buckingham et al. 1996), whereas the latter have been correlated with the Ipswichian Interglacial (Substage 5e), based upon the presence of the diagnostic Hippopotamus fauna (Bridgland 1994). Correlation of the Stanton Harcourt Gravel with the intervening cold episode, Stage 6, is therefore established.
7.5.2. Palaeontology

The following species list has been compiled from species listed by Sandford (1924, 1926, 1954) and Currant (1985b), which were not seen during the present study. Five species were recorded.

Carnivora

*Ursus* sp., indet. bear

Proboscidea

*Mammuthus primigenius* (Blumenbach), woolly mammoth

Perissodactyla

*Equus ferus* Boddaert, horse

*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros

Artiodactyla

*Bison priscus* Bojanus, bison

7.5.3. Palaeoenvironmental and palaeoclimatic interpretation

The mammals from the Stanton Harcourt Gravel are indicative of open environments, as attested to by the presence of *Equus ferus*, in association with other large grazing or part-grazing herbivores. All of the above-named taxa are known from cold and temperate episodes but the absence of any obligate thermophiles from the assemblage suggests that at the time of deposition of the gravel, the prevailing climate was cold. This is confirmed by the evidence of periglacial phenomena, such as ice-wedge casts and involutions and by the presence of a molluscan fauna of open-ground affinities from an extensive silt band near the base of the gravel. The low-diversity molluscan assemblage is dominated by terrestrial species, such as *Oxyloma pfeifferi* and *Pupilla muscorum* (Gilbertson 1976; Briggs and Gilbertson 1980; Seddon and Holyoak 1985), which require an exposed, open habitat. This, and the absence of woodland indicators, suggests that the silt accumulated under climatic conditions that were cooler than at present. Pollen and plant remains, characterised by herb species of arctic and alpine affinities, were also recovered from the silt bands (Seddon and Holyoak *ibid*).
7.5.4. **Biostratigraphy and correlation**

The mammalian assemblage from the Stanton Harcourt Gravel Member contains no species of particular biostratigraphic significance, but as a whole, is not inconsistent with a Stage 6 age for the deposits. All the taxa recorded (with the exception of *Ursus*) are known from other deposits attributed to the immediately pre-Ipswichian cold stage in the present study.

7.5.5. **Discussion and conclusions**

The position of the Stanton Harcourt Gravel Member, post-dating the Stage 7 Stanton Harcourt Channel Deposits and pre-dating the Ipswichian Eynsham Gravel, strongly suggests correlation with Stage 6. This contradicts thermoluminescence age-estimates 91 000 ± 8000 and 93 000 ± 9000 years B.P. on silts within the gravels (Seddon and Holyoak 1985), which would imply correlation with the Devensian. However, thermoluminescence dating has frequently been observed to under-estimate the age of Pleistocene deposits (see for example Swanscombe, 5.2) and it seems likely that this is also the case here. Similarly, an infinite radiocarbon age-estimate of around 35 000 years B.P. was also obtained from this level by these authors. The mammalian biostratigraphic evidence from the underlying Stage 7 channel-infill and the overlying Substage 5e deposits provides far more convincing evidence for regarding the Stanton Harcourt Gravel as Stage 6 in age. This is supported by ancillary evidence in the form of periglacial structures, which suggest severely cold climatic conditions at the time of deposition, and by floral and faunal evidence of cold-climate affinities. The mammalian evidence from the Stanton Harcourt Gravel is also consistent with a Stage 6 age, since all the elements (with the exception of *Ursus*) have been recorded from other sites attributed to Stage 6 in the present study.
7.6. BALDERTON SAND AND GRAVEL, LINCOLNSHIRE

7.6.1. Location of the sites

The mammalian remains are from a series of gravel pits in the Balderton Sand and Gravel, which underlies the Balderton Terrace between Newark and Lincoln. Six gravel pits have yielded material of interest to the present study (after Brandon and Sumbler 1991):

1. Norton Bottoms Quarry (C and G Concrete) (SK 866589)
2. Thurlby Quarry (Butterly Aggregates Ltd.) (SK 890609, SK 890611 and SK 893613)
3. Whisby Quarry (Steetley Construction Materials Ltd.) (SK 897668, SK 897666 and SK 898666)
4. Whisby Quarry (Robert Teal Ltd.) (SK 921668, SK 930673, SK 929676 and SK 924667)
5. Hykeham Quarry (Butterly Aggregates Ltd.) (SK 935668 and SK 936670)
6. Hykeham Quarry (Redland Aggregates Ltd.) (SK 932 676 and SK 935677).

The distribution of the Balderton Sand and Gravel between Newark and Lincoln and the location of the six sites (numbered 1 to 6) is shown in Figure 7.7.

7.6.2. History of research

The terrace deposits of the Rivers Trent and Witham were originally mapped by the Geological Survey at the end of the last century (Jukes-Brown 1885), since when, aggregate extraction has provided numerous sections through the Balderton Sand and Gravel and associated deposits. Pits at Balderton (SK 825519, SK 806520, SK 825519), Winthorpe (SK 815565), Newark (SK 809530) and Whisby (SK 915675) were described by Jukes Brown (1885), Lamplugh et al. (1908a) and Armstrong (1939), although most of these have since been backfilled or flooded for recreational purposes (Brandon and Sumbler 1991). The mammalian remains of interest to the present study were collected from fluviatile sand and gravel deposits at the six sites listed above during the late 1980s and 1990 (Brandon and Sumbler 1991; Lister and Brandon 1991).
7.6.3. Geological background and provenance of mammalian remains

Four suites of sands and gravels were mapped in the Trent area by Brandon and Sumbler (1988): the Eagle Moor, Balderton, Fulbeck and Floodplain Sands and Gravels. These were arranged in order of descending height (and by inference, in order of decreasing age). The corresponding terraces of the same name were considered by the same authors to be contemporaneous with their respective sands and gravels, although the surfaces are modified to varying degrees by later processes.
Brandon and Sumbler (1988, 1991) described the Balderton Terrace as a sinuous, almost flat, gravelly plateau, 1.5-3km wide and extending for 30km from Newark in the southwest to Lincoln in the northeast. The surface level of the terrace falls from approximately 18m O.D. (7m above the present-day Trent floodplain) at Newark, to about 11m O.D. at Lincoln (Brandon and Sumbler ibid).

Swinnerton (1937) correlated the height of the Balderton Terrace deposits with those from beneath the Beeston and Allenton Terraces further upstream in the Trent valley, between Derby and Nottingham, a correlation also accepted by Clayton (1953, 1957b), Posnansky (1960), Straw (1963), Rice (1968b) and Straw and Clayton (1979). The presence of abundant *Hippopotamus* was considered to indicate an Ipswichian age for the Beeston and Allenton deposits (Bemrose and Deeley 1896; Jones and Stanley 1974) and a similar age for the Balderton Terrace was therefore inferred (Swinnerton 1937). More recently however, study of the topographical and geomorphological relationships of the Balderton Sand and Gravel to the Fulbeck Sand and Gravel in the Witham valley by Brandon and Sumbler (1988) has indicated that the former pre-dates the latter. The presence of abundant *Hippopotamus* in the Fulbeck Sand and Gravel would suggest that this deposit is of Ipswichian age and the Balderton Sand and Gravel must therefore be pre-Ipswichian.

In the same study, Brandon and Sumbler considered the flint-rich Eagle Moor Sand and Gravel to be glaciofluvial outwash from the glaciation which deposited the chalky tills of the region. This glaciation is widely held to be of Anglian age (Perrin et al. 1979). The reconstructed long profile of the Balderton Sand and Gravel is topographically lower than that of the Eagle Moor Sand and Gravel, but higher than that of the Fulbeck Sand and Gravel (Brandon and Sumbler 1988, 1991). A post-Anglian, pre-Ipswichian age for the Balderton deposits was therefore inferred. The great difference in height (approximately 18m) between the Eagle Moor and Balderton Terraces and the greater degree of dissection of the former deposits implies a large age difference between them (Brandon and Sumbler 1988).

Beneath the Balderton Terrace, the Balderton Sand and Gravel infills a broad, shallow channel cut into Lower Lias bedrock (Figure 7.8). The channel is generally 7-8.5m thick, with a maximum known depth of 10.9m in boreholes (Brandon and Sumbler
The Balderton Sand and Gravel is a poorly-sorted gravel, with a clean, sharp, medium to coarse-grained sand matrix, varying in colour from pale/medium orange brown to strong brown. Where cover deposits are absent, the topmost 1-1.5m is dark yellowish-brown with pale grey mottles, passing upwards into approximately 0.4m of greyish-brown pebbly soil. The exposures generally show cross-bedding in the Sands and Gravels, although massive gravel beds also occur. An overall fining-upward trend is discernible. Numerous ice-wedge casts, up to 5m deep and 1m wide and filled with sand and gravel, are present above 2m from the base of the Balderton Sand and Gravel. The tops of the wedges are truncated, except at the top of the Balderton Sand and Gravel, where complete casts and involutions may be observed. The lowest ice-wedge truncation surface occurs at around 3.5-4m above the base of the Balderton Sand and Gravel. This level may represent a single, laterally-extensive surface that was subsequently eroded by renewed fluvial activity after a prolonged hiatus. There is no structural evidence of permafrost conditions during deposition of the lowermost 2m of the Balderton Sand and Gravel (Brandon and Sumbler ibid).

Figure 7.8 Schematic cross section of the Balderton Terrace deposits (modified from Brandon and Sumbler 1988).
In places, small channels infilled with red sand are found in the top 2m of the Balderton Sand and Gravel. Other channels infilled with laminated brown and grey fine sands, silts and silty clays, rarely with scattered pebbles and thin interbeds of gravel, occur within the basal 2m of the Balderton Sand and Gravel. These latter channels are mostly less than 25m wide, although at Hykeham Quarry (SK 935677), a channel up to 200m wide and contain with clayey silt and silty sand up to 2.5m thick, was observed. Layers of matted plant debris are common within the lower channels and these deposits have also yielded molluscs, ostracods, beetles, pollen and occasional vertebrate remains (Brandon and Sumbler *ibid*).

Remnants of later deposits, up to 2.5m thick, are preserved above the Balderton Sand and Gravel at most pits. The top of the Sand and Gravel contains large ice-wedge casts and cryogenic involutions, the latter infilled with clay and Whisby Sand and containing pockets of vegetation-rich material, yielding cold-climate pollen. The overlying Whisby Sand generally rests sharply and probably erosively on the Balderton Sand and Gravel. It consists of a fine to medium-grained silty sand, up to 1.5m thick. The presence of sporadic, small, polished quartz, quartzite and flint pebbles within the sand suggests aeolian action, although particle size analysis also indicates a fluvial origin (Brandon and Sumbler *ibid*). These authors therefore suggest that the Whisby Sand is a fluvial deposit that has, in part, been reworked by aeolian action, or *vice versa*. In a few places, the Whisby Sand contains traces of rubification, indicating the presence of a palaeosol, possibly formed during the Ipswichian (Brandon and Sumbler *ibid*). A pale brown, fine-grained sand, similar in colour and texture to local Devensian coversands occurs occasionally within rubified Whisby Sand or within ice-wedge casts in the Whisby Sand and Balderton Sand and Gravel. Near the margin of the Balderton Sand and Gravel channel, up to 0.4m of medium grey, pebbly, silty sand rests on involuted Balderton Sand and Gravel, Whisby Sand and Lias clay. The base of this unit is sharp and rests on an erosion surface that cuts across both cryoturbation and colour mottling in the underlying deposits. It is interpreted as a Late Devensian gelifluction deposit derived from the nearby gravel-capped hill and the subjacent Lias bedrock (Brandon and Sumbler 1991).

Numerous mammalian remains have come from the Balderton Sand and Gravel (Lister and Brandon 1991), most of which are thought to have come from near the base, below
the main ice-wedge truncation level. Unfortunately, only two bones were found in situ (in a silt-filled channel), the rest having been picked from conveyor belts. However, the adhering sediment indicates that many come from the sand and gravel itself.

7.6.4. Palaeontology

The following species list has been compiled from the species list published by Lister and Brandon (1991) and conserved in the University Museum of Zoology, Cambridge. These were not seen during the present study. Further material was seen by the author in the private collection of Dr A. Brandon of the British Geological Survey but does not contain any unpublished species. Twelve mammalian species are present.

Species List (Mammalia) from the Balderton Sand and Gravel, Lincolnshire

Carnivora

Canis lupus L., wolf

Ursus cf. arctos L., brown bear

Panthera leo (L.), lion

Proboscidea

Palaeoloxodon antiquus (Falconer and Cautley), straight-tusked elephant

Mammuthus primigenius (Blumenbach), woolly mammoth

Perissodactyla

Equus ferus Boddaert, horse

Stephanorhinus cf. hemitoechus (Falconer), narrow-nosed rhinoceros

Coelodonta antiquitatis (Blumenbach), woolly rhinoceros

Artiodactyla

Cervus elaphus L., red deer

Rangifer tarandus (L.), reindeer

cf. Bison priscus Bojanus, bison

Ovibos moschatus Zimmerman, musk ox

7.6.5. Palaeoenvironmental and palaeoclimatic interpretation

The Balderton mammalian assemblage as a whole is indicative of a largely open
environment. The prevailing climate at the time of deposition is difficult to assess, but the balance of evidence suggests that it was probably cold. The presence of *Ovibos moschatus* (which is today restricted to the arctic tundra of North America and Greenland) and *Rangifer tarandus* (also an inhabitant of tundra and boreal forest), provide the clearest indication of prevailing cold and open conditions, although this must be accepted with a degree of caution. *O. moschatus* is also recorded from the temperate-climate *Corbicula* Bed at Crayford (6.18) and its presence therefore appears to be governed less by climatic constraints than by the availability of suitable vegetation. Although restricted at the present day to the far north, it seems clear that this species could survive in the past in environments for which there is no modern analogue. An open environment is supported by the occurrence of *Coelodonta antiquitatis*, *Equus ferus* and *cf. Bison priscus*. These species are also found in temperate-climate deposits, for example at Uphall Pit, Ilford (6.2) but their presence in association with *O. moschatus* and *R. tarandus* would favour a cold-climate interpretation.

The presence of two temperate-indicator species, *Palaeoloxodon antiquus* and *S. cf. hemitoechus*, seems somewhat at odds with the rest of the assemblage. *P. antiquus* has been reported from interstadial deposits within the Anglian Baginton-Lillington gravels at Snitterfield (Lister *et al.* 1990), although it is absent from typical cold stage mammalian assemblages (Stuart 1982). The specimens of *P. antiquus* and *S. cf. hemitoechus* apparently show no more evidence of rolling or abrasion than any of the other specimens (Lister and Brandon 1991) and it thus seems unlikely that they have been derived from a much earlier deposit. Lister and Brandon *ibid*) suggest two possible interpretations: i. if the entire vertebrate assemblage is penecontemporaneous, it would most likely have to correspond to an interstadial phase, in order to accommodate the more temperate elements, or ii. The assemblage spans a period of time encompassing a range of climatic phases within a cold stage. The lack of ice-wedge casts in the main mammaliferous levels of the Balderton Sand and Gravel (Brandon and Sumbler 1991) implies that the assemblage did not accumulate under fully arctic conditions. This in itself seems unlikely from the range of mammals represented, many of which have substantial grazing requirements. The presence of a rich, open herbaceous vegetation is therefore inferred, with climatic conditions varying from the sub-arctic to rather more temperate. This is very much supported by the evidence from other biological sources (see below).
Molluscs from a silt-infilled channel at the base of the Balderton Sand and Gravel consist mainly of aquatic species, suggesting the present of a plant-rich stream with muddy margins. The low species diversity is typical of a cold stage assemblage, although all the species represented are ecologically tolerant and occur in Britain at the present day and specifically arctic or alpine elements are absent (Preece, in Brandon and Sumbler 1991). *Perca fluviatilis* (perch) was also identified in the mollusc-bearing silt and suggests quiet water conditions, as do ostracods from the same silt. One species, *Limnocythere sanctipatrici*, is characteristic of modern alpine lakes (Robinson, in Brandon and Sumbler 1991). The coleoptera from these silt-filled channels are indicative of open habitats with a cold climate more continental than that of modern Britain. Mean July temperatures are estimated to be around 10°C and January temperatures at or below -20°C (Coope and Taylor, in Brandon and Sumbler 1991). This is supported by pollen from the base of the Balderton Sand and Gravel, which indicates a cold stage open herbaceous vegetation, without significant trees or shrubs and with grasses dominating sedges (Peglar, Bonny and Gibbard, in Brandon and Sumbler 1991).

7.7.6. Biostratigraphy and correlation

Mammalian studies

The Balderton mammalian assemblage is difficult to pin down on the basis of biostratigraphy, since all species from the site are known from at least one other cold stage and all except *R. tarandus* are known from at least one temperate stage. However, the presence of *P. antiquus* and *S. hemitoechus* are taken to indicate a pre-Devensian age, since there is no evidence for their survival after the Ipswichian in Britain (Stuart 1982).

The remains of *M. primigenius* from Balderton are represented exclusively by an advanced form and are morphologically very close dentally to the fully-evolved *M. primigenius* of the Last Cold Stage. The *E. ferus* is of large body size, above the range of Last Cold Stage material from Britain and France, but within the range of pre-Devensian material (Lister and Brandon 1991). This contrasts with the evidence from other sites attributed to the immediately pre-Ipswichian cold stage in this study, where a
small caballine horse has been noted (see 7.1, 7.3, 7.4 and 7.7). The remains of *P. leo* from Balderton have also been described as being of large size, comparable to other specimens from Sandford Hill (a cave site of Devensian age, A.P. Currant pers. comm.) and Bleadon Cave (6.22), the Marsworth Lower Channel (6.10) and Crayford (6.18) (Lister and Brandon *ibid*), all of which have been attributed to Stage 7 in the present study. The *O. moschatus* is also of larger size than the modern species. Comparable material is known from both Devensian and pre-Devensian deposits (Lister and Brandon *ibid*).

The Balderton Sand and Gravel marks the first post-Anglian appearance in Britain of *R. tarandus*. A single record is known from probable Anglian deposits at Westbury-sub-Mendip (Stringer et al. 1996) but no other material has been found in any cold stage deposit prior to the Devensian, with the exception of Balderton.

**Coleopteran studies**

The coleopteran fauna from Balderton is typical of many Middle and Late Pleistocene cold stages, but lacks many species that are common in the Devensian. A pre-Devensian age is therefore inferred (Coope, in Brandon and Sumbler 1991).

**7.6.8. Discussion and conclusions**

The height relationships of the Balderton Sand and Gravel, above the *Hippopotamus*-bearing Fulbeck Sand and Gravel but below the Anglian Eagle Moor Sand and Gravel, suggest a post-Anglian, pre-Ipswichian age. The presence of a rubified palaeosol in the upper part of the Balderton Sand and Gravel, locally affected by subsequent cryoturbation, is interpreted as indicative of a significant pre-Flandrian temperate period post-dating the Balderton Sand and Gravel. The age of the palaeosol is tentatively attributed to the Ipswichian, thereby suggesting that the Balderton Sand and Gravel should be correlated with the immediately preceding cold episode (Stage 6) (Brandon and Sumbler 1991). In support of a Stage 6 age for the Balderton Sand and Gravel, Brandon and Sumbler (*ibid*) cite evidence from interglacial channel deposits at Coronation Farm (TF 15366684) in the Witham valley, which they tentatively attribute on palynological grounds to Stage 7. The channel deposits are overlain by gravelly
deposits of the Southrey Terrace, which on the basis of lithology and reconstructed long profile, appear to equate with the Balderton Sand and Gravel. A post-Stage 7 age is therefore inferred. Brandon and Sumbler (ibid) also draw comparisons between the Balderton Sand and Gravel and the syndepositionally cryoturbated deposits overlying the Marsworth Lower Channel (6.10, 7.4) and the Stanton Harcourt Channel (6.11, 7.5) and at Tattershall Thorpe. A Stage 6 age for the Balderton Sand and Gravel has also received support from Electron Spin Resonance dating of elephant teeth, which has produced age estimates of between 130-190 000 years B.P. (Grun, in Brandon and Sumbler 1991). Amino acid racemisation ratios of 0.13 ± 0.01 on Valvata piscinalis (Miller and Hollin, in Brandon and Sumbler 1991) place the Balderton Sand and Gravel in an intermediate position between the ratios established for Stage 7 and Substage 5e by Bowen et al. (1989), thereby implying a Stage 6 correlation.

The mammalian evidence cannot confirm or refute a Stage 6 age for the Balderton Sand and Gravel. The position of the Balderton Sand and Gravel between the Eagle Moor Sand and Gravel and the Fulbeck Sand and Gravel suggests a post-Anglian, pre-Ipswichian age, a position which is confirmed by the presence of P. antiquus and S. cf. hemitoechoechus. However, the Balderton mammalian assemblage could really fit within any of the intervening cold episodes implied in the oxygen isotope record, Stages 10, 8 or 6 and the absence of a full suite of terraces in the Trent does not facilitate further refining of the age of the deposits. Overall the assemblage compares most closely with that from Crayford (6.18), with R. tarandus being the only species not represented at the latter locality. Points of difference between the Balderton assemblage and those from other sites attributed to Stage 6 in the present study include the presence of a large E. ferus and R. tarandus at the former. If Balderton is of Stage 6 age, the presence of a large E. ferus implies more in common with earlier (i.e. Stage 7) assemblages and consequently suggests that the Balderton Sand and Gravel were deposited earlier in the succeeding cold episode, rather than later. R. tarandus has not been recorded from any other site attributed to Stage 6 in the present study. The relative proportions of the of the mammalian species from Balderton has also been cited as support for a Stage 6 age (Lister and Brandon 1991).

It is therefore concluded that the mammalian evidence is not inconsistent with a Stage 6 age for the Balderton Sand and Gravel, but suggests that there was variation in the
mammalian faunas of this period. More research is required in order to demonstrate a positive correlation. A line of evidence worth pursuing would be further investigation of the putative Stage 7 deposits at Coronation Farm (see above), for if equivalence of the overlying Southrey Terrace deposits with the Balderton Sand and Gravel can be ascertained, this would imply a post-Stage 7, pre-Ipswichian age for the latter.
7.7. BLACK ROCK RAISED BEACH DEPOSITS, BRIGHTON, EAST SUSSEX (TQ 335033)

7.7.1. Location of the site

The raised beach deposits in question are situated along the south coast of East Sussex, in the vicinity of Brighton. The best-known exposure is at Black Rock, near the Brighton marina (TQ 335033).

7.7.2. History of research

The presence of raised marine deposits in the coastal area of Sussex has been known since the early part of the 19th century. At Black Rock, Brighton, a fossil cliff with a shingle beach, overlain by fossiliferous chalk solifluction deposits and scree (Coombe Rock), was first recorded by Mantell (1883). Mantell (ibid) described the raised beach and noted the proliferation of elephant remains, together with horse and deer. No systematic excavations have ever been undertaken at the site and fossil material appears to have been collected as and when new exposures became available. Further references to the site are provided by Prestwich (1858), Martin (1909, 1929), White (1924) and Kellaway and Shephard-Thorn (1977). The remains of woolly mammoth were described by Adams (1877-81). The Black Rock locality is now a Site of Special Scientific Interest.

7.7.3. Geological background and provenance of mammalian remains

The Black Rock beach is the lowest of a series of raised beaches on the Sussex coastal plain and has been traced extensively to the west of Brighton as far as the Portsmouth area (Hodgson 1964, 1967). Its base height is at approximately 8.5m O.D., extending up to 11.9m O.D. (Keen 1995). The oldest descriptions by Mantell (1883) and Prestwich (1858) indicate that exposures at the end of the 19th century were superior to those available at the present day. Severe degradation of the cliff has occurred since the turn of the century (Martin 1909)
The following section was recorded by Mantell (1883) (numbering after Mantell):

a. 'Elephant Bed' or 'Coombe Rock', unstratified deposit consisting of broken Chalk with angular flint fragments, embedded in a calcareous mass of yellowish colour and forming a very hard and coarse conglomerate. The Chalk becomes coarser further up the sequence and the flints increase in size and number. Organic remains, including aurochs, deer, horse and mammoth are present, although not particularly abundant. A layer of shells is present at the junction with Bed b, 15-18m.

b. ancient shingle, consisting of rounded pebbles of Chalk, granite, porphyry, slate, limestone, sandstone etc. The upper part of the bed is cemented, 1.5-2.4m.

c. ancient sand: a fine sand varying from pure white to light reddish brown. Thins about a mile to the east of Kemptown, where Bed b rests immediately upon Chalk.

d. basal 1.8-2.4m of Chalk cliff, dipping southwards and extending for an unknown distance into the sea.

e. modern beach

f. modern sand

g. Chalk bedrock

A similar section was described by Kellaway and Shephard-Thorn (1977) (Figure 7.9)

A: cliff and platform, B: raised beach shingle with interbedded chalky debris, C: Coombe Rock with pebbles, D: Coombe Rock, E: late solifluction deposits, cryoturbated at cliff-top.

Figure 7.9 Section through the Black Rock deposits, Brighton (modified from Kellaway and Shephard-Thorn 1977).
The Black Rock raised beach was previously regarded as Last Interglacial (Zeuner 1945; Mottershead 1977) but is now widely considered to be of Stage 7 age (Keen 1995). This correlation is supported by amino-acid ratios on molluscan shell from the beach (Davies 1984) and by comparison with other raised beach deposits, also considered to be of Stage 7 age in the present study, such as Selsey (6.13). The chalky solifluction deposits overlying the raised beach can be divided into two units by the radically different depositional dips (10° for the upper unit and 20° for the lower one) (Keen 1995). At the contact between the two units, a reddened horizon occurs, which may be a palaeosol (Keen ibid). The succession may therefore consist of a marine unit deposited during Stage 7, followed by terrestrial deposition in Stages 6 and 4-2, separated by a palaeosol of Stage 5 age. Strikingly similar sequences are known from raised beach deposits at Sangatte in northern France (Keen ibid). Although it is not stated in the literature, it seems most likely that the mammalian remains came from the lower part of the Coombe Rock deposits. This is based on the presence of lumps of pebbly conglomerate, which are frequently encountered adhering to the bones. Examination of the section drawing by Kellaway and Shephard-Thorn (1977) (Figure 7.9) indicates that the pebbles are concentrated in the lower part of the Coombe Rock. A Stage 6 age for the Brighton mammalian assemblage is therefore inferred.

7.7.4. Palaeontology

The following species list has been compiled from material in the Natural History Museum, London, the Booth Museum of Natural History in Brighton and the British Geological Survey Museum at Keyworth. The majority of the material was collected by G. Mantell, with smaller collections made by Beccles, P. Lockward, A.L. Henshall, E.A.J. Davis, E. Curwen, J.E. Hall and H. Willett. The present study confirmed the presence of 4 species, on the basis of 119 specimens. The remains of deer, recorded by Mantell (1833), were not located. The material is generally abraded and varies in colour from a mid-brown to a chalky pale yellow and many specimens have traces of a rounded pebbly conglomerate adhering to them.
Species list (Mammalia) from Brighton, East Sussex

**Proboscidea**
*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Perissodactyla**
*Equus ferus* Boddaert, horse
*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros

**Artiodactyla**
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

Table 7.5 below provides a breakdown of the species list into numbers of specimens per species, also expressed as a percentage of the total mammalian assemblage from the site. Minimum numbers of individuals have also been calculated.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of specimens</th>
<th>Percentage of total assemblage (%)</th>
<th>Minimum number of individuals (M.N.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proboscidea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. primigenius</em></td>
<td>9</td>
<td>7.56</td>
<td>3</td>
</tr>
<tr>
<td><strong>Perissodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. ferus</em></td>
<td>99</td>
<td>83.19</td>
<td>7 (4 juv., 3 adults)</td>
</tr>
<tr>
<td><em>C. antiquitatis</em></td>
<td>4</td>
<td>3.36</td>
<td>1</td>
</tr>
<tr>
<td><strong>Artiodactyla</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bovidae sp.</td>
<td>7</td>
<td>5.88</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7.5 Breakdown of the mammalian species list from the Coombe Rock deposits overlying the Brighton raised beach, showing numbers of specimens per species, the percentage of the total assemblage per species and minimum numbers of individuals.

7.7.5. **Palaeoenvironmental and palaeoclimatic interpretation**

The mammalian assemblage from the Coombe Rock is indicative of open conditions, as witnessed by the abundance of remains of *Equus ferus* (83.19% of the assemblage). Other large grazing herbivores are also present, including *Mammuthus primigenius*, *Coelodonta antiquitatis* and large bovids. The lack of any thermophilous species suggests that the climate was cold. Sollas (in Martin 1909) reported that in the 19th century, plant remains had been found in the Coombe Rock but were not identifiable.
7.7.6. Biostratigraphy and correlation

Mammalian studies

The remains of *E. ferus* from the Brighton Coombe Rock deposits are of particular interest because of their small size. This is considered to be a feature of biostratigraphic significance, since it has been recorded in the late Middle Pleistocene only in cold-climate deposits immediately pre-dating the Ipswichian. The reduction in body size has also been noted in *Equus* remains from the basal sands in Bacon Hole (7.1), Clevedon Cave (7.3) and in Coombe Rock deposits at Marsworth (7.4). Figure 7.3) gives an indication of the small size of material from the immediately pre-Ipswichian cold stage when compared to a typically large late Middle Pleistocene interglacial *E. ferus*. As outlined in Chapter 3, a decrease in body size in these animals may be the direct response to worsening climatic conditions (Forstén 1996). A dental peculiarity, in the form of hypoconal constrictions, is also present in the upper molars of the small caballines.

Small numbers of *M. primigenius* and *C. antiquitatis* are also present in the Brighton Coombe Rock deposits. The former appears to be represented by a fully evolved morphotype, similar to those noted from the Balderton Sands and Gravels (Lister and Brandon 1991).

7.7.7. Discussion and conclusions

The mammalian remains under consideration are thought to have come from the lower part of the extensive chalky solifluction deposits at Black Rock. These deposits are considered to post-date the raised beach, now widely regarded as Stage 7 in age, and to pre-date the putative Ipswichian (Substage 5e) palaeosol in the upper part of the Coombe Rock (Keen 1995). A Stage 6 age for the Brighton assemblage is therefore inferred. The mammalian evidence is entirely consistent with this correlation, based upon the presence in the assemblage of the biostratigraphically significant small caballine horse, in association with *M. primigenius* and *C. antiquitatis*. The Brighton assemblage is closely comparable with those from other sites attributed to Stage 6 in the present study, particularly Bacon Hole (7.1), Clevedon Cave (6.3) and the cold-climate
deposits overlying the Lower Channel at Marsworth (7.4), in which the same small horse is also present. Remains of fully-evolved *M. primigenius* have also been noted in Stage 6 deposits at Marsworth, in the Stanton Harcourt Gravel (7.5) and at Balderton (7.6), whereas *C. antiquitatis* is known also from the latter two localities.
7.8. AVON TERRACE NO. 4, TWYNING, GLOUCESTERSHIRE (centred on 895365)

7.8.1. Location of the site

The village of Twyning is located in the lower Avon valley, approximately 4km north of Tewkesbury (Figure 6.40).

7.8.2. History of research

Palaeolithic artefacts and faunal remains were collected from the deposits of Avon Terrace No.4 at Twyning by Mr P.F. Whitehead between 1972 and 1986 (Whitehead 1988, 1989a). These deposits were formerly interpreted as Devensian in age (see below) but recent reappraisal of Terrace No.4 within the wider context of the terrace sequence of the Avon valley (Bridgland et al. 1989; Whitehead 1989a; Maddy 1989; Maddy et al. 1991) has suggested that they may relate to an unnamed pre-Ipswichian cold stage.

7.8.3. Geological background and provenance of mammalian remains

Whitehead (1988, 1989a) described the No. 4 Terrace at Twyning as being composed of two lithologically distinct members, separated by a phase of erosion. The basal member contained Jurassic-rich gravels and a cold-climate biota, whereas the upper one contained Triassic-rich sands and gravels with syndepositional ice-wedge casts. A fresh valve of *Corbicula fluminalis* was apparently found *in situ* in the upper member (Whitehead 1989a) (Figure 7.10).
Terrace No. 4 was originally identified by Tomlinson (1925) as one of a series of five terraces in the Avon but early interpretations led to the full complexity of the terrace sequence not being appreciated until relatively recently. Terraces No.3 and 4 were originally interpreted as the result of a single aggradational sequence to the higher (No.4) level, into which the lower terrace surface (No. 3) had been incised at a later date. Thus, the sediments under Terrace No. 4, although higher, were considered to be younger than the deposits underlying Terrace No. 3 (Tomlinson ibid). An Ipswichian age for Terrace No. 3 was established on the basis of the presence of *Hippopotamus* and the deposits of Terrace No. 4 were consequently assigned to the Last Glacial (Tomlinson ibid; Shotton 1968).

However, recent reappraisal of the Avon terrace stratigraphy has demonstrated unequivocally that the higher Terrace No. 4 deposits are not underlain by Terrace No. 3 sediments as envisaged by Tomlinson (Bridgland et al.1989). This is supported by important differences in the molluscan faunas from the two terraces. Terrace No. 4 deposits at Ailstone, Warwickshire (SP 211 513), are characterised by the presence of *Corbicula fluminalis* and absence of *Belgrandia marginata*, whereas in Terrace No. 3
deposits at Eckington (SO 919 417) and the New Inn cutting at Cropthorne (SO 997 443), (both in Worcestershire), the reverse is true (Bridgland et al. ibid). The revised stratigraphic model presented by these authors interprets Terraces No. 3 and 4 as entirely separate aggradations, with the higher deposits being the older of the two. An important stratigraphical argument in favour of this re-interpretation is that the Ailstone site appears to contain temperate-episode sediments, which are overlain by cold stage deposits (the Ailstone Member), the latter forming the main Terrace No. 4 aggradation (Bridgland et al. ibid). It is these cold-climate gravels that are exposed at Twyning and which are the source of the mammalian remains considered here, but unlike Ailstone, no underlying temperate deposits have been recorded.

The cold stage gravels present at Twyning and Ailstone in Terrace No. 4 clearly separate the temperate interval represented at Ailstone from the Ipswichian Interglacial, which is represented by sediments beneath Terrace No. 3. Correlation of the *Hippopotamus*-rich deposits of Terrace No. 3 with Substage 5e suggests that the interglacial represented at Ailstone should be correlated with the post-Hoxnian, pre-Ipswichian interglacial indicated by Stage 7 in the oxygen isotope record. This correlation has received support from amino acid ratios, which are consistent with a Stage 7 attribution, and from molluscan biostratigraphy, which suggests similarity between the molluscs from Ailstone and those from Stanton Harcourt (6.11) and Stoke Goldington (6.16) (Bridgland et al. 1989). A Stage 6 age for the intervening cold-climate gravels at Twyning is therefore inferred.

7.8.4. Palaeontology

The following mammalian species list has been compiled from material in the Natural History Museum, London, collected by Mr P.F. Whitehead. The presence of five species was confirmed, although many specimens listed in the Whitehead catalogue were not able to be located and an important record of *Rangifer tarandus* (listed in Whitehead 1989a) could not be confirmed. The species list must therefore be regarded as potentially incomplete and for that reason, no figures of total species numbers or minimum numbers of individuals are given.
Species List (Mammalia) from Twyning (Terrace no.4), Gloucestershire

**Proboscidea**
*Mammuthus primigenius* (Blumenbach), woolly mammoth

**Perissodactyla**
*Equus ferus* Boddaert, horse
*Coelodonta antiquitatis* (Blumenbach), woolly rhinoceros

**Artiodactyla**
Cervidae cf. *Cervus elaphus* L., red deer
Bovidae sp., indet. large bovid (*Bos* or *Bison*)

7.8.5. **Palaeoenvironmental and palaeoclimatic interpretation**

The mammalian assemblage from Terrace No. 4 at Twyning is composed of species characteristic of open environments. No indication of climate is apparent, since all taxa listed are known from both cold and temperate episodes in the Pleistocene. However, the lithology of the deposits and the presence of syndepositional ice-wedge casts strongly suggests that the climate was cold. However, the presence of *Pisidium vincentianum* (now a Mediterranean and near-Eastern species) in the lower part of the gravel and of *Corbicula fluminalis*, apparently *in situ* in the upper part of the gravel, would suggest a temperate climate, although this is difficult to reconcile with the occurrence of periglacial phenomena. However, as already observed at Crayford (6.18) and Balderton (7.6), it is possible that much more continental conditions prevailed in the past, with summers warm enough to support a thermophilous species such as *C. fluminalis*.

7.8.6. **Biostratigraphy and correlation**

The mammalian assemblage from Terrace No.4 at Twyning contains no species of biostratigraphic significance. No complete molars of *M. primigenius* were seen in the Whitehead collection, so it is not known whether these represent an advanced form or otherwise. It is unfortunate that the record of *R. tarandus* (Whitehead 1989a) could not be verified as the presence of this species in a post-Anglian, pre-Ipswichian context might have been a useful indicator in demonstrating age-equivalence with the Balderton
Sand and Gravel, the only other deposit of this age from which this species is recorded (7.6).

**7.8.7. Discussion and conclusions**

The age of the Twyning Terrace No.4 gravels has been established primarily on the basis of its stratigraphic relationships with other terrace deposits in the Avon valley. The gravels can be demonstrated to post-date the temperate-climate Stage 7 deposits at Ailstone, but to pre-date the Ipswichian deposits of Terrace No.3 (Bridgland *et al.* 1989). A Stage 6 age for the main cold-climate aggradation of Terrace No.4 is therefore postulated. The mammalian evidence is not inconsistent with this correlation, although it can contribute little to a positive affirmation of a Stage 6 age. *M. primigenius* of fully-advanced morphology is known from other localities attributed to Stage 6 in the present study, including the cold-climate deposits overlying the Lower Channel at Marsworth (7.4), the Stanton Harcourt Gravel (7.5), the Balderton Sand and Gravel (7.6) and the Coombe Rock deposits overlying the Brighton raised beach (7.7). All of these can confidently be shown to post-date the Stage 7 interglacial. *E. ferus* is also known from all of the above sites, although from the limited amount of material available to the author, it was not possible to determine whether the Twyning terrace No.4 horse was of the large or small-bodied variety.

In the oxygen isotope curve, Stage 6 appears to have been a particularly severe cold episode and the similarity of the above deposits in showing clear evidence of periglacial activity is perhaps therefore noteworthy. The presence of *Corbicula fluminalis* in the upper part of the Twyning No.4 aggradation is also important, since it suggests that the mammaliferous deposits below pre-date the Ipswichian (Keen 1990). A final piece of evidence is the occurrence of Levallois cores in the Twyning deposits. Comparison with the long fluvial sequence of the Lower Thames suggest an age for the deposits between Stage 8 (when this industry first appears in Britain) and Stage 6 (when it disappears) (Bridgland 1994).

In summary, the stratigraphic evidence provides the clearest indication of the age of the Twyning Terrace No.4 deposits, since they can be demonstrated to post-date temperate-climate deposits of the Ailstone Member attributed to Stage 7, but to pre-date the Last
Interglacial deposits in Avon Terrace No.3. Correlation of the main aggradation of the No.4 Terrace with Stage 6 is therefore proposed, a position which is consistent with evidence of periglacial conditions within the deposits. The presence of *M. primigenius*, *E. ferus*, *C. antiquitatis*, cf. *C. elaphus* and large bovids in the British Stage 6 fauna is therefore suggested.
7.9. **Summary of evidence from the “Stage 6 cold episode”**

The Stage 6 cold episode was of relatively long duration, compared to Stages 10 and 8, and the mammalian evidence from the various localities therefore reflects sites of differing ages within this period. However, two species of potential biostratigraphic significance have nevertheless been identified: a large form of *Microtus oeconomus* and a small-bodied *Equus ferus*. Other species that are consistently encountered include a fully-evolved form of *Mammuthus primigenius* and *Coelodonta antiquitatis*, although temperate components, such as *Stephanorhinus hemitoechus* and *Palaeoloxodon antiquus* have also been noted, again reflecting the range of climatic episodes represented by the Stage 6 fauna. The Stage 6 cold episode also marks the first occurrence of *Rangifer tarandus* since the Anglian.
CHAPTER 8. DISCUSSION OF RESULTS AND CONCLUSIONS

In the study presented above, it has been demonstrated that biostratigraphic evidence from fossil mammals is an appropriate tool for establishing the number and nature of the different climatic episodes in the British late Middle Pleistocene. The results suggest that there were four complete climatic cycles between the Anglian and the Holocene, their temperate phases corresponding to Stages 11, 9, 7 and 5 of the oxygen isotope record and each with its own distinctive mammalian suite. Previous biostratigraphic models based on mammals (Sutcliffe 1976; Currant 1986) and molluscs (Allen 1977) acknowledged a greater degree of climatic complexity than had been allowed for in the stratigraphic scheme of Mitchell et al. (1973), but still only recognised three post-Anglian interglacials. The present findings are in complete support of a model put forward on the basis of terrace stratigraphy by Bridgland (1994) and in partial support of the aminostratigraphic scheme of Bowen et al. (1989). In addition, it has also been possible to identify subdivisions within these temperate stages. There is good evidence for believing that these represent smaller-scale climatic fluctuations within an interglacial; for example, the five warm-cold oscillations in Stage 11 and the three in Stage 7, all of which have previously been recognised as Substages 11e-a and 7c-a.

In recent years, long fluvial sequences in Britain have been successfully related to the oxygen isotope record, thereby providing a detailed archive of climatic change through the Pleistocene. The Thames valley was selected as a framework for the relative dating of the various climatic fluctuations of the late Middle Pleistocene, since it is claimed to have the most reliably-dated long terrestrial sequence in Britain (Bridgland 1994). The Bridgland model is, however, controversial and is challenged by Gibbard (1994, 1995a). It was therefore decided to adopt the Bridgland model as a testable hypothesis, against which the mammalian evidence could be compared. For each temperate episode represented in the Thames sequence, a 'type assemblage' was identified from a sound stratigraphic context at a given locality. In contrast, the mammalian faunas from cold-climate episodes are relatively sparse and consequently much less well-known than those from temperate stages. Information on these faunas was therefore assembled from cold-climate deposits either pre- or post-dating interglacial deposits of established age, either in the Thames valley or elsewhere.
A major objective in the present study was to establish whether the mammalian evidence supports the controversial aminostratigraphic attribution of the Hoxnian Interglacial to Stage 9 by Bowen et al. (1989). The same study placed other sites formerly also regarded as Hoxnian in age, such as Swanscombe (4.2) and Clacton (4.4), in the immediately preceding interglacial, Stage 11, a correlation which is in agreement with the topographical position of these sites within the Lower Thames terrace sequence (Bridgland 1994). The division of the Hoxnian group of sites into two separate interglacials has raised evident problems with regard to nomenclature, for if the interglacial at Hoxne is no longer immediately post-Anglian in age, then the deposits at Swanscombe and Clacton must consequently relate to an unnamed interglacial.

Examination of the mammalian assemblages from both Hoxne (4.1) and Swanscombe in the present study has demonstrated beyond reasonable doubt that the faunas from these two localities are contemporary, on the basis of highly significant presences and absences and other biostratigraphic information, such as size change and particular stages of morphological evolution. The Hoxnian mammal fauna is differentiated from that of the immediately pre-Anglian early Middle Pleistocene on the basis of several important characters, beginning with a marked decrease in the diversity of the small mammal assemblage with the disappearance of the shrews Sorex (Drepanosorex) savini and Sorex runtonensis, as well as the vole Pliomys episcopalis. Large mammals of the late Cromerian Complex, such as Megaloceros verticornis are also absent. At Swanscombe, the earlier Middle Pleistocene cave bear Ursus deningeri is replaced by the more advanced form Ursus spelaeus.

The Hoxnian Interglacial also witnesses the first appearance in Britain of four species that are not found in the preceding Cromerian Complex: field vole (Microtus agrestis), narrow-nosed rhinoceros (Stephanorhinus hemitoechus), giant deer (Megaloceros giganteus) and aurochs (Bos primigenius). Swanscombe also records the first occurrence in Britain of Merck's rhinoceros (Stephanorhinus hemitoechus), the extinct 'ass' (Equus hydruntinus) and a large form of fallow deer, identifiable as Dama dama clactoniana. Other biostratigraphically significant elements of the Hoxnian fauna include the small mole Talpa minor, the giant beaver Trogonthierium cuvieri and the European pine vole Microtus (Terricola) subterraneus. The Hoxnian water vole is referrable to the primitive morphotype Arvicola terrestris cantiana, with the enamel of
the trailing (convex) edges being markedly thicker than that of the leading (concave) edges of the molars. Specimens retaining the ancestral Mimomys fold, a primitive feature which is present at low frequency in stratigraphically early populations of Arvicola, have also been noted. A large form of Russian desman (Desmana moschata), rabbit (Oryctolagus cuniculus) and Norway lemming (Lemmus lemmus), together with macaque monkey (Macaca sylvanus), lion (Panthera leo), a small wolf (Canis lupus) and a small form of red deer (Cervus elaphus) are also consistently encountered. The complete Hoxnian faunal list is shown in Table 8.1. Important absences from the Hoxnian fauna are the spotted hyaena (Crocuta crocuta) and the hippopotamus (Hippopotamus amphibius).

Having established contemporaneity of the Hoxne and Swanscombe sequences, the question of dating these deposits was then addressed. The interglacial sediments at Hoxne directly overlie Anglian Lowestoft Till, an important stratigraphic marker which provides a terminus ante quem for the temperate stage deposits. Although the superposition of the Hoxnian lake beds above the till cannot in itself demonstrate an immediately post-Anglian age for the interglacial deposits, both the lithostratigraphic and palynological records at the site suggest an unbroken transition from the end of the Anglian to the Hoxnian. This would therefore support the view that Hoxne represents the first of the four post-Anglian temperate episodes that are implicated in the oxygen isotope record, i.e. Stage 11, if the correlation of the Anglian with Stage 12 is correct, and would consequently cast considerable doubt on the validity of the amino acid ratios that suggest a Stage 9 age.

However, when considering the stratigraphic position of Swanscombe (with which the Hoxne interglacial deposits and their contained mammal assemblage have been correlated) an immediately post-Anglian context for the Hoxnian Interglacial can be established.

The Swanscombe temperate-climate deposits are part of the Orsett Heath Gravel Formation, the highest (and therefore the oldest) terrace of the Lower Thames (Chapter 2; 4.2). The Lower Thames sequence is in its entirety Anglian and post-Anglian in age, since the river was only diverted into this part of the valley through London by the Anglian glaciation. At Hornchurch, these deposits directly overlie Anglian till (see
Four post-Anglian interglacials are indicated in the oxygen isotope record and since Swanscombe is the earliest of the latter, it must \textit{ipso facto} be correlated with Stage 11. Correlation of the Hoxnian Interglacial with Stage 11 is also therefore established. Using information from the biostratigraphically diagnostic mammalian fauna established at Hoxne and Swanscombe, other sites of Hoxnian age could be identified in the same terrace as Swanscombe, at Ingress Vale (4.3) and Clacton (4.4). The accumulated evidence from these four sites in turn permitted the identification of other sites of Hoxnian age outside the Thames valley, at Barnham (4.5), Beeches Pit (4.6), Copford (4.7), Hitchin (4.8) and Woodston (4.9).

Attribution of these faunas to the Hoxnian Interglacial depends upon a post-Anglian age for the sites being unequivocally established on lithostratigraphic grounds and on the presence of one or more of the following biostratigraphically significant Stage 11 indicators: \textit{Talpa minor}, \textit{Oryctolagus cuniculus}, \textit{Trogontherium cuvieri}, \textit{Microtus (Terricola) subterraneus}, \textit{Ursus spelaeus} or \textit{Dama dama clactoniana}. All of these species (with the exception of \textit{U. spelaeus} and \textit{D. d. clactoniana}) are present in the preceding Cromerian Complex and should therefore not be taken in isolation as Hoxnian indicators. However, in combination, they form a coherent and distinctive group that can be consistently observed in a range of depositional environments and in a relatively widespread geographical area. None of these species has been recovered from British Pleistocene deposits any later than the Hoxnian, although \textit{O. cuniculus} and \textit{M. (T.) subterraneus} are still extant. The recognition of a diagnostic Hoxnian mammal fauna has therefore proved invaluable in demonstrating the age of sites outside long fluvial sequences, in particular those which lie immediately on top of Anglian till, but which otherwise have no chronostratigraphic control. The evidence from mammalian biostratigraphy is further reinforced by molluscan biostratigraphy at some sites, for example, the presence of the distinctive ‘Rhenish’ fauna at Swanscombe (4.2), Ingress Vale (4.3) and Clacton (4.4), and the presence of the ‘\textit{Lyrodiscus’ (\textit{Retinella}) fauna at Beeches Pit (4.6) and Hitchin (4.8).

In addition to recognition of a distinctive Hoxnian mammal fauna and the attribution of this fauna to Stage 11 of the oxygen isotope record, attempts to further refine the dating of these Hoxnian localities were also made in the present study. At Swanscombe (4.2), a complex sequence of five climatic oscillations has been identified, including three
separate temperate peaks, separated by cooler troughs. This sequence of small-scale fluctuations has not, however, been recognised in the palynological record at any Hoxnian site, since by definition, an interglacial period allows only for unimodal development of the floral sequence (Turner and West 1968). In contrast, the mammalian fossil record is able to monitor these short-term changes and deposits representing two of the temperate peaks at Swanscombe contain mammalian material that can be used to demonstrate this.

The present study is thus the first to identify mammalian assemblages corresponding to isotopic substages. During the Hoxnian Interglacial, it can further be demonstrated that the first two temperate peaks are quite different in terms of their palaeoenvironment. At Swanscombe, the Lower Gravel and Lower Loam (Phase I) are considered to represent the first warm peak of Stage 11, Substage 11c. The large body of mammalian and other faunal evidence from these units supports the prevalence of fully temperate climatic conditions during this period (as warm as Britain at the present day), with the development of abundant mixed or deciduous woodland and open grassland. The large subspecies of fallow deer, *D. d. clactoniana* is the dominant taxon during this part of the interglacial. The break in deposition at the top of the Lower Loam is thought to reflect a cooling of climate during Substage 11d, which permitted a fluvial link to be established with the Rhine and the immigration of the distinctive ‘Rhenish’ suite of molluscs. This was followed by a return to fully-temperate conditions in the Lower and Upper Middle Gravels (Phase II), suggested as representing the second temperate peak of Stage 11, Substage 11c. However, in contrast to the mammals from the Phase I/Substage 11c deposits, the mammalian remains from Substage 11c suggest that this period was characterised by much more open conditions than witnessed previously, as attested to by the dramatic decrease in woodland indicators, such as *D. dama*, and the increase in large bovids and *E. ferus*. *Lemmus lemmus* also appears in the fauna at this time. A second phase of cold conditions, referred to Substage 11b, is represented by the Upper Sands, while the Upper Loams are considered to record the final temperate peak in Stage 11 (Substage 11a), although no fauna or flora is known from this phase.

Comparison of this evidence with the sequence at Hoxne has revealed similar patterns, suggesting that two temperate substages are also present there, separated by a period of cooler conditions. Strong parallels may be drawn between the Lower Sequence at
Hoxne (Stratum E) and Phase I at Swanscombe, and between the Upper Sequence at Hoxne (Beds 4 (Stratum C) and 5) and Phase II at Swanscombe. As at Swanscombe, the early temperate deposits at Hoxne (characterised by *T. cuvieri*, *P. antiquus* and *C. elaphus* of small body size) are separated from the remainder of the sequence by a depositional hiatus, probably corresponding to a period of climatic cooling, during which sea level fell. A return to fully temperate conditions is indicated by Bed 4/Stratum C and Bed 5 of the Hoxne Upper Sequence, although as at Swanscombe, the inferred environment is considerably more open than at the time of deposition of the Lower Sequence. *E. ferus* becomes increasingly important at this time and *L. lemmus* is also present. The hypothesis of Wymer (1985) that the Hoxne sequence contains deposits of Stage II in the Lower Sequence and Stage 9 age in the Upper Sequence was rejected on the basis that three of the established Stage II ‘indicator species’, *T. minor*, *T. cuvieri* and *M. (T.) subterraneus*, are present in Bed 4 of the Upper Sequence.

The likelihood of there being two temperate phases represented at Clacton is also suggested, although amalgamation of the fauna from the various beds has made observations of faunal change within the sequence difficult. However, in terms of species composition, the assemblage reportedly from the Lower Freshwater Beds most closely resembles that from Phase I at Swanscombe, attributed to Substage 11e in the present study. It is consequently possible that the minor depositional break apparent at the top of the Freshwater Beds at Clacton corresponds with the depositional hiatus at the top of the Swanscombe Lower Loam (Substage 11d). A lowering of sea level during this period would have allowed the immigration of the ‘Rhenish’ suite of molluscs, which first appear at the top of the Freshwater Beds and in the overlying Estuarine Beds. Mammalian remains from the Estuarine Beds at Clacton might thus be expected to resemble those from Phase II at Swanscombe (Substage 11c), although unfortunately the lack of stratigraphic data on the specimens makes this impossible to verify.

Sites with mammalian assemblages of Hoxnian age are shown in Table 8.1. All localities can be unequivocally demonstrated as post-Anglian in age and all contain at least one of the established Stage II indicator species. In the case of Swanscombe and Hoxne, the mammalian assemblage has been subdivided into two groups, each one considered to correspond to an isotopic substage.
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Table 8.1 The Hoxnian (Stage 11) mammal fauna.
Asterisks denote the confirmed occurrence of a particular species. Bracketed asterisks indicate that specimens of this genus have been found, although specific determination was not possible. Where undetermined large bovids have been recorded, both *Bos* and *Bison* are indicated with a bracket. Where *Microtus agrestis* *Microtus arvalis* has been identified, both species are indicated with bracket. The presence of early hominids is confirmed on the basis of skeletal remains when present, butchery marks on bones or contemporaneous (*i.e.* *in situ* or at least not obviously derived) artefacts.

Refutation of a Stage 9 age for the Hoxnian Interglacial enabled the presence of the genuine Stage 9 interglacial fauna to be identified for the first time in the British Isles. The Stage 9 interglacial is a newly-recognised temperate episode, which is considered to be the second of the four post-Anglian temperate episodes implied in the oxygen isotope record. The model for terrace succession in the Lower Thames valley proposed by Bridgland (1994) recognises interglacial sediments of putative Stage 9 age within the second post-Anglian gravel terrace, the Corbets Tey Gravel Formation, equivalent to the Lynch Hill Gravel Formation of the Middle Thames and the Barling-Dammer Wick Gravel of eastern Essex (Bridgland et al. 1993; Bridgland 1994). According to Bridgland’s model, these Stage 9 interglacial deposits occupy an intermediate topographic position in the Thames terrace ‘staircase’, on the one hand clearly younger than the Hoxnian/Stage 11 interglacial deposits of the Orsett Heath terrace, and on the other ostensibly older than the interglacial deposits present within the Mucking terrace (see Figure 2.8). The difference in the heights of the deposits would consequently imply that they are of different ages and it would therefore be expected that faunal differences should be apparent between mammalian assemblages from the older Hoxnian interglacial and the putative Stage 9 mammalian assemblage, and between Stage 9 and the younger Mucking interglacial. However, the presence of Stage 9 deposits in the Lower Thames is challenged by Gibbard (1994, 1995b), who assigns all of the Corbets Tey interglacial deposits to the Ipswichian Interglacial.

Once again, the mammalian biostratigraphic evidence was used to test the relative merits of each lithostratigraphic scheme. In order to do this, new excavations were undertaken by the author at Purfleet in Essex (5.1), with the specific aim of recovering a mammalian assemblage from a sound stratigraphic context, in order that a full-scale comparison could be made with the Hoxnian mammal fauna. It was anticipated that
excavation of the Purfleet site would provide an excellent opportunity for testing, in a more wide-ranging way, the four-interglacial scheme proposed by Bridgland (1994).

The author's investigations recovered a highly diagnostic suite of mammals from Purfleet, analysis of which confirmed the hypothesis that interglacial deposits are present in the Lower Thames valley that cannot be related to any previously recognised temperate stage, either Stage 11, 7 or Substage 5e. Similar assemblages were also recognised in existing collections from Grays (5.2) and Belhus Park (5.4), and from Thames tributary deposits at Cudmore Grove on Mersea Island (5.3).

The Stage 9 mammalian assemblage is different from that of the preceding Hoxnian Interglacial in a variety of ways. For example, the four Hoxnian small mammal indicator species, *T. minor*, *O. cuniculus*, *T. cuvieri* and *M. (T.) subterraneus* are all absent from the Stage 9 interglacial. Although this constitutes negative evidence, their absence at six sites attributed in the present study to Stage 9 (two of which, Purfleet and Cudmore Grove, have been extensively sieved for small mammal remains), from a combined assemblage of over 3000 specimens, including quantities of small mammal remains of other species, is a strong indication that these species are genuinely absent from the British fauna by this time. Other important changes may be seen in the Castoridae, with the disappearance of *T. cuvieri*, and in the Ursidae, with the disappearance of *U. spelaeus*. The modern European species *Castor fiber* continues to be present in Stage 9, while the cave bear is replaced by the brown bear *Ursus arctos*. The extinct ‘ass’ *E. hydruntinus*, which is known from the preceding Hoxnian Interglacial, has not been recorded, although the general rarity of this species in the British fossil record must be considered. The Stage 9 mammalian assemblage is also differentiated from that of the Hoxnian Interglacial by the presence of the bicoloured white-toothed shrew (*Crocidura cf. leucodon*), which makes its first appearance in the British Isles at this time, by the presence of the spotted hyaena *C. crocuta*, which has never been recovered from any Hoxnian site and by the presence of *Alces sp.*, which equally has never been found in a Hoxnian context, although again, this species is a rare component of the British fossil record.

Unfortunately, no antlers of fallow deer have been recovered from any Stage 9 site and in the absence of these crucial diagnostic elements, the subspecific identity of the Stage
9 Dama dama remains unknown. However, the small size of the Stage 9 postcranial material suggests that it does not belong to the clactoniana subspecies of the Hoxnian Interglacial, but may well be referable to the modern D. d. dama. An increase in body size in the Stage 9 red deer, compared to those from the basal deposits at Hoxne and Swanscombe is also apparent. Other biostratigraphically significant elements of the Stage 9 fauna include the water shrew Neomys browni, a species that is larger than the Neomys newtoni of the Cromerian Complex but smaller than the modern Neomys fodiens, and the water vole Arvicola cantiana terrestris. The water vole remains from Stage 9 localities are of a slightly more advanced morphology than those from Hoxnian sites, although they are still referable to the archaic morphotype, with enamel thicker on the convex sides of the salient angles. Very occasional occurrences of the ancestral Mimomys fold were noted. P. leo is apparently very poorly represented during this interglacial, with only a single specimen from the Cauliflower Pit at Ilford noted. This contrasts markedly with the abundance of other carnivore remains from Stage 9 deposits, in particular U. arctos.

In the light of the Stage 9 mammal fauna established in the Lower Thames valley, assemblages from two further sites, attributed to Stage 9 on the basis of their position within the terrace system of the Avon and the Upper Thames, Pershore (5.5) and Wolvercote (5.6) respectively, were also examined. The assemblages from these latter sites unfortunately did not contain any species of biostratigraphic significance but were not inconsistent with the lithostratigraphic interpretations. They were therefore also included in the Stage 9 group. The complete Stage 9 mammal fauna is given in Table 8.2, with presence/absence shown at selected localities.

The Stage 9 mammal fauna is differentiated from that of the Stage 7 interglacial by the presence of the more primitive morphotype of water vole and M. sylvanus, which is unknown in all later British Pleistocene deposits. The paucity of P. leo in the Stage 9 fauna is also deemed to be a significant feature, since remains of this species have been noted in fifteen of the twenty-six sites attributed in the present study to Stage 7 (see below), often in some abundance. Similarly, the combined presence of C. cf. leucodon, E. ferus, Homo sp. (attested to by artefacts and butchery marks) and S. kirchbergensis clearly differentiates these faunas from those of the Ipwsichian Interglacial (Substage 5e). A pre-Last Interglacial age is also supported by the abundant present at Purfleet of
the bivalve *Corbicula fluminalis*, a species which was apparently absent from the British Isles during the Last Interglacial (Keen 1990; Bridgland 1994; Meijer and Preece 1995). This conclusion is therefore inconsistent with the attribution of Purfleet, Grays and Belhus Park to the Ipswichian by Gibbard (1994, 1995b). Moreover, the findings of the present study oppose the Mar Dyke origin for the Purfleet deposits, suggested by Gibbard (1994, 1995b), and support the Thames origin proposed by Bridgland (1988, 1994). This latter interpretation indicates that at the time of deposition of the Corbets Tey Gravel Formation, the Thames occupied a more sinuous course across the area now drained by the Mar Dyke. The results of the author's excavations at Purfleet have confirmed that the gravels there are of Thames type, corroborated by palaeoecological information from the molluscan remains, which suggest deposition in a large river up to 5m deep (clearly a far more imposing body of water than the Mar Dyke at any stage in its history). Taken in conjunction with terrace stratigraphy and new mammalian biostratigraphic evidence, it is clear that an Ipswichian age for Purfleet can no longer be substantiated.

TheStage 9 mammal fauna is differentiated from that of both the Hoxnian and Stage 7 interglacials in terms of its palaeoecology. The most distinctive aspect of the Stage 9 fauna is the presence of a very diverse group of woodland species, including *E. serotinus, M. sylvanus, S. sciurus, C. fiber, C. glareolus, A. sylvaticus, U. arctos, P. antiquus, S. scrofa, D. dama, A. cf. alces* and *C. capreolus*. These clearly outnumber species requiring more open environments, such as *E. ferus, M. giganteus* and *B. primigenius*. Fully temperate conditions are indicated by the presence of *Crocidura* sp., *D. dama* and *P. antiquus*, with a climate possibly slightly warmer than today, based on the more southerly distribution of *Crocidura* at the present day.

The recognition of a diagnostic Stage 9 mammal fauna is considered here to be a very real step forward in the understanding of the British Quaternary succession, since no other biostratigraphic scheme has previously been able to differentiate between Stages 11 and 9. Separation of the ‘Hoxnian’ group of sites into two distinct interglacials in the present study has confirmed the presence of *Abies* (silver fir), the unidentified palynomorph ‘Type X’ and the water fern *Azolla filiculoides* in both episodes. In terms
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<td><em>C. cf. leucodon</em></td>
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<td><em>Homo sp.</em></td>
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<td><em>U. arctos</em></td>
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<td><em>S hemitoechus</em></td>
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<td><em>S. kirchbergensis</em></td>
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<td><em>D. dama ssp. indet.</em></td>
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<td><em>A alces</em></td>
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<td><em>C. capreolus</em></td>
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<td><em>B primigenius</em></td>
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<td><em>B cf. pricus</em></td>
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1 Presence inferred on the basis of a coprolite.

Table 8.2 The Stage 9 mammal fauna.
of their palynology, Stages 11 and 9 therefore appear to have similar characteristics and
doubt must be consequently be cast on the use of the three aforementioned taxa as
‘Hoxnian’ indicators. However, their presence is still considered to be useful in
demonstrating a pre-Stage 7 age in the post-Anglian Middle Pleistocene. This situation
is paralleled in mainland Europe, where *Abies*, ‘Type X’ and *A. filiculoides* are also
known from more than one post-Elsterian interglacial (Urban *et al.* 1991; de Jong 1991).
Other relative dating methods, such as aminostratigraphy have produced inconsistent
and widely-differing results on this group of sites. It is therefore concluded that the
mammalian biostratigraphic evidence established in the present study provides an
important step in separating the Hoxnian Interglacial from Stage 9.

The third post-Anglian interglacial, correlated with Stage 7 of the oxygen isotope
record, was also examined in detail during the present study. Debate concerning the
validity of a separate Stage 7 interglacial originally centred on three localities in the
Thames valley, Aveley (6.1), Ilford (6.2) and Trafalgar Square. Not only are the
temperate-climate deposits at Aveley and Ilford situated at a higher terrace level than
Trafalgar Square, they also yielded different mammalian assemblages that, according to
Sutcliffe (1975), were impossible to reconcile with the view that all three sites should be
placed within the Ipswichian. While the mammalian assemblage from Trafalgar Square
is characterised by an assemblage including *Hippopotamus amphibius, Palaeoloxodon
antiquus, Dama dama* and *Stephanorhinus hemitoechus*, the Aveley and Ilford
assemblages are dominated by a primitive form of *Mammuthus primigenius* and *Equus
ferus.* *Stephanorhinus kirchbergensis* (found in the preceding Hoxnian interglacial) is
also present at Ilford, whereas *Hippopotamus* is apparently absent. These assemblages
are differentiated from those of the preceding Stage 9 interglacial in the absence of *M.
sylvanu*s and the presence of a more advanced morphotype of *Arvicola* (see below).

The differences in the mammalian assemblages make it unlikely that all these deposits
could be contemporaneous and it was therefore suggested that they must either represent
different parts of the same interglacial, or two different interglacials (Sutcliffe 1964,
1976; Sutcliffe and Kowalski 1976). The palynological succession would oblige the
mammoth-horse fauna of zones Ip III - Ip IV to be later in time than the hippopotamus
fauna of zone IIb - beginning of zone III; but in reality, a mammalian assemblage of
Aveley/Ilford type has never been found to overlie a hippopotamus assemblage in any Pleistocene deposit (Stringer et al. 1986).

The combined evidence from mammalian biostratigraphy and differences in the heights of the interglacial deposits led Sutcliffe to conclude that the Trafalgar Square deposits were laid down during the Ipswichian Interglacial but that the Aveley and Ilford deposits accumulated during an earlier, post-Hoxnian, pre-Ipswichian temperate interval, now correlated with Stage 7 of the oxygen isotope record. This has been upheld in recent years by the model of terrace succession in the Lower Thames of Bridgland (1994), although dating of these deposits continues to be a matter of controversy and the hypothesis of a single, complex Ipswichian Stage is still favoured by certain workers, such as Gibbard (1994, 1995b). However, despite the increasing recognition of a separate Stage 7 interglacial, the details of mammalian succession within this interglacial remain relatively poorly known. Twenty-six sites were examined in an attempt to define more precisely the nature of the Stage 7 interglacial and to identify the species of biostratigraphic significance.

For the purposes of the present study, the Lower Thames valley was again employed as a base model for investigating and correlating deposits of putative Stage 7 age and further fieldwork was undertaken by the author at Aveley, resulting in the collection of an important new mammalian assemblage.

The mammalian biostratigraphic evidence from Aveley thoroughly supports the recognition of a separate Stage 7 interglacial in the Lower Thames valley. Corroborative evidence has come from aminostratigraphy, with sites of Stage 7 age consistently producing higher ratios than sites of Last Interglacial age (Bowen et al. 1989). Several factors make the Aveley assemblage difficult to reconcile with an Ipswichian age, namely the absence of *Hippopotamus* and especially the presence of *E. ferus* and *Crocidura* in deposits attributed to zone Ip IIb. The presence of *Hippopotamus* in Ip IIb deposits is considered to be diagnostic of that part of the Ipswichian Interglacial, as is the absence of *Equus*, according to Stuart (1976). To find these occurrences inverted is incompatible with an Ipswichian age. The presence of *M. primigenus* in a fully interglacial context also argues against an Ipswichian age for the Aveley deposits.
The fact that an assemblage of Aveley type has never been found to overlie a *Hippopotamus* assemblage becomes immediately understandable if it is accepted that the deposits at Aveley are actually older than that at Trafalgar Square, and indeed, the relative positions of the two sites in the Thames sequence bears testimony to this. The need to invoke complicated tectonic movements, massive rises in sea level or the action of tributary rivers to explain the differences in height between these sites also becomes unnecessary if the existence of a separate earlier interglacial is acknowledged. The dangers of continued reliance on correlations based upon palynological evidence are particularly well illustrated here, since the Aveley Silts and Sands Member of Gibbard (1994, 1995b) includes deposits that occur at a variety of altitudes and in what are interpreted here as three separate terraces, but which the pollen biostratigraphy places in a single Ipswichian stage. Thus, Aveley is correlated with sites as widely separated in time as Purfleet (5.1) and Trafalgar Square, an interpretation which is inconsistent with every other line of evidence, including the mammalian biostratigraphic model established in the present study.

However, in addition to differentiation of the Stage 7 mammal fauna from that of the Ipswichian, further interesting patterns were noted in assemblages attributed to this age.

The findings of the present study indicate that the mammal fauna from the Stage 7 interglacial may be divided into two discrete groups, considered to correspond to the earlier part of the interglacial and the later part of the interglacial respectively (Substages 7c and 7a). Examination of the oxygen isotope curve reveals that Stage 7 contains three major climatic oscillations, consisting of two temperate peaks (Substages 7c and 7a), separated by a short period of colder conditions (Substage 7b). This is the first time that the mammalian remains from the Stage 7 interglacial have been interpreted in a way other than as part of a single temperate episode. The occurrence of two substages is difficult to reconcile with the single climatically-unimodal interglacial proposed by the pollen record because both assemblages (although different in their ecology) are apparently equally temperate in character. Aveley was selected as the type locality on account of the apparent presence of both temperate substages.

The earlier of the two temperate episodes is characterised by a predominance of woodland indicators. Important diagnostic features of this period include the presence
of the greater white-toothed shrew, *Crocidura cf. russula*, in association with *P. antiquus* and *D. dama*. This interglacial also marks the first known occurrence in Britain of the extinct clawless otter *Cynnaonyx antiqua*. The wide range of temperate woodland indicators that characterises this part of the Stage 7 interglacial includes *E. europaeus, S. araneus, S. minutus, B. barbastellus, S. vulgaris, A. sylvaticus* and *M. meles*. Water vole remains from this period are significantly larger and of a more advanced morphology than those of the Stage 9 interglacial. They display no visible signs of enamel differentiation and the primitive ancestral *Mimomys* fold is absent. *E. ferus, C. elaphus, B. primigenius* and *B. priscus* are also present but *M. primigenius* is apparently absent. Assemblages assigned to this early part of the Stage 7 interglacial, tentatively correlated with Substage 7c, include the Bed 2 ‘Lower Elephant’ deposits at Aveley, the detrital muds (Bed D) at Itteringham, Stone Point and the Otter Stratum in Tomewton Cave.

A break in deposition, suggested by preliminary evidence of the development of a soil at the top of Bed 2 at Aveley and an erosional phase at the top of Bed d at Itteringham, is considered to represent a period of cooler conditions (Substage 7b?).

A return to fully-temperate conditions is indicated by Substage 7a. In contrast to the woodland assemblages of the early part of the Stage 7 interglacial, the mammal fauna of the later temperate peak is characterised by a predominance of open grassland species. Important characteristics of this period include the co-occurrence of *M. primigenius* with *P. antiquus* and *E. ferus*. The Stage 7 *M. primigenius* is represented frequently (but not exclusively) by the ‘Ilford type’ mammoth, a primitive form characterised by a combination of small size and low plate count in the molars. The percentage of molars attributed to the ‘Ilford type’ is 100% at some localities. The presence of this form is considered here to be of particular biostratigraphic significance in demonstrating a Stage 7 age, although the presence of *M. primigenius* in a fully temperate context is in itself a diagnostic feature of the Stage 7 interglacial. The small mammal fauna from the later part of the Stage 7 interglacial is characterised by a large form of *M. oeconomus* and an advanced morphotype of *A. t. cantiana* with undifferentiated enamel. *L. lemmus* is also present, with *O. pusilla, C. citellus, C. cricetus* and *D. torquatus* making their first appearance since the Cromerian Complex, and the first potential records in Britain of *A. bursae* and *M. gregalis*. 
In addition, other large grazing or part-grazing herbivores, including *S. hemitoechus*, *C. elaphus*, *B. primigenius* and *B. priscus*, are consistently present. Remains of *S. kirchbergensis*, *C. antiquitatis* are also *M. giganteus* frequently encountered. The predominance of open grassland conditions at this time is shown particularly clearly in the elephant and rhinoceros assemblages, with the grassland indicators *M. primigenius*, *S. hemitoechus* and *C. antiquitatis* outnumbering *P. antiquus* and *S. kirchbergensis*. The Carnivora are represented by a large form of *P. leo*, which was apparently the most abundant predator at this time, with *C. lupus* and *U. arctos* also important, the latter presenting spelaeoid features in its dentition in certain cases. In addition, smaller numbers of *C. crocuta* are consistently recorded and *P. pardus* is present in upland cave sites. The Stage 7 interglacial also marks the only known occurrence of *F. chaus* in Britain, although the biostratigraphic significance of this species cannot be established on the basis of a single individual. Assemblages attributed to the later temperate episode in Stage 7 include those from the upper part of the sequence at Aveley, Ilford (Uphall Pit), Itteringham Bed dm, West Thurrock, Northfleet, Brndon, Stoke Tunnel, Stutton, Harkstead, the Lower Channel at Marsworth, the Stanton Harcourt Channel Deposits, Lexden, Selsey, West Wittering, Bielsbeck, Stoke Goldington, Upper Strensham, Crayford, Great Yeldham, Sible Hedingham, Bleadon Cave, Hutton Cave, Oreston, Pontnewydd Cave and Hindlow Cave. The complete Stage 7 mammal fauna is shown in Table 8.3, with presences and absences indicated at the various localities.

The findings of this study provide an interesting synthesis of the previous mammalian biostratigraphic models of Sutcliffe (1976) and Stuart (1976). Although Sutcliffe’s view of Thames stratigraphy has ultimately proved correct, the discovery of differences of substage level, adheres closely to Stuart’s concept of faunas changing within a stage to reflect changing environmental conditions.

The changes witnessed in the composition of the mammalian fauna between the earlier and the later part of the Stage 7 interglacial lend support to the idea of an intervening cooler episode. This would have permitted a lowering of sea level, thereby allowing the immigration of species, such as *C. citellus*, *D. torquatus*, *L. lemmus*, *M. primigenius*, *C. antiquitatis* and *O. moschatus* in the second half of the interglacial. Without this mechanism, it is difficult to see how these species could have appeared in the British fauna at this time. The aforementioned species would generally be viewed as indicative
of cold-climate conditions, but all occur in temperate contexts in the second part of the Stage 7 interglacial, for example the occurrence of *O. moschatus* in the *Corbicula* Bed at Crayford. Their presence in Britain at this time is interpreted here as a response to the development of more continental climatic conditions and the availability of temperate steppe-like grassland.

Examination of Table 8.3 reveals that there are only four assemblages that can be attributed to the early part of the Stage 7 interglacial and twenty-five that can be confidently assigned to the later part. This difference may be the result of taphonomic factors relating to the mode of deposition of these assemblages. Examination of a range of pollen-dated sites attributed to the Last Interglacial indicates that the majority of them were deposited in zone Ip II. These are the ‘classic’ *Hippopotamus* assemblages of the Ipswichian, correlated with Substage 5e. Comparatively few sites have been found that contain assemblages that can be confidently dated by any method (pollen included) to other parts of the Last Interglacial. A possible explanation for this is that the *Hippopotamus* assemblages are the result of rapid (perhaps even catastrophic) depositional events, occurring in a relatively short space of time, or even one major event. A similar situation may be apparent in the Stage 7 interglacial, with the major phase of deposition occurring towards the end of this temperate episode. The assemblages from all of the fluvial sites examined in the present study show a remarkable degree of consistency, in terms of species composition and relative abundance. It is therefore possible that they were all deposited within a relatively short time of each other, as a result of perhaps a single depositional event, affecting a wide area, probably climatically-driven. Possible indications of a catastrophic depositional episode, perhaps a major flood, have come from the Channel Deposits at Stanton Harcourt, where partial carcasses of *M. primigenius* are found in association with tree trunks.

A comparison of the mammalian faunas of the interglacials of the British late Middle Pleistocene is shown in Table 8.4, indicating the presence and absence of selected species of biostratigraphic significance.
Insectivora
E. europaeus
S. araneus
S. minutus
N. fodiens
C. cf. russula
Chiroptera
B. barbastellus
Primates
Homo sp.
Lagomorpha
O. puilla
Lepus sp./Leporidae
Rodentia
S. scirurus
C. citellus
C. crimctus
A. bursae
C. fiber
D. torquatus
L. lemmus
C. glareolus
A. t. cantiana
M. agrestis
M. arvalis
M. gregalis
M. oeconomus
A. sylvaticus
A. australis
A. australis
(Crass) 

Carnivora
C. lupus
V. vulpes
U. arctos
M. nivalis
M. putorius
M. meles
C. antiqua
C. crocuta
F. chaus
F. sylvestris
P. leo
P. pardus
Proboscidea
P. antiquus
M. primigenius
Perissodactyla
E. ferus
E. hydruntinus
S. hemitoechus
S. kirchbergensis
C. antiquatus
Artiodactyla
S. scrofa
M. giganteus
D. doma ssp. indet.
C. elaphus
C. capreolus
B. primigenius
B. cf. priscus

Table 8.3 The Stage 7 mammal fauna

1 presence inferred on the basis of a coprolite
2 presence inferred on the basis of gnawmarks
Table 8.4 Comparison of the Stage 11 (Hoxnian), Stage 9 and Stage 7 interglacials, showing presence and absence of biostratigraphically significant species.

<table>
<thead>
<tr>
<th>Mammal Order</th>
<th>Substage 11e</th>
<th>Substage 11c</th>
<th>Stage 9</th>
<th>Substage 7c</th>
<th>Substage 7a</th>
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<td><em>C. cf. russula</em></td>
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<td><em>D. moschata</em></td>
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<td><em>T. minor</em></td>
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<td>Primates</td>
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<td><em>M. sylvanus</em></td>
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<td>Lagomorpha</td>
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<td><em>O. pusilla</em></td>
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<td><em>O. cuniculus</em></td>
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<td>Rodentia</td>
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<td><em>C. citellus</em></td>
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<td><em>C. fiber</em></td>
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<td><em>D. torquatus</em></td>
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<td><em>B. cf. priscus</em></td>
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1 Primitive morphotype (enamel thicker on convex sides of the salient angles, *Mimomys* fold present)
2 Advanced morphotype (undifferentiated enamel, *Mimomys* fold absent)
3 Identified on the basis of a single specimen out of 3000
4 Identified at Barnham in undifferentiated Stage 11 deposits.
Attempts were also made in the present study to assess the nature of the mammalian fauna during the periods of cold-climate conditions in the late Middle Pleistocene, although this was considerably more difficult than for the interglacial episodes, on account of the paucity of sites and the lack of well-provenanced, well-dated material. Many of the cold periods in the Middle Pleistocene were of long duration. Evidence from sites of putative Anglian (Stage 12) age was considered first, following the review of mammaliferous sites attributed to the Anglian by Lister (1989). The Homersfield Terrace in the Waveney valley has been cited in the past as providing evidence of an Anglian mammal fauna (Stuart 1982; Lister 1989), with *M. primigenius*, *C. antiquitatis*, *M. giganteus* and *Bos primigenius* listed by Funnell (1955) and additional remains of *E. feras* and *Rangifer tarandus* recorded by Stuart (1982). As noted by Lister (1989), the presence of *C. antiquitatis*, *M. giganteus* and an apparently fully-evolved morphotype of *M. primigenius* in deposits of Anglian age would represent the first known occurrence of these species in Europe, none of them being otherwise known before the Hoxnian/Holsteinian Interglacial. Re-examination of this material, labelled ‘Homersfield Gravel Pit’, in the present study has questioned the provenance of these specimens. Rather confusingly, the village of Homersfield is actually located on the lower Broome Terrace and in the absence of any stratigraphic data on the specimens, the possibility that they came from a pit near the village, in this lower (and therefore younger) terrace, must therefore be seriously considered. The remains of *M. giganteus*, which display a completely different preservation type to the rest of Funnell’s assemblage, are considered particularly suspect. It was therefore decided that this poorly-provenanced material could not be safely regarded as providing evidence either of an Anglian fauna, or of first occurrences of certain species.

During the course of the present study, the author was informed of new specimens collected *in situ* from gravels in Flixton Quarry in the Homersfield Terrace (TM 2985), by Mr R. Much of Lowestoft. These included *E. feras*, *C. antiquitatis* and further remains of a fully-evolved *M. primigenius*. Analysis of sediments within the Homersfield Terrace remnant at Flixton Quarry by Coxon (1979) has suggested that the terrace was produced by braided channel deposition in cold-climate conditions. The presence of interdigitated lobes of chalky till of Lowestoft Till type in the Homersfield Terrace led Coxon (*ibid*) to conclude that the terrace was deposited during retreat of the Anglian ice. However, it is equally possible that the lobes of flow till could have
become incorporated into the terrace during any cold stage after the Anglian (P. Coxon pers. comm.). The Flixton Pit assemblage as it stands contains no species of biostratigraphic significance, since all the aforementioned species are known from other cold stages in the Middle and Late Pleistocene (see below). This fact, together with the potential uncertainties as to the age of the Homersfield Terrace deposits, means that the Flixton Pit assemblage can only tentatively be attributed to the Anglian at this stage. It is hoped that future work and improved collections may yield further information about this site.

However, possible corroborative evidence for an Anglian age for the Flixton Pit mammalian assemblage has come from Lillington in Warwickshire. Several pits in this area have yielded mammalian remains from the Baginton Sand and Baginton-Lillington Gravels. Some of the material is poorly provenanced, labelled simply ‘Lillington’. However, forty-one well-provenanced specimens were seen in the present study, in the collections of the Lapworth Museum of Birmingham University. These remains are all recorded as coming from the base of the Baginton-Lillington Gravels at Pratt’s Pit (SP 327 675) and Manor Pit (SP 335 671) (Shotton 1929, 1953) (Lister 1989). The Baginton-Lillington Gravels were formerly regarded as part of the type sequence of the Wolstonian stage (Shotton 1953) but are now widely regarded as pertaining to a pre-Anglian river that flowed across the Midlands (Rose 1987, 1989b). The Baginton-Lillington sequence is thought to represent a valley fill of the Proto-Soar, dating to between Stages 16 and 12 inclusive (D. Maddy and D.R. Bridgland pers. comm.). Faunal remains from these deposits may therefore include material from a range of ages, some of which may be Anglian.

The mammalian assemblage from Pratt’s Pit and Manor Pit is broadly indicative of a cold climate and open conditions. *E. ferus* is most abundant, with *C. antiquitatis*, a fully evolved morphotype of *M. primigenius*, a large bovid (cf. *Bison*) and a single record each of *P. leo* and *R. tarandus*. *P. antiquus* is also present. The combination of these species suggests that the deposits are either of interstadial status, or that they represent multiple climatic episodes. On balance, the second option seems the most plausible, given the varied states of preservation and degrees of rolling between the specimens. Further remains of *P. antiquus* and *M. primigenius*, together with *M.* cf. *arvalis*, have
also been recovered from the Baginton-Lillington Gravels at Snitterfield, Warwickshire (SP 234 595) (Lister et al. 1990).

The material from Kings Newnham or Lawford Pit in Warwickshire (SP 464 774) was also reviewed in the present study. Shotton (1953, 1983c) correlated the sands from which the mammalian remains were recovered with the Baginton Sand and Baginton-Lillington Gravels. However, according to Sumbler (1983a), the bulk of the Pleistocene deposits in the area of the pit pertain to the Devensian Avon Terrace No. 2. The provenance of much of the material must therefore be called into question (Lister 1989). Furthermore, in the area of the pit which can be demonstrated to contain deposits other than the Terrace No. 2 gravels, recent analysis of the ‘Anglian’ deposits has revealed that they are lithologically dissimilar to the Baginton-Lillington Gravels (Maddy 1989) and cannot therefore be correlated with them. The Kings Newnham/Lawford assemblage was therefore excluded from the present study.

Evidence of the mammalian fauna from Stage 10 is even more elusive. Only musk ox (*Ovibos moschatus*), reported by Conway and Waechter (1977), from the Upper Gravel at Swanscombe, post-dating the main interglacial, is a possible candidate for inclusion in this stage.

Analysis of the mammalian fauna of Stage 8 fared slightly better, due to the greater availability of fossiliferous deposits attributable to this period. Material was assessed from two localities with cold-climate gravels considered to immediately post-date deposits of Stage 9 age, namely Botany Pit, Purfleet and Barling, and from two localities with cold-climate gravels immediately preceding the Stage 7 interglacial, at Northfleet and Aveley.

The Upper Gravel at Botany Pit has been correlated with the beginning of Stage 8, on account of its position within the Corbets Tey Gravel Formation, directly succeeding interglacial deposits of established Stage 9 age (Bridgland 1994). Taxa recorded from here comprise *E. ferus*, *C. elaphus* and an indeterminate large bovid (*Bos* or *Bison*), together with evidence of early hominids, in the form of artefacts of proto-Levallois type. The Barling Gravel Formation is regarded as the equivalent of the Corbets Tey Formation of the Lower Thames by Bridgland (1994, 1995) and is thought to represent
deposition during OIS 10-8. The Barling Upper Gravel, from which mammalian remains have been recovered, overlies the temperate deposits of the Shoeburyness Channel, which have been correlated with Stage 9 (Bridgland ibid). A Stage 8 age for the Barling Upper Gravel is therefore inferred. The Barling assemblage contains the following taxa: *P. antiquus*, *M. primigenius*, *E. ferus*, an indeterminate rhinoceros, *C. elaphus*, a possible record of *B. primigenius* and *B. priscus*. However, the assemblage is extremely rolled and it is not known what proportion of the assemblage may safely be considered contemporaneous with deposition of the gravel and what proportion is derived. The remains of *P. antiquus* in particular appear somewhat incongruous in a cold stage fauna, since this species is only known from woodland interglacial episodes (Stuart 1982). It therefore seems likely that either these specimens are derived from earlier temperate-climate deposits, or that they relate to an interstadial period within Stage 8. A precedent for the occurrence of *P. antiquus* within cold-climate deposits is known from Snitterfield (see above).

A single record of *Coelodonta antiquitatis*, together with *in situ* artefacts of a proto-Levallois type, is known from the Main Coombe Rock deposits at the base of the Northfleet sequence, pre-dating a Stage 7 interglacial sequence. A Stage 8 age is therefore postulated, corroborated by the evidence of severe periglacial conditions in the Coombe Rock deposits themselves. A single specimen of *P. leo* was also recovered by the author from the Mucking Lower Gravel, pre-dating the main interglacial horizon at Aveley. This Member has also yielded artefacts of proto-Levallois type at the Lion Pit tramway cutting, West Thurrock. The identification of sites of putative Stage 8 age has been critical in testing the recently-proposed hypothesis that the first use of the Levallois technique dates to this period (Bridgland 1994).

Mammalian remains from the Stage 6 cold episode were also examined. Information from a range of sites was combined in order to gain as comprehensive a picture as possible of the mammalian fauna from this period. The localities in question (with the exception of Clevedon Cave) were either sites where cold-climate deposits could be proved to immediately pre-date temperate-climate sediments of established Ipswichian age (Bacon Hole, Minchin Hole and Balderton) or where they could be demonstrated to overlie sediments of Stage 7 age (Brighton, Twyning and Stoke Goldington). The most fortuitous situation were encountered at Marsworth and Stanton Harcourt, where cold-
climate deposits could be demonstrated to both overlie Stage 7 interglacial deposits and to underlie Substage 5e deposits. Additional records from the Taplow Gravel of the Middle Thames, cited by Gibbard (1985), were also incorporated into the Stage 6 faunal group, although the remains in question were not seen during the present study. According to the oxygen isotope record, Stage 6 was an extremely severe cold episode and, on the continent, the maximum extent of the Saalian ice sheet is considered to have occurred during this period (Zagwijn 1985). Although in the British Isles, at this time, ice reached no further than the Midlands (Maddy et al. 1995), there is no doubt that severe periglacial conditions prevailed. The Stage 6 cold episode was of relatively long duration compared to Stages 10 and 8, and the mammalian evidence from the various localities therefore reflects sites of differing ages.

Species of potential biostratigraphic significance from the Stage 6 cold episode include a large form of *M. oeconomus*. Measurements undertaken during the present study of the length of the first molar in *M. oeconomus* show a progressive increase in size through time, culminating in the cold episode immediately pre-dating the Ipswichian Interglacial, *i.e.* Stage 6. The presence of both large-bodied and small-bodied horses has also been noted in the Stage 6 cold episode. The large form shows no particular features of biostratigraphic significance, but the small form is considered here to be a potentially useful indicator for a late Stage 6 age. The reduction in size of *E. ferus*, compared to the large forms encountered in late Middle Pleistocene interglacials, is believed to have been an adaptation to increasingly severe conditions (Forstén 1996). The small horse represented at Bacon Hole and other sites is therefore considered to be of possible biostratigraphic significance in demonstrating a Stage 6 age in the late Middle Pleistocene. At Stage 6 sites where *E. ferus* is present, it is either the large or the small-bodied form that is encountered. At no locality were both forms discovered together. This would appear to confirm the hypothesis that the Stage 6 sites considered in the present study span a wide time period. On account of their closer correspondence with the large-bodied *E. ferus* of the preceding Stage 7 interglacial, it is therefore suggested that sites of Stage 6 age containing the large horse may relate to an earlier part of the cold stage than sites yielding the small-bodied form.
Other species present in deposits attributed to the Stage 6 cold episode include *P. antiquus*, a fully-evolved form of *M. primigenius*, *C. antiquitatis*, *S. cf. hemitoechus*, *C. lupus*, *V. vulpes*, *U. arctos*, *P. leo*, *C. elaphus*, *R. tarandus*, large bovids and *O. moschatus*. These assemblages clearly contain a temperate component and it is again suggested that several climatic episodes are represented within this generalised Stage 6 group.

The mammal faunas from Stages 12, 10, 8 and 6 are compared in Table 8.5.

In conclusion, the results of the present study have identified consistent faunal differences between the various temperate episodes, and have confirmed the presence of four post-Anglian interglacials, corresponding with Stages 11, 9, 7 and Substage 5e of the oxygen isotope record. Important advances have been made in the differentiation of the Stage 11 and Stage 9 group of sites and correlation of the Hoxnian Interglacial with Stage 11 has been established. The attribution of the Hoxnian type site to Stage 9 on the basis of aminostratigraphy (Bowen *et al.* 1989) is therefore rejected. Furthermore, detailed examination of the composition of the Hoxnian mammalian fauna has permitted the identification of small-scale changes throughout the interglacial, which have been found to correspond with isotopic substages. Five substages have consequently been recognised within the Stage 11/Hoxnian interglacial.

The Stage 9 mammal fauna has been comprehensively described for the first time and species of biostratigraphic importance identified. This has permitted the attribution of a number of localities (which had previously been erroneously assigned to either the traditional Hoxnian or Ipswichian Interglacials) to a more appropriate position within the British Quaternary sequence. The Stage 7 mammalian fauna has also been examined in detail and its existence as a separate entity from the Ipswichian *Hippopotamus* fauna confirmed. The presence of two equally temperate episodes with corresponding mammal faunas has also been identified in the Stage 7 interglacial. These are considered to equate with Substages 7c and 7a of the oxygen isotope record, again, the first time that the Stage 7 mammal fauna has been assigned to isotopic substages.
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Primates

Homo sp.

Rodentia

M. arvalis

M. oeconomus

Carnivora

C. lupus

V. vulpes

U. arctos

P. leo

Proboscidea

P. antiquus

M. primigenius

Perissodactyla

E. foer

S. hemitoechus

C. antiquitatis

Artiodactyla

C. elaphus

R. tarandus

B. primigenius

B. cf. priscus

O. moschatus

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Table 8.5 Comparison of the Stage 12 (Anglian), Stage 10, Stage 8 and Stage 6 cold episodes, showing presence and absence of various mammalian species.
The mammalian faunas of the Anglian and post-Anglian cold episodes in the Middle Pleistocene have been demonstrated to be rather constant in their species composition, although some characteristics of biostratigraphic importance were identified, which may be of potential use in differentiating between stages. However, a major hurdle is the general lack of fossiliferous cold-stage deposits in the Middle Pleistocene and the uncertain age of the few that are known.

The present findings are in complete support of models put forward on the basis of terrace stratigraphy by Bridgland (1994), with the long fluvial archive in the Thames valley proving an excellent framework for the dating and correlation of deposits both within the Thames terrace sequence and further afield. Given the uncertainties of many methods of absolute dating, the selective inconsistency of aminostratigraphy and the potential shortcomings of the palynostratigraphic model, the existence of a sound mammalian biostratigraphic scheme has become all the more important to the understanding of the British Quaternary succession. The present study has demonstrated conclusively that, to date, the evidence from fossil mammals has proved a uniquely effective tool for establishing the number and nature of the different climatic episodes within the British late Middle Pleistocene.

This study has established a new biostratigraphic framework for the British Isles, which can be tested and refined as more sites come to light in the future. The scene is now also set for a program of research comparing the evidence from sites in continental north-west Europe against this scheme.
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