



Chapter 4: Terrestrial fluvial landscapes

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INTRODUCTION

As noted elsewhere in this volume (see Chapters 1 and 6), the investigation of the Pleistocene fluvial archive for Palaeolithic and Pleistocene information has a long and rich history in Britain, beginning in earnest back in the mid 19th century when antiquarian collectors would tour active sand and gravel pits, making finds themselves or remunerating the workmen for their recovery of artefacts and faunal remains (Fig. 4.1). Hand-extraction and sorting of the aggregate resources provided unparalleled opportunities for the recovery of fossil and

artefactual remains, leading to the creation of an exceptional repository of such finds, still preserved today in regional and national museum collections across Britain. Spanning nearly 100 years, this period saw the tremendous florescence of both antiquarian and wider public interest in what is now known as Quaternary Science, coinciding with new understanding of human antiquity, past geomorphological processes and biological evolution.

This chapter outlines the range of ALSF-funded investigations into Pleistocene fluvial deposits (ie those laid down by rivers), and discusses the



Fig. 4.1 The 19th century antiquarian Worthington George Smith indicates the position of Palaeolithic artefacts from the site of Gaddesden Row, Bedfordshire (courtesy of Luton Museum Service)



evidence they provide for past climatic and landscape reconstruction at different spatial scales. By their very nature, since river deposits comprise sands and gravels that are frequently of economic interest, this type of deposit is the single most important context for the preservation of Palaeolithic and associated Pleistocene palaeoenvironmental evidence, both in terms of sheer numbers of sites and assemblages and also the geographical scope of ALSF projects. As explained in Chapter 1, the commercial exploitation of fluvial aggregate deposits presents something of a double-edged sword for those interested in deeper archaeological time. It is clear that without quarrying activities, such deeply buried sites will only rarely come to light, but equally, there is no statutory protection for this precious resource, and thus far, exceptionally limited opportunities for archaeological mitigation in comparison to traditional 'surface' archaeology.

In contrast to the past, opportunities today for 'preservation by record' have been made extremely difficult by the advance of mechanised, large-scale quarrying. Thus, as recognised in English Heritage's 2008 *Research and Conservation Framework for the British Palaeolithic* (funded by the ALSF), the very process of modern aggregates extraction can destroy both sites and material unseen (see Chapter 1). Given the voracious exploitation of aggregates by today's society and constant development pressures, these risks are only likely to increase. In the Thames Gateway area alone the archaeological and geological resource has experienced sustained pressure from industrial development over 150 years, and the construction of High Speed 1 (the Channel Tunnel Rail Link) with further threats implicit in the government's strategic plan identifying north Kent and south Essex as priority spots for regeneration, as well as in the mooted expansion of Stansted airport. The situation is compounded by the issues outlined in Chapter 1 regarding the frequent misunderstanding as to the very different nature of Palaeolithic and Pleistocene remains and how these might be most effectively and economically recorded and investigated (see Chapter 2). In consequence, a number of the projects described here specifically focussed on raising public and professional awareness of the Palaeolithic and Pleistocene in order to stimulate interest in, and increase knowledge of, the distant archaeological past in a diversity of stakeholders. These audiences naturally include those who work in the aggregates industry and who therefore may be closely involved in any new discoveries. In a period where recognisable archaeological features are minimal (or more usually completely absent), it is critical to accept that investigation of our Palaeolithic archaeological heritage should include not only anthropogenic artefacts but also study of deposits that may be archaeologically sterile but which contain chronological or palaeoenvironmental data. Only through this holistic and interdisciplinary approach can more light be shed on past human behaviour.

As noted throughout this volume, one major benefit of ALSF funding has been the opportunity to revisit often poorly known collections and to place them within an updated chronological, stratigraphical and palaeoenvironmental framework, thereby maximising 'added value' to the museum resource, and providing new educational and outreach opportunities. Equally important, however, is the need to assist the curatorial and professional archaeological community in managing the Palaeolithic and Pleistocene resource contained in the contemporary aggregate extraction landscape. This is imperative since nationally both original Sites and Monuments Records (SMRs) and more wide-ranging Historic Environment Records (HERs) are notably poor in basic, verifiable information concerning the Palaeolithic and its palaeoenvironmental context. Urgent enhancement of these resources is therefore required, and indeed was one of the desired outcomes of many of the fluvial ALSF projects described here. The generation of both site-specific and valley-wide datasets therefore not only allows the characterisation and predictive modelling of the Palaeolithic resource in individual river systems but also facilitates the identification of particular areas of significance, which can then inform future research priorities. Finally, the range of fluvial projects provided an opportunity to highlight to archaeological professionals the range and applicability of appropriate methods for evaluating and excavating Palaeolithic and Pleistocene sites. ALSF funding thus provided an important opening not only for contextualising knowledge gained from past aggregates extraction but also for exploring new sites and creating a new predictive resource to enable planning authorities and the aggregates industry to minimise the impact of extraction on the historic environment in future.

THE POTENTIAL OF FLUVIAL SEQUENCES FOR RECONSTRUCTING PAST LANDSCAPES AND HOMININ OCCUPATION

The importance of fluvial sequences to Palaeolithic archaeology lies in their role as an archive for the preservation of both artefactual and multi-proxy Pleistocene palaeoenvironmental evidence, including a range of biological proxies as well as the sediments and soils themselves. River valleys are not only believed to have acted as important conduits through the landscape for early hominins (Ashton *et al.* 2006) but also to have provided the essential raw material for stone tool manufacture, as they erode through bedrock and accumulate gravel deposits, thereby further influencing patterns of movement around the landscape. Rivers therefore acted as focal points in the distant past, providing valuable raw material as well as other resources in the form of fresh water, plants and animals. Although stone tools in secondary contexts are often clearly transported from their point of origin, potential equally exists within fluvial sequences for

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the recovery of refitting material from discrete knapping episodes and (rarely) for elucidation of hominin subsistence patterns and behaviour, through the recovery of butchered or otherwise humanly modified faunal material. Even when archaeology may not be present, it is increasingly recognised that the study of geological sequences is of great value for its own sake, not only for the direct information concerning the past climates and environments that hominins inhabited but also for dating the Palaeolithic record, through lithostratigraphy, biostratigraphy and geochronology (see also Chapter 2).

Pleistocene river terrace sequences are present all over the world but are particularly well preserved in temperate latitudes (cf. Bridgland and Maddy 2002). They are interpreted as relict fragments of former floodplains, which are left perched above the river's level by subsequent fluvial downcutting, a process known as rejuvenation. In the majority of cases the downcutting is progressive, leaving behind a 'staircase' of bench-like terraces that increase in age with height above the river. In recent years, it has been accepted by many workers that river terrace formation occurs as a combined response to two forces: climate change and tectonic uplift (Bridgland 1994; 2000; Bridgland and Allen 1996; Maddy 1997; Maddy and Bridgland 2000; Bridgland and Westaway 2007).

Climatic change is a key driver of fluvial activity, triggering the depositional and erosional events preserved in terrace sequences and acting both directly, for example through variability and mode of precipitation, seasonally increased discharge associated with permafrost melt, and indirectly by influencing vegetation and its effect on slope stability and sediment supply (Bull 1991; Bridgland 1994; Vandenberghe 2003; 2007; Westaway and Bridgland 2010). During the last 3 million years, while the south of England has been uplifted, the southern North Sea Basin has been subsiding, with the hinge line for this movement lying on a roughly north-south axis close to the present coast of Suffolk and Essex (Rose *et al.* 1999). The rate of uplift has been calculated at around 0.07 m ka^{-1} in the west of the region (eg Maddy 1997) while over the same period the southern North Sea basin has subsided at an average rate of 0.15 m per thousand years. This pattern of uplift and tilting has been a major factor in the formation of the terraces.

Debate continues about the formation of depositional river terraces. Previous workers (for example, Zeuner 1945; 1959) believed that terraces in the lower reaches of rivers were aggraded in response to sea-level rise, itself climatically influenced during the Quaternary. River terrace aggradation was also believed to happen as a single event during one temperate climate episode, on account of the large quantities of warm-climate fossils that were seemingly

found in the gravel. More recently, however, the observation that typical river terrace gravels have accumulated under conditions of extreme cold, often associated with permafrost features (for example, Rose and Allen 1977; Green and McGregor 1980; Gibbard 1985) has overturned this view. In Britain, evidence from the exceptional record in the Lower Thames (see below) provided corroboration that both cold- and warm-climatic episodes could be recorded within terrace sequences, and that their disposition could help explain the relation between terrace formation and climatic fluctuation (Bridgland 1994; 2000; 2006). The modified paradigm of climatically-triggered terrace formation, driven by progressive uplift, has been widely accepted in the Quaternary fluvial community (see, however, Kiden and Tornqvist 1998; Gibbard and Lewin 2008; Lewin and Gibbard 2010). Based on empirical evidence from the Lower Thames (see below), a climatic model for terrace formation is now envisaged, in which the major incision event is believed to have coincided with warming transitions in the climate cycle (Fig. 4.2; Bridgland and Allen 1996; Bridgland 2000; 2006; 2014). Gravel aggradations thus occur mainly under cold, periglacial conditions and river terrace deposits form over multiple climatic stages.

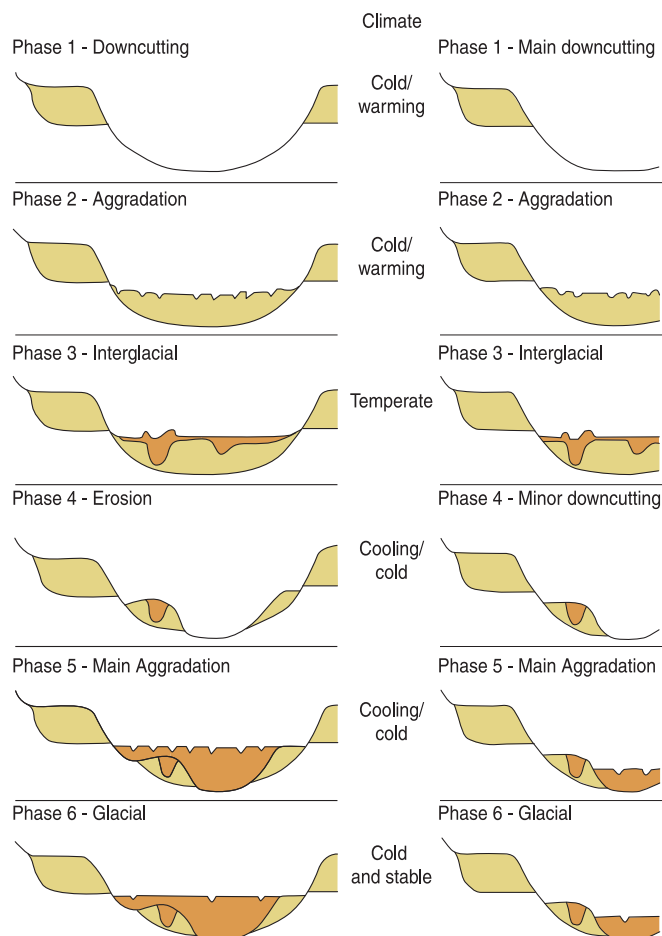


Fig. 4.2 Phased model of fluvial aggradation in synchrony with climatic change (from Bridgland 2014)

Lost Landscapes of Palaeolithic Britain

Within this scheme, fossiliferous deposits are generally laid down during periods of temperate climate between gravel aggradations, comprising finer-grained sediments of silt, clay and peat, thereby creating a cold-warm-cold 'sandwich' of deposits.

The Pleistocene deposits of the river Thames and its tributaries are of international importance, since they form a chronostratigraphical framework for this part of the geological record in Britain, linking the glacial stratigraphy of East Anglia, the fluvial stratigraphy of the Rhine and Seine, and global climatic stratigraphy (Morigi *et al.* 2011). Although other English rivers possess long terrace sequences, they do not contain as rich an archaeological and palaeontological record, particularly for the last half million years. The Thames is therefore used here as a powerful example of the potential information that can be derived from fluvial sequences. As well as preserving a long stratigraphical record through the Pleistocene, the Thames deposits are also blessed by good preservation of vertebrate and molluscan remains, on account of the calcareous groundwater conditions and Chalk bedrock in this part of the country. Finally, the Thames has a long pedigree of archaeological collection, prospection and excavation, meaning that its extensive Palaeolithic collections can be fully integrated with state-of-the-art chronological and palaeoenvironmental information.

In the Thames Valley, there are about eighteen different terraces along the pre-Anglian course of

the ancient Thames, although they are not all present in any one section of the river valley. The best-preserved flight of terraces is in the Middle Thames between Reading and Rickmansworth where up to thirteen terraces have been recognised. However, it is the Lower Thames (that part of the river's course through and downstream from London), which possesses one of the best archives globally of climatic events since the Anglian glaciation, *c.* 450,000 BP. The Thames has flowed in its present course through London only since the Anglian ice sheet blocked its former valley in the Vale of St Albans, ultimately leading to catastrophic overflow from ice-dammed lakes and diversion of the river into the pre-existing Medway-Darent drainage basin to the south (Gibbard 1977; 1979; Bridgland 1988; 1999; Bridgland and Gibbard 1997). Four post-Anglian terraces can be recognised, with the lowest of these buried beneath the modern floodplain downstream from London (Fig. 4.3). In the case of the Lower Thames, the process of terrace formation has led to the creation of approximately one terrace per 100,000 year climatic cycle, with interglacial sediments in the Lower Thames correlated with MIS 11, 9, 7 and 5e (Bridgland 1994; 2000). This chronological model has been applied as an interpretative tool in sequences lacking the empirical palaeoclimatic evidence, such as the Bytham River in East Anglia (Lee *et al.* 2004), although not without controversy (Banham *et al.* 2001). Indeed, the Lower Thames record may be atypical, even within the wider Thames system as a

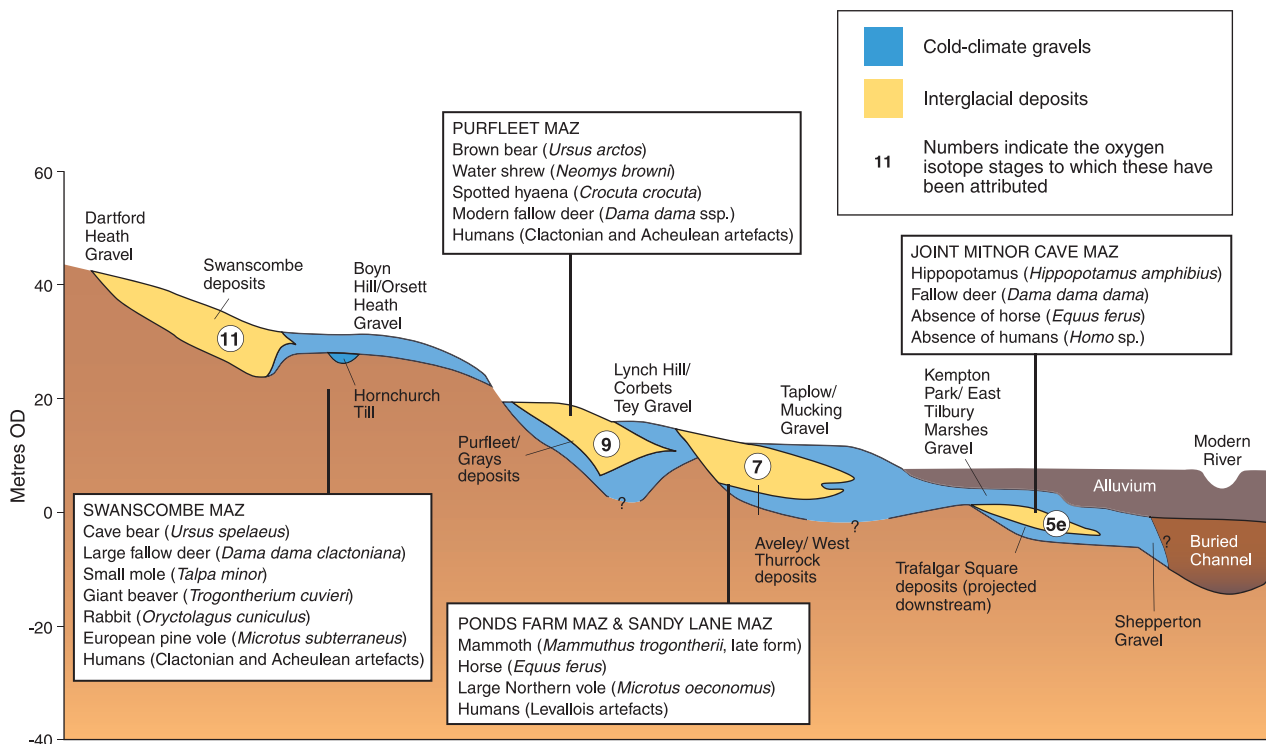


Fig. 4.3 Schematic cross-section through the Lower Thames terraces, showing four post-Anglian terraces. Proposed correlations with the marine oxygen isotope record are shown, together with mammalian biostratigraphical characteristics (MAZ = mammalian assemblage zone)

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whole. Many rivers have formed terraces less frequently than one per cycle and some (more rarely) display more than one terrace per climate cycle, as indeed occurs in one of Britain's most extensive records, that of the River Solent in southern England (Fig. 4.4; Westaway *et al.* 2006). Major advances in the dating of the Lower Thames, through the application of terrace stratigraphy (Bridgland 1994), mammalian (Box 4.1) and molluscan biostratigraphy (Fig. 4.3; Keen 2001; Schreve 2001) and geochronology (Penkman *et al.* 2011; Bridgland *et al.* 2012) have now permitted detailed understanding of the timing and environments under which sediments, fossils and archaeology were deposited, allowing the landscapes of early hominins, patterns of settlement and abandonment, and technological and behavioural changes to be reconstructed and interpreted.

As outlined in Chapter 2, the fluvial archive can be examined on a range of spatial scales, from the macro-scale (whereby questions concerning the palaeogeography of ancestral rivers or connections to the continental mainland, for example, can be explored), through the meso-scale (investigation of individual geomorphological systems such as river valleys), to the micro-scale (site-specific studies). Since no ALSF projects have directly addressed the first of these, the information presented below focuses on the second and third categories, which formed the main corpus of Palaeolithic and Pleistocene studies funded since 2002. The following description of projects is not intended to be exhaustive for the entire range of funded studies but rather to provide an illustration of relevant examples and their outcomes.

THE BIGGER PICTURE: MESO-SCALE INVESTIGATION OF RIVER VALLEYS

In accordance with the overarching research themes later formalised in the 2008 *Research and Conservation Framework for the British Palaeolithic*, a core goal of many of the ALSF projects was to generate up-to-date and integrated chronological and stratigraphical frameworks for individual geomorphological systems in order to explore patterns of hominin occupation, cultural change and responses to palaeoenvironmental oscillations. A number of projects therefore focussed on generating new information for selected river valleys through examination of borehole records and reappraisal of museum artefact collections, as well as targeted fieldwork combined with new geochronological and palaeoenvironmental analyses (see descriptions of methods employed in ALSF projects in Chapter 2). Although opportunities occasionally presented themselves for detailed site-specific investigations as part of these valley-wide projects (see below), the main emphasis was on the understanding of 'bigger picture' questions concerning palaeogeography, geochronology and palaeoenvironmental change, as well as the generation of landscape-scale deposit models and GIS maps as predictive tools.

Developing predictive modelling – Mapping the Sub-Surface Drift Geology of Greater London project

A typical example of this approach comes from the *Mapping the Sub-Surface Drift Geology of Greater London* project (also known as the *Lea Valley Mapping Project, LVMP*) undertaken by the Museum of

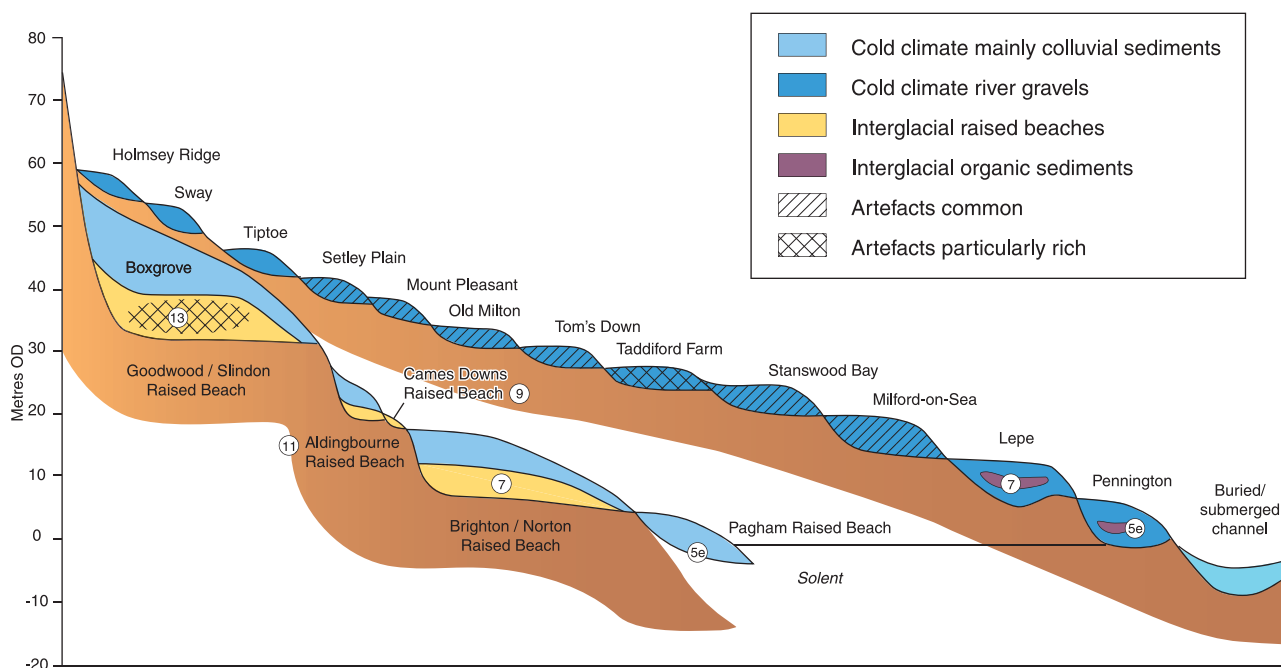


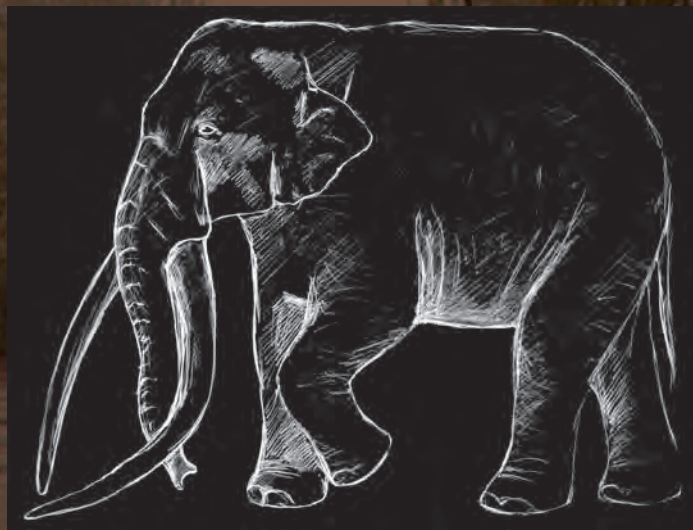
Fig. 4.4 Schematic cross-section through the terraces of the Solent Valley and correlation with the raised beach sequence of the Sussex coastal plain (after Bridgland 2000)

LATE PLEISTOCENE MAMMALIAN TURNOVER IN BRITAIN

BOX 4.1

The mammalian faunas of the British Late Pleistocene demonstrate an exceptional degree of turnover, in response to the sharp climatic fluctuations of the period. This has led to the recognition of a succession of discrete Mammal Assemblage-Zones (MAZ) based on evidence of faunal replacement, evolutionary trends and extinction events.

The Late Pleistocene covers Marine Oxygen Isotope Stages (MIS) 5-2 inclusive, comprising the Last (Ipswichian) interglacial (MIS 5e, the first temperate substage in the oxygen isotope record of MIS 5) and a complex last glacial, the Devensian Glaciation, which covers MIS 5d-2. The Last Interglacial is well represented in both cave and open sites across Britain. Its mammalian fauna (Joint Mitnor Cave MAZ) is of typically temperate, woodland character, reflecting mean summer temperatures around 5°C warmer than at present, including fallow deer (*Dama dama*), bison (*Bison priscus*), straight-tusked elephant (*Palaeoloxodon antiquus*), narrow-nosed rhinoceros (*Stephanorhinus hemitoechus*) and a highly characteristic element, in the form of hippopotamus (*Hippopotamus amphibius*). No faunal records are known from the very earliest cold-climate phase of the Early Devensian (MIS 5d, nor indeed from the later MIS 5b), although the MIS 5c interstadial (a short episode of relatively mild climatic conditions) is represented by the Bacon Hole MAZ of the Gower peninsula in south Wales. The mammalian assemblage from MIS 5c is of temperate character, with straight-tusked elephant, but has lost hippopotamus, the most thermophilous (warm-loving) element.

4.1.1 *Palaeoloxodon antiquus*

The mammals from the final part of the Early Devensian are attributed to MIS 5a, a correlation supported by Uranium-series dating on flowstones from caves encasing bones. This faunal grouping (the Banwell Bone Cave MAZ) is formed by a very distinctive group of cold, maritime species, indicative of high snow cover. Biodiversity is low, possibly reflecting island isolation at this time, with only reindeer (*Rangifer tarandus*) and bison (*Bison priscus*) represented in any great numbers. The major predator is a brown bear (*Ursus arctos*), of exceptionally large body size; indeed, early findings of this bear were initially misidentified as polar bear. Reconnection to the continent occurred around 65,000 years ago, in conjunction with the broad climatic amelioration of MIS 3 (the Middle Devensian, 65-25,000 years ago). The mammalian fauna of the Pin Hole Cave MAZ, of which the Lynford and Whitemoor Haye assemblages are typical examples, reflects the extensive spread of a non-analogue grassland environment, often referred to as the Mammoth Steppe, an arid but exceptionally rich habitat that could support many tons of large herbivore biomass. Although reindeer and bison were still present, the fauna is dominated by woolly mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), horse (*Equus ferus*), spotted hyaena (*Crocuta crocuta*). MIS 3 also witnesses the reappearance in Britain of Neanderthals after a protracted absence of around 100,000 years, and their subsequent replacement by modern humans. This period, although the warmest part of the last glaciation is characterised by multiple abrupt climatic oscillations on a submillennial scale. It is also at this time that many of the Pleistocene megafauna begin to go extinct, at least partly because of climatically-driven ecological stress.

The ensuing dramatic climatic deterioration of the Last Glacial Maximum, around 22,000 years ago, is characterised by a restricted fauna including reindeer, woolly mammoth and musk ox (*Ovibos moschatus*). Later, the brief initial warming of the Late glacial Interstadial (Bølling interstadial, 14,800 years ago) caused the return of a temperate fauna (the Gough's Cave MAZ), this time comprising mostly wild horse, red deer (*Cervus elaphus*), mountain hare (*Lepus timidus*), rare records of saiga antelope (*Saiga tatarica*) and modern humans. Faunas of the later parts of the interstadial (Allerød interstadial) include red deer and elk (*Alces alces*) and reflect the spread of birch woodland in Britain, before the climatic deterioration of the Younger Dryas (12,900 years ago) brought about the return of reindeer, arctic fox (*Alopex lagopus*) and other cold-climate species. These species enjoyed a brief reign before the climatic warming of the Holocene (11,500 years ago) and the spread of woodland led to the formation of Britain's modern mammal fauna.

4.1.2 *Hippopotamus amphibius*

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London Archaeology Service (Corcoran *et al.* 2011). This project focussed on the Quaternary deposits of the lower Lea Valley, an area of regionally significant large-scale aggregate extraction, and one where the combination of a built-up urban location, deeply-buried deposits and lack of previous major archaeological excavations presented particular challenges to the understanding and interpretation of the fluvial sequence. Extending across the six London boroughs of Enfield, Waltham Forest, Haringey, Hackney, Tower Hamlets and Newham, as well as part of Epping Forest in Essex, the study area covered 80.64 km² in its northern part and 30.50 km² in the south (Fig. 4.5), as five mapped areas, encompassing the Lea floodplain and pre-Holocene terraces in the north and the floodplain and lower-most adjacent valley sides in the south.

The project drew on over 3000 British Geological Survey (BGS) borehole logs and archaeological records from small-scale excavation and evaluation studies in order to create a digital geoarchaeological database, a gazetteer of finds and subsequently, an integrated GIS for the lower Lea Valley and its confluence with the Thames. This was then used to generate a series of deposit models and maps with the aim of reconstructing the topography and palaeoenvironments of the lower Lea Valley during the late Pleistocene and Holocene, so as to be able to predict areas of archaeological potential and future risk. As a core objective (and in common with the majority of similar landscape-scale fluvial ALSF projects), the LVMP undertook to engage with a broad audience and specifically to engage with a diversity of professional archaeological, industrial and non-professional stakeholders to provide 'meaningful information about a range of issues of relevance to the understanding and management of the past landscape and archaeological resource...' (Corcoran *et al.* 2011, 4).

As Corcoran *et al.* (2011) indicate, arguably the single most useful concept and product of the LVMP project was the formulation of a pre-Holocene Digital Elevation Model (DEM) for the study area (Fig. 4.6), which creates a lattice of known elevation points in order to form a palaeogeographical visualisation of the height of a given surface. This enables borehole profiles and transects to be accurately placed within their past topographical context, thereby forming the template upon which alluvial/colluvial deposition subsequently occurred during the Holocene. The irregular nature of the topography can then be examined in order to assess differences in archaeological potential. For example the presence of topographic 'highs' and 'lows' on the floodplain might indicate islands, promontories, pools or channels, all of which might have been attractive to past inhabitants and be focal points for future archaeological investigation. Although the DEM created presents the situation at the start of the Holocene (and hence offers insight into the landscape of the earliest Mesolithic occupants of the Lea Valley), the result nonetheless provides a snapshot of the

complex land surface present at the end of the Pleistocene and clearly demonstrates applicability to more distant Palaeolithic time periods. The irregular surface of the gravel on the river terraces noted by Corcoran *et al.* (2011) may be partly the reflection of erosion during the Pleistocene (since such processes are likely to have been much more active than during the Holocene). However, in an area such as the Lea

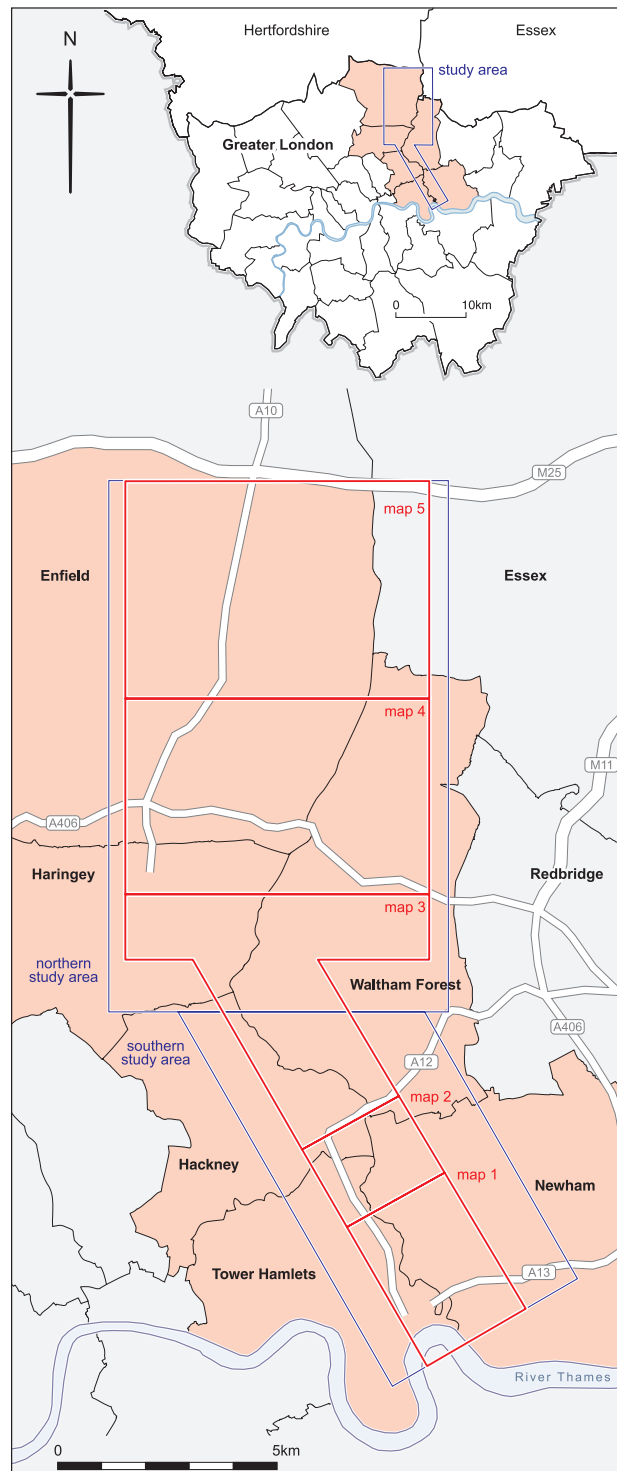


Fig. 4.5 Location map of the Mapping the Sub-Surface Drift Geology of Greater London project study area

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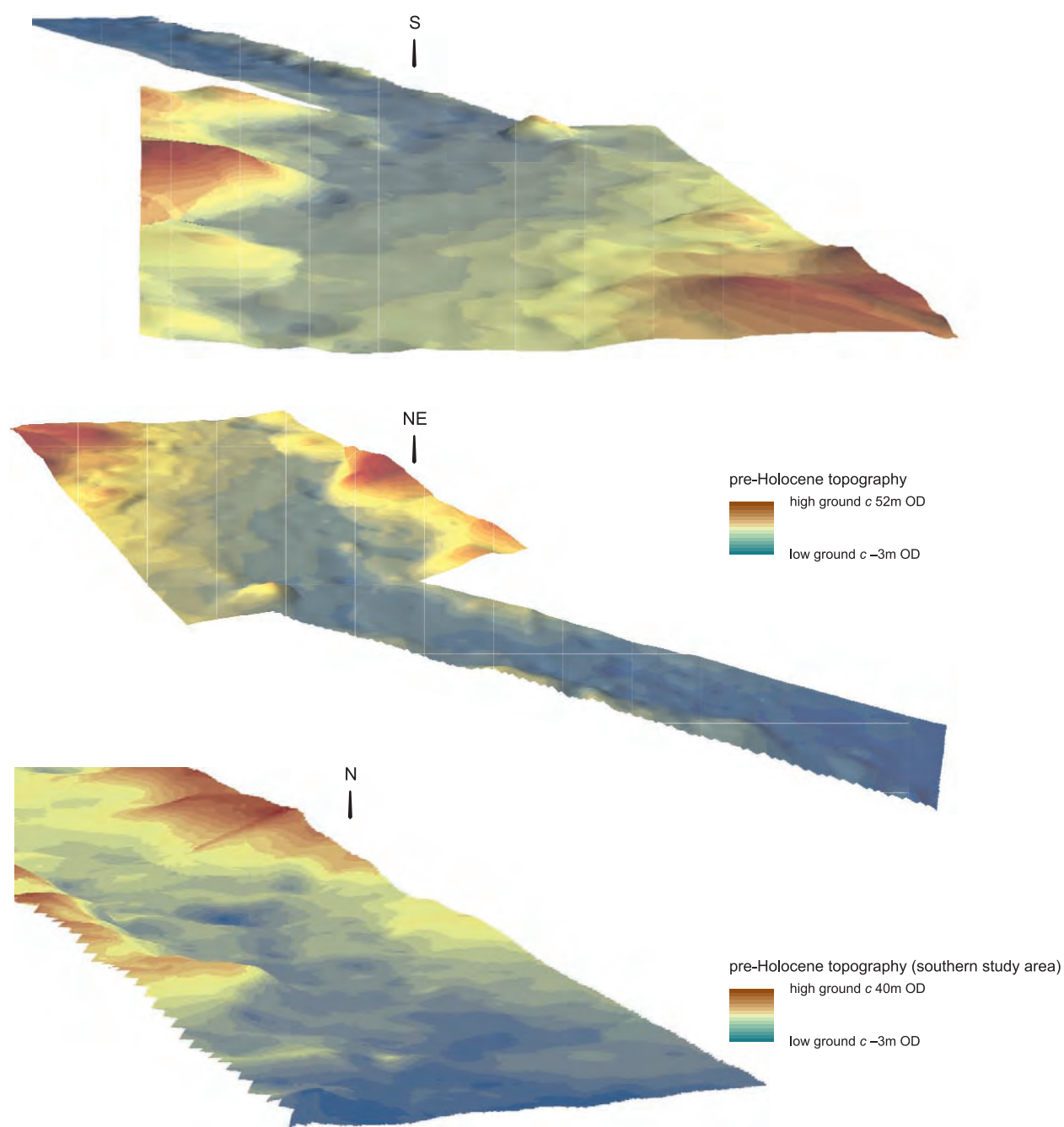


Fig. 4.6 3-D plots of the 'pre-Holocene' landscape surface (vertical exaggeration $\times 4$) (from Corcoran et al. 2011)

Valley, where there has been extensive landscaping and quarrying, much of the irregularity may be down to human activity. Thus, in many cases, the pre-Holocene gravel surface is likely to have been higher than as modelled currently.

Borehole transects and contour maps were then combined to provide an overview of pre-Holocene landscape and deposit characteristics (Fig. 4.7) and the area subdivided into buried 'landscape zones' (Fig. 4.8). This approach allowed the recognition of six 'terrain' types, which could then be traced across individual mapped areas and used to address wider questions beyond any single development site.

Terrain 1 represents the main part of the river channel and valley floor (floodplain), at the base of which (in the study area) are Pleistocene gravels. Terrain 2 represents the marginal zone at the peripheries of the floodplain, characterised by the frequent presence of colluvial deposits, the preservation of archaeological and palaeoenvironmental remains in abandoned floodplain-edge depressions and the presence of infilled scour features representing the mouths of tributary valleys. Terrain 3 is represented by a low terrace of Devensian (last cold stage) age, frequently dissected by fluvial channels, lying immediately above or just below the flood-

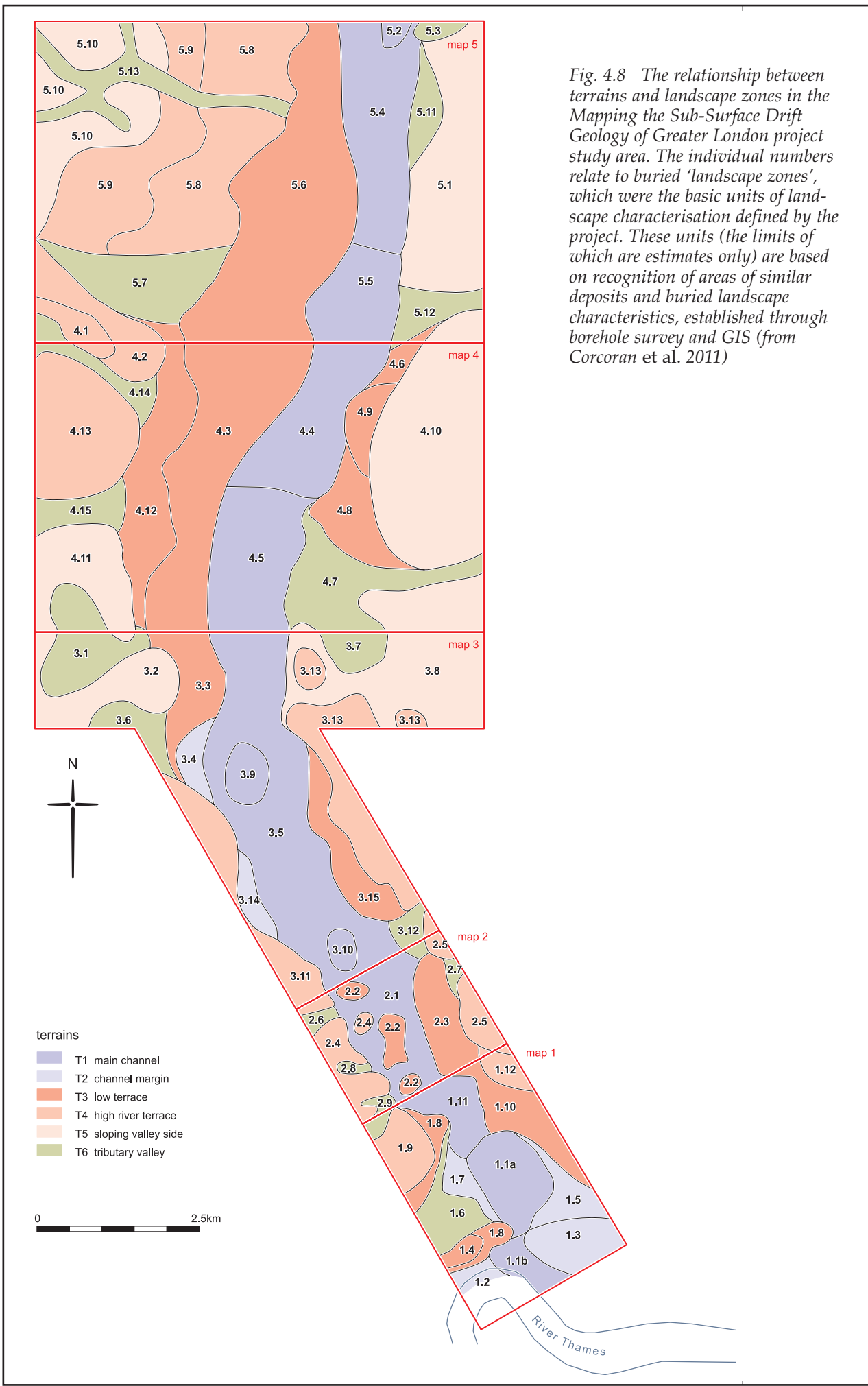


Fig. 4.8 The relationship between terrains and landscape zones in the Mapping the Sub-Surface Drift Geology of Greater London project study area. The individual numbers relate to buried 'landscape zones', which were the basic units of landscape characterisation defined by the project. These units (the limits of which are estimates only) are based on recognition of areas of similar deposits and buried landscape characteristics, established through borehole survey and GIS (from Corcoran et al. 2011)



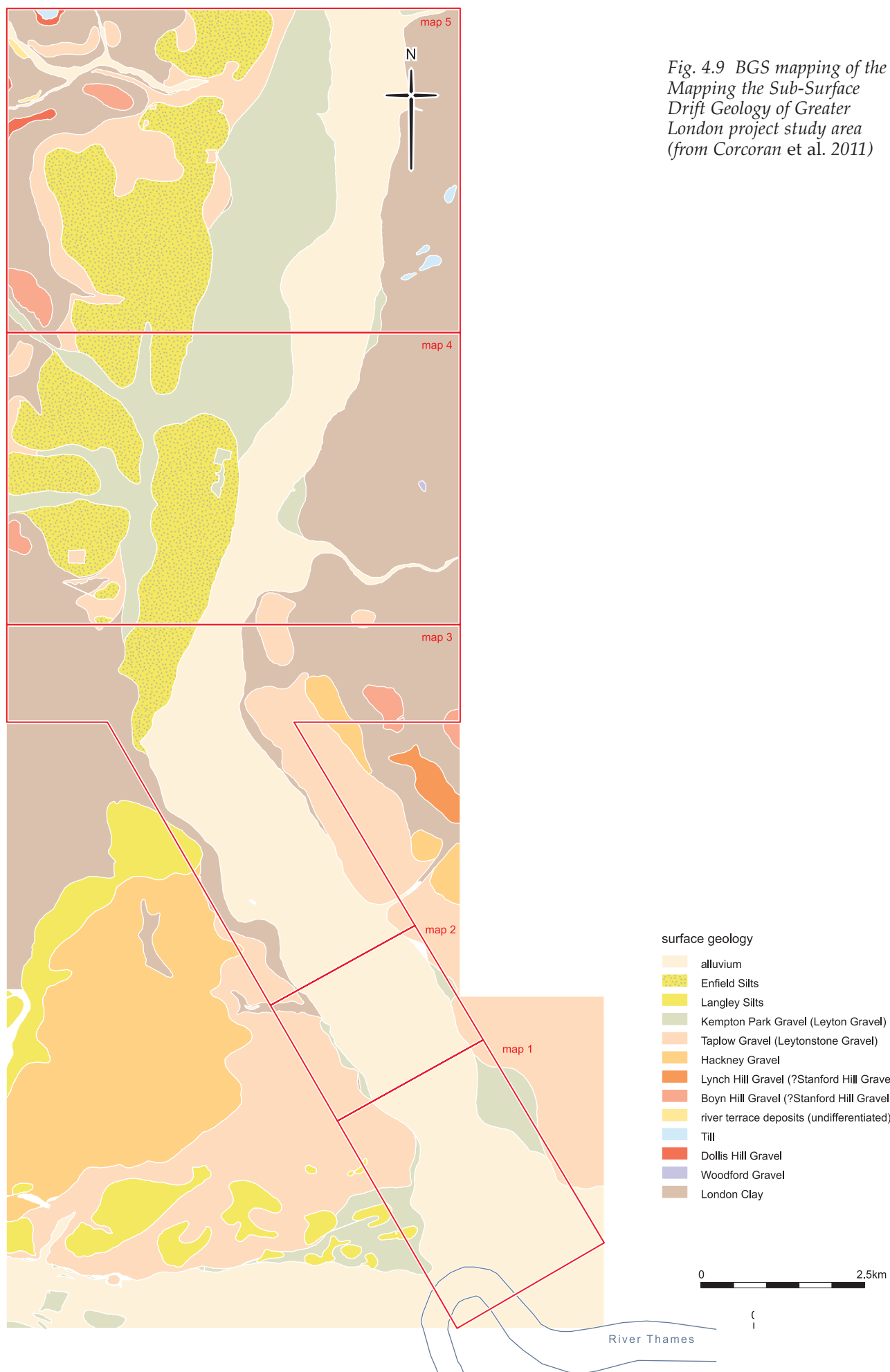
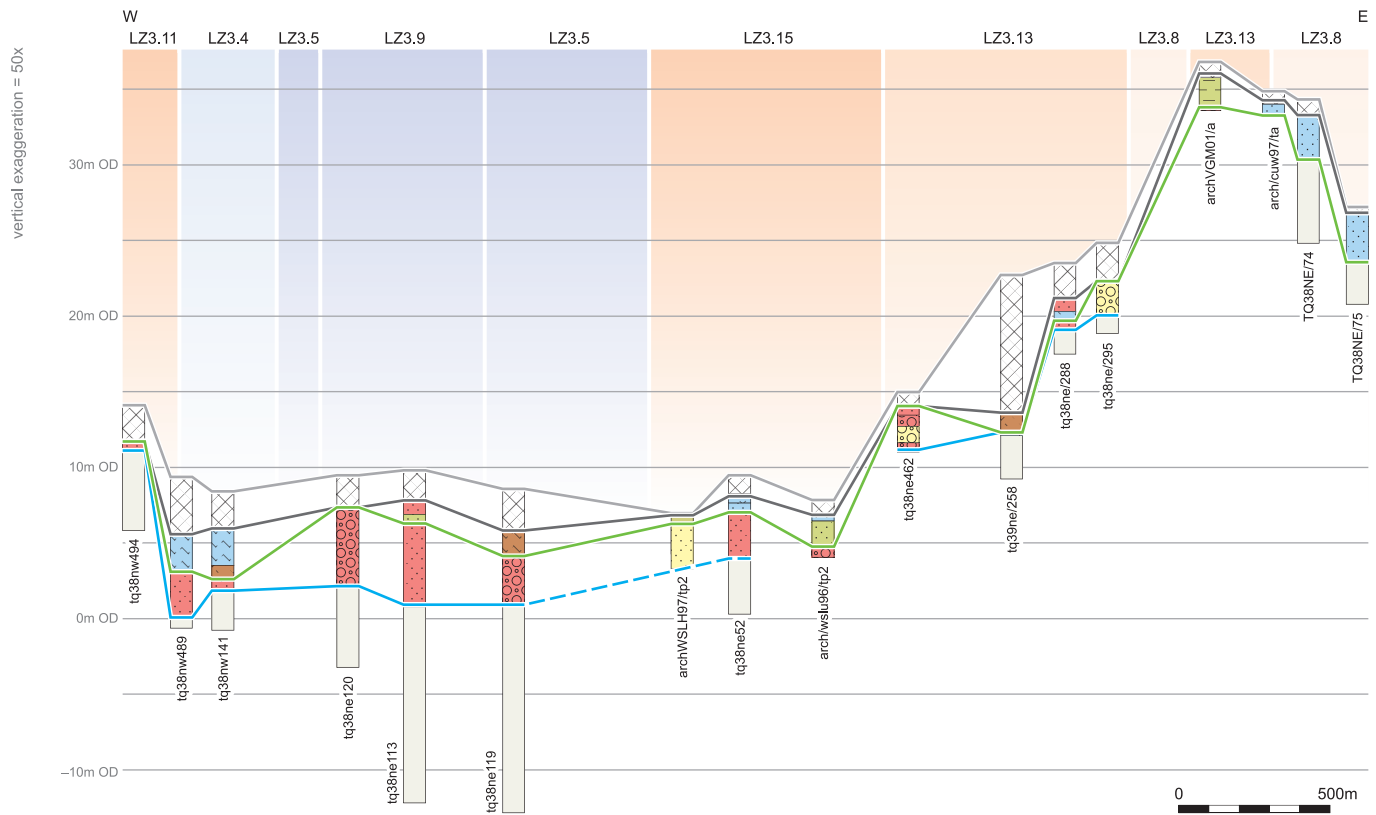


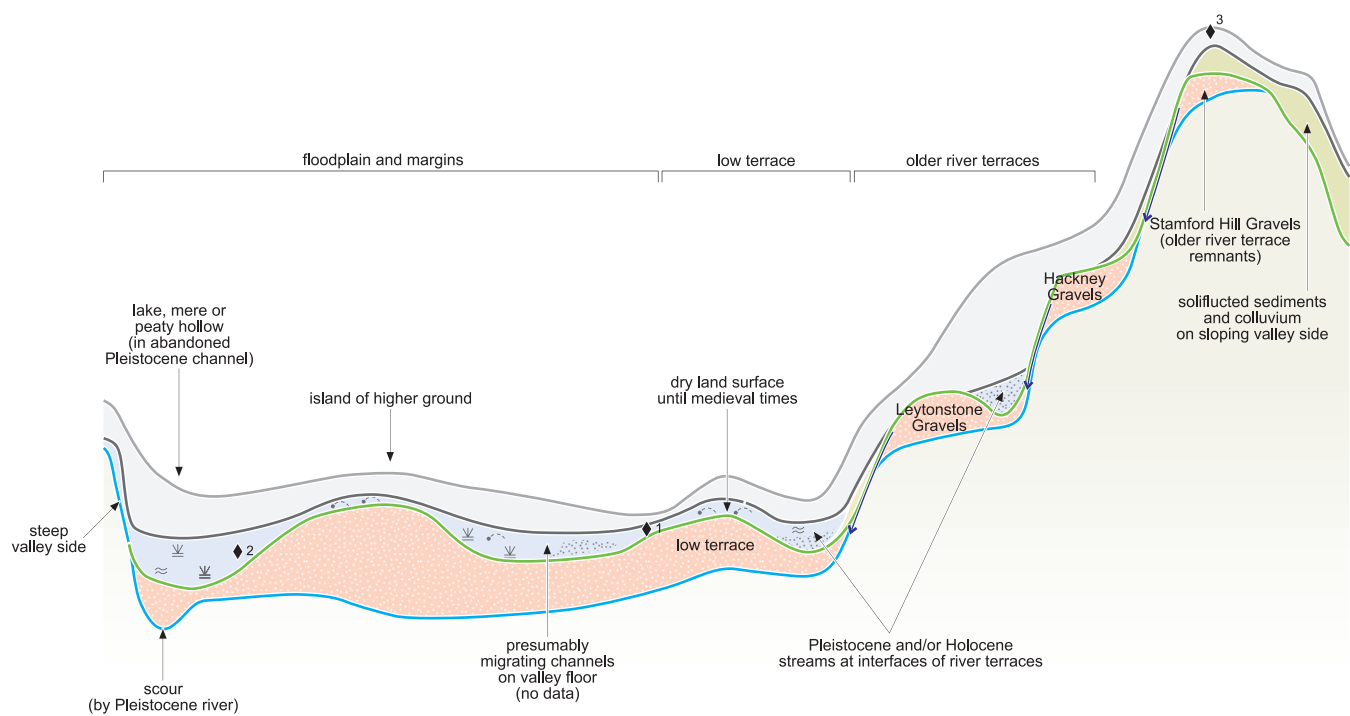
Fig. 4.9 BGS mapping of the Mapping the Sub-Surface Drift Geology of Greater London project study area (from Corcoran et al. 2011)

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borehole transect



reconstructed schematic section



- 1 Low Hall: medieval manor
- 2 (Saxon) piled structure (crannog)
- 3 Saxon + medieval settlement of Walthamstow

Fig. 4.10 Borehole transect and schematic cross-section through the central part of Map 3 of the Mapping the Sub-Surface Drift Geology of Greater London project study area (from Corcoran et al. 2011)

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plain and variably underlain by either the Leyton Gravels or the Lea Valley Gravels (= Kempton Park Gravel of the BGS; Fig. 4.9) depending on the mapping area. Terrain 4 represents higher (and older) river terraces, today lying around 20m OD, well above the modern floodplain. These terraces

are typically underlain by the Leytonstone Gravels (= Taplow Gravel of the BGS) laid down in the late Middle Pleistocene between Marine Oxygen Isotope Stage (MIS) 8 and MIS 6, *c.* 280,000–128,000 BP and by the Hackney Gravel, the latter most recently considered to be of MIS 8 age, since it



Fig. 4.11 Lea Valley Arctic Beds (a-e) in the Angel Road ballast pit, north London (from Warren 1912)

overlies fossiliferous interglacial silts attributed to MIS 9 (Green *et al.* 2006). Occasional remnants of higher, older terraces such as that formed by the Stamford Hill Gravel, are also noted (Fig. 4.10). Terrain 5 represents sloping valley-side areas, usually associated with exposed London Clay bedrock and overlain by colluvium and solifluction deposits, whereas Terrain 6 represents tributary valleys, often dating back to the Pleistocene and typified by alluvial sediments.

The characteristics of each landscape zone were noted in terms of the typical sequence of deposits (with anticipated depths and thicknesses) and inferred formation process and then integrated with any available archaeological and palaeoenvironmental evidence. Although there is archaeological potential for the recovery of Late Glacial remains from the 'pre Holocene' land surface of Terrain 1 (for example, palaeoenvironmental evidence preserved within topographic lows on the floodplain), the terrains with the greatest potential for preservation of Palaeolithic and Pleistocene palaeoenvironmental evidence are Terrains 3, 4 and 6. At any given point in time, older terrace remnants, lying just above the valley floor wetlands, would have enabled good access to water sources and to patches of higher ground, thereby creating an attractive location for hominin activity and resource exploitation. Historical accounts noted the presence of Lower Palaeolithic handaxes and rarer Middle Palaeolithic material from the low terrace of Terrain 3, although these are likely to have been *ex situ* within later Holocene deposits. Upstream of the study area, the gravels of the low terrace preserve organic deposits rich in mosses, dwarf birch and dwarf willow, associated with a cold-climate mammalian assemblage, including woolly mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), collared lemming (*Dicrostonyx henseli = torquatus*) and reindeer (*Rangifer tarandus*; Warren 1915). These deposits are known as the Lea Valley Arctic Beds (Fig. 4.11; Warren 1912; 1915) and have been radiocarbon-dated to the Late Pleistocene, 28,000–20,000 BP, immediately prior to the Last Glacial Maximum (LGM). In places, these former floodplain deposits are thought to have been locally reworked as frozen blocks of peaty sediment, under cold climate conditions, as the river continued to incise after the LGM (Gibbard 1994). Analysis of insect remains by Coope and Tallon (1983) suggested the presence of a sparsely vegetated landscape with meltwater puddles and the proximity of large herbivores, as indicated by the dung beetle genus *Aphodius*. The beetles indicated a comparable climate to that of modern arctic Russia, with mean summer temperatures of 9.5°C and mean winter temperatures of -10.9°C. On the basis of observations and deposit modelling, the LVMP study further identified zones with considerable potential for preservation of these important organic beds within Terrain 3, along both banks of the main channel.

For Terrain 4, deposits in the Stoke Newington area of north London have long been known for

their exceptional assemblages of Lower Palaeolithic archaeology (Prestwich 1855; Smith 1883; 1884; Harding and Gibbard 1983). At the nearby Nightingale Estate in Hackney, rich palaeoenvironmental evidence from the Highbury Silts and Sands (preserved within a palaeochannel) has indicated interglacial conditions with elevated summer temperatures, correlated with MIS 9 (Green *et al.* 2006). Although many historic records of handaxes from Terrain 4 are unstratified, deposits of archaeological and palaeoenvironmental potential are thus highly likely to occur within the fine-grained sediments that overlie and are sandwiched between the Pleistocene gravels of Terrain 4. These represent areas either within or marginal to the river channels of the Middle Pleistocene valley and would be expected to have been prime spots for animal and hominin activity. Equally, the overlying brickearth and colluvial deposits that cap the Pleistocene gravels of Terrain 4 are likely to have potential for both *in situ* and redeposited Palaeolithic archaeology.

Testing predictive models: the Medway Valley Palaeolithic Project

A recurring element of the study of past fluvial deposits concerns the migration of rivers through time, sometimes resulting in the preservation of sediments and contained archaeology and palaeoenvironmental evidence at distance from the modern river, or in other cases associated with a now extinct fluvial system such as the Bytham River (Rose 1994). One such project, the Medway Valley Palaeolithic Project (MVPP), focused on the investigation of aggregate deposits in north Kent and south-east Essex associated with the River Medway (Wenban-Smith *et al.* 2007a and b). Today, the Medway is an exclusively Kentish river, flowing northwards from its source in the Weald, through Maidstone and joining the Thames Estuary at Chatham. However, earlier in the Quaternary, the drainage pattern was rather different, with the Thames occupying a more northerly route than today and the Medway flowing across southeastern Essex to its confluence with the Thames. The path of the early Medway is therefore traced via substantial sand and gravel aggregate deposits in southern and eastern Essex, as well as northern Kent.

Amongst others, the MVPP built on an earlier ALSF-funded 2003 *Greater Thames Survey of Known Mineral Extraction Sites* (TEMES) undertaken by Essex and Kent County Councils (Essex County Council/Kent County Council 2004). This project was the first to create a GIS map and database for both banks of the Lower Thames estuary to the east of London, examining past, present and proposed aggregate extraction sites and related historic environment features in order to document important archaeological and geological sites within the area. The very high number of mineral extraction sites (c 1600) initially documented in the study area

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Fig. 4.12 The Greater Thames Survey of Known Mineral Extraction Sites project study area, showing zone of 3-D modelling in red

underlines the increasing development pressure in this region and emphasises the urgent need for protection and better management of this important archaeological and geological resource. From there, a smaller pilot study was developed for parts of the boroughs of Dartford and Gravesend in Kent and the unitary authority of Thurrock in Essex (Fig. 4.12). 3D modelling of deposits, based on borehole logs, was undertaken by the British Geological Survey, and each identified site in the revised study area was examined for Pleistocene and Holocene deposits, Palaeolithic and post-Palaeolithic archaeology and mineral-extraction related industrial archaeology, through a combination of desk-top survey and/or site visits to assess geological, palaeoenvironmental and Palaeolithic archaeological potential (Fig. 4.13).

Subsequently, the MVPP provided the opportunity to expand upon a part of the TEMES study area – that which related specifically to Medway deposits of Essex and Kent – by re-examining over 1300 borehole and other sedimentary records and carrying out fieldwork at over 40 sites. This was combined with a number of specialist analyses on exposures, in particular Optically-Stimulated Luminescence (OSL) and Amino Acid Racemization (AAR), in order to improve the geochronological framework of the Medway deposits. Within eastern Essex, a particular aim was to resolve the stratigraphical relationships between the various Medway gravel aggradations and the spatially-restricted fine-

grained channel deposits reported in the region (see Brown 1840; Lake *et al.* 1977; 1986; Roe 1999; 2001; Roe *et al.* 2009) by providing a series of dated tie-points within this sequence. The results confirmed the attribution of all ‘high level’ channel deposits to MIS 11, as previously suggested by Bridgland (1988; 2003) and Roe (2001), and all ‘low level’ channel deposits, together with the intermediate Rochford Channel, to MIS 9 (Bridgland *et al.* 2001; Roe *et al.* 2009; 2011; see Briant *et al.* 2012 for discussion), in addition to the well-constrained Last Interglacial channel deposits from the East Mersea Restaurant Site (Bridgland *et al.* 1995) and Hippopotamus Site (Bridgland and Sutcliffe 1995). In Kent, the MVPP proposed additional terrace sequences for both the Maidstone and Hoo areas. These might potentially represent depositional phases within temperate MIS stages, although the lack of interglacial deposits and the problems of incorporating estuarine sediments in the Hoo area into a terrace framework leave this matter unresolved.

A limited amount of palaeobiological data was recovered during the course of the MVPP. Most notable were samples from East Hyde borehole and Bradwell Hall, from the Tillingham palaeochannel previously described by Roe (2001) and considered to have accumulated during the late temperate substage of the Hoxnian interglacial, correlated with MIS 11 *c.* 400,000 BP. The analyses confirmed the presence of an unusual molluscan assemblage (following Roe and Preece 1995), the so-called

Lost Landscapes of Palaeolithic Britain

Site visit pro-forma GV

ALSF THAMES GATEWAY PROJECT GEOLOGICAL SITE VISIT (GV)

SITE **Date**

Visit by

GV1 Quantity of Pleistocene sediments present		0 - None/unknown	GV2 Location of Pleistocene sediments		0 - None/Unknown
		1 - Small amount			1 - On site/quarry floor
		2 - Moderate amount			2 - In quarry sides/walls
		3 - Abundant sediments			3 - At land surface adjacent to quarry, within or contiguous with property boundaries

GV3 Potential of sediments (physical environmental information)		0 - None	GV4 Potential of sediments (biological environmental information)		0 - None
		1 - Limited potential for sedimentological information (stone counts, heavy minerals)			1 - Limited potential for bio-environmental information (microfossils e.g. pollen)
		2 - Medium potential (some measurable features, e.g. x-beds)			2 - Medium potential (e.g. possibility of microvertebrates)
		3 - High potential (many measurable features, e.g. x-beds, clast fabrics, deformation structures)			3 - High potential (e.g. macrovertebrates, molluscs, beetles, plant macros)

GV5 Stratigraphic value of site		0 - None	GV6 Accessibility		0 - No deposit
		1 - Limited (e.g. cold stage gravels only)			1 - Poor: covered by roads or housing; no faces or very inaccessible faces
		2 - Medium (sediments with limited stratigraphic indicators)			2 - Moderate; faces with limited potential for cleaning; restricted or difficult top access
		3 - High potential (e.g. sediments of more than one stage with clear stratigraphic indicators)			3 - Good; direct unrestricted access to face and from above

Notes

Fig. 4.13 Example of a proforma for recording geological characteristics for The Greater Thames Survey of Known Mineral Extraction Sites project

'Rhenish fauna', which entered Britain during a period of confluence of the Thames and Rhine drainage systems and is equally known from the classic Lower Thames sites of Clacton-on-Sea (Essex), Barnfield Pit at Swanscombe and Dierden's Pit at Ingress Vale (both Kent; Kennard 1942; Kerney 1971). The molluscan and ostracod assemblages from these sites also provided significant palaeoenvironmental evidence, in particular revealing brackish conditions (corresponding with high sea-levels), as attested by the presence of hydrobiids

such as *Helebia* sp (= *Paladilhia radigueli* auctt.) and other marine taxa such as *Cerastoderma glaucum* at Bradwell Hall and barnacles at East Hyde), as well as the brackish water ostracod *Cyprideis torosa* (Preece, in Wenban-Smith 2007b).

In addition, all known Palaeolithic material in the study area was documented and two particular highlights are singled out. These include the discovery at Cuxton (Kent) of two contrasting types of handaxe, a cleaver and a ficon, within the same archaeological horizon. In addition, new OSL dating

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of the Cuxton site to *c* 230,000 BP (the onset of MIS 7) makes it the youngest site in the UK with an almost exclusively handaxe-focused material culture, at a time when Middle Palaeolithic Levalloisian assemblages were beginning to become common elsewhere in southern England. The re-dating of the site and the presence within a single assemblage of two very different types of handaxe thus has important implications for understanding the cognitive capabilities of early hominins and regional cultural variation. At the other end of the study area, in Essex, a single small flint waste flake was recovered from the Clinch Street/Canewdon Gravel at Westcliff High School for Girls. With an assumed age for the gravel of *c* 600,000 BP, this artefact represents the earliest evidence of hominin presence in proto-Medway deposits in either Essex or Kent.

In contrast to the archaeologically and palaeontologically rich river terrace deposits of southern England, other meso-scale studies concentrated on areas where the investigation of early hominin occupation and Quaternary palaeoenvironmental change had been relatively neglected, such as the Fenland rivers of Cambridgeshire, the rivers of south-west Britain and the river Trent in the English Midlands. The *Fenland Rivers of Cambridgeshire Palaeolithic Project* (FRCP) was conceived as a short collaborative project between Durham University, the University of Cambridge and Cambridgeshire County Council, in recognition of the fact that Cambridgeshire has received scant attention compared to the well-studied Palaeolithic landscapes of the neighbouring counties of Norfolk and Suffolk, despite having a diverse archaeological record dating back *c* 500,000 years. The project provided the first review of Lower and Middle Palaeolithic artefacts from sites across the county and synthesised lithostratigraphic and palaeoenvironmental records from the deposits of the major rivers flowing across the Cambridgeshire Fenland towards the Wash (the Great Ouse and Nene, as well as important tributaries such as the Cam; White *et al.* 2008a). The final product not only significantly enhanced the HER for this part of East Anglia but also determined the impact of past aggregates extraction and provided a reference point for establishing potential in the face of future extraction.

Closing the lacunae: Palaeolithic Rivers of Southwest Britain project

In similar vein, the *Palaeolithic Rivers of Southwest Britain* project (PRoSWeB) and (in part) the *Archaeological Potential of Secondary Contexts* project (APSC), tackled another region where baseline information was extremely sketchy and a geo-chronological framework for Pleistocene fluvial deposits was largely absent. Unlike other regions, the aggregates threats in the south-west were viewed as distinctive, comprising small, episodically exploited quarries, prohibition order sites and

local 'borrow' pits. The project, led by the Universities of Exeter and Reading, provided the first up-to-date statement of the known archaeological materials from the region's fluvial aggregate deposits, an assessment of the archaeological and geological potential of those deposits and guidelines for the management and mitigation of aggregates extraction (Hosfield *et al.* 2007). The study area focussed on the Rivers Axe, Otter and Exe and on the palaeo-Washford at Doniford Cliffs, modelling the evolution and development of these river systems, partially underpinning the resultant terrace models with OSL and integrating the poorly-known Lower and Middle Palaeolithic archaeological record. The PRoSWeB project also included a detailed programme of public outreach and dissemination activity, which is discussed further below.

The clear disparity with south-east England (where the Palaeolithic resource of counties such as Kent and Essex is comparatively well documented) was apparent at an early stage of the project, when desktop data collection and museum visits succeeded in increasing the number of known archaeological findspots by almost 50%. Although overall numbers are still small in comparison with south-east England, Palaeolithic artefacts were recorded in association with Terraces 5 of the River Exe, 2 and 5 of the River Otter, and the fill terraces of the River Axe, confirming a Lower Palaeolithic occupation in the Axe Valley and a Middle (and probably also a Lower) Palaeolithic occupation west of the Axe (Hosfield *et al.* 2007). Field investigations utilised new remote sensing methods, such as ground penetrating radar (GPR) and interferometric synthetic aperture radar (IFSAR), as well as OSL dating, fieldwalking of terrace landform surfaces, and coring/trenching of suitable fluvial deposits in order to map and characterise deposits with archaeological potential. The results of the fieldwork highlighted the fill terrace nature of the Axe sediments and the contrasting deposit types present, including extensive sequences of fluvial, colluvial and debris deposits of potential interest to the aggregates industry at sites such as Broom and Chard Junction. At the same time, the Axe was particularly identified as a system where fine-grained units may be present, in which artefacts may be concentrated with minimal reworking, together with organic channel deposits for palaeo-environmental recovery. In contrast, the landforms and deposits from the Exe and the Otter river valleys were characterised by strath terrace systems (ie those resulting from the river downcutting through bedrock), with relatively thin sediments (in comparison to the Axe terraces), frequently heavily cryoturbated and/or truncated in some locations. These deposits are unlikely to be of high priority interest for aggregates extraction and equally, any contained archaeology is thought likely to have been either significantly disturbed or reworked (Hosfield *et al.* 2007).

The extensive programme of OSL dating undertaken during the PROSWEB project revealed that the modern north-south drainage patterns of the Exe, Otter and probably also the Axe are of relatively recent origin, post-dating a major realignment of palaeo-drainage systems sometime after MIS 9 (around 300,000 BP). As well as providing a more secure dating context for Palaeolithic sites such as Broom in the Axe Valley, the new geochronological framework had further implications for the archaeological record, implying that any pre-MIS 9 artefacts were likely to have been substantially reworked, resulting in single artefact or low concentration findspots.

One can hope that as predictive estimates of potential move beyond simple counts of known finds and towards such reconstructions of palaeogeography, curatorial decisions will become better informed, and the hopes for predictive tools expressed in Chapter 1 will be fully realised. However, another issue of scale is at work. Even the most prolific historical sites rarely yield major new riches, even from developer-funded projects over relatively large areas. Modern scholars rarely have the luxury of unlimited time or access to the vast expanses of deposits available to previous generations. Apparent abundances may have been highly localised or entirely illusory, as highlighted at the site of Sturry in the Kentish Stour, where the 500 plus handaxes in museum collections were estimated to have occurred at the rate of just one per six tons of gravel (Dewey 1926). This is not always the case though, as shown by the recent spate of work at Purfleet, which produced hundreds of new finds and completely revised our understanding of the MIS 9 human landscape (Schreve *et al.* 2002; Bates *et al.* 1999; Bridgland *et al.* 2012).

Investigating the northern boundaries: Trent Valley Palaeolithic Project

The final case study presented here also focussed on what might previously have been considered to be a more marginal area for Lower and Middle Palaeolithic settlement, at the northern edge of hominin territories. The *Trent Valley Palaeolithic Project* (TVPP), a collaborative project by Durham University and the University of Birmingham, aimed to reveal the Palaeolithic archive of the Trent Valley, to establish a robust geological, chronological and palaeoenvironmental context for these assemblages and to provide an informed basis for future resource management. This was achieved through exhaustive study of museum and private artefact and fossil collections, combined with extensive fieldwork in operational quarries, palaeoenvironmental sampling, a programme of OSL and AAR dating and novel mathematical modelling of fluvial incision as recorded by the river terrace deposits. Significant new data were generated, including the discovery of new sites of archaeological and palaeoenvironmental importance, evidence for a hitherto unrecog-

nized late Middle Pleistocene glaciation and previously unrecognized fluvial deposits, the results of which are presented in an extensive series of publications including a monograph (Bridgland *et al.* 2014), a field guide (White *et al.* 2007a) and various journal articles (Howard *et al.* 2007; 2011; White *et al.* 2007b; 2008b; 2009; 2010).

The Trent sedimentary sequence spans around a half a million years, with its earliest deposits known to pre-date the Anglian glaciation, *c.* 450,000 BP. It plays an important role in the wider reconstruction of Pleistocene palaeo-drainage in Britain, and in particular its previous contribution to the headwaters, in the west Midlands, of the Bytham River (also referred to as the Baginton–Ingham river system), which existed prior to the Anglian glaciation (cf Rose 1994; Bridgland 2010). Furthermore, the Trent is the largest of the British rivers that combined to create the post-Anglian Fen Basin fluvial network, a major northward-flowing system now submerged beneath the North Sea and which doubtless formed an important corridor for animal movement and human migration. Over the last 500,000 years the course of the Trent has changed significantly, probably as a result of glaciations, and indeed the Trent is unique amongst the major English rivers in that it has flowed in close proximity to (and has sometimes been over-ridden by) ice sheets during several glacial episodes (White *et al.* 2007a; 2010; Bridgland *et al.* 2010).

The Palaeolithic record of the east Midlands has traditionally been viewed as patchy and uninspiring compared to that from East Anglia, despite attempts to raise its profile by several review articles (Posnansky 1963; McNabb 2001; McNabb 2006; Graf 2002). The issue has been compounded by the absence of high-quality flint in the area, a problem that would have been equally significant for early hominins in the landscape. As a result, the majority of artefacts have been made on quartzite, a raw material that rapidly becomes abraded by fluvial transport (tested by the TVPP in taphonomic experimentation), is difficult to spot against a quartzite-rich gravel (in contrast to flint) and often difficult to differentiate from natural material even when fresh. Although few find-spots have yielded more than a handful of stone tools, careful prospection by local collectors has amassed significant assemblages (by Trent Valley standards) from the villages of Hilton and Willington in Derbyshire, at Beeston in Nottinghamshire and the beach deposits at Kirmington in north Lincolnshire. These, and all other documented finds, are comprehensively reviewed in Bridgland *et al.* (2014). Little can be stated unequivocally about the earliest human occupants of the Trent system, with only the Waverley Wood lithic assemblage, including spectacular examples of volcanic andesitic handaxes (Lang and Keen 2005a and 2005b; Keen *et al.* 2006) and other scattered finds from the Baginton–Thurmaston Sands and Gravels providing any evidence for pre-Anglian hominin settlement in the wider Midlands region. The immediate post-

Anglian period (MIS 11-9) is equally obscure archaeologically, a fact that has previously been attributed to the Anglian extinction of the Bytham River, removing the main conduit into the Midlands (Keen *et al.* 2006), or to the greater proximity of the Trent region to the ice margins of the MIS 10 and 8 glaciations (Bridgland *et al.* 2014). However, the TVPP has revealed that little remains of the fluvial deposits laid down during MIS 11-9 so the absence of an archaeological signature from this period may be entirely explicable in terms of the paucity of terrace deposits of this age. In addition, large collections of heavily rolled artefacts in the MIS 8, 6, 4 and 2 terrace deposits doubtless reflect periods of earlier hominin occupation rather than their contemporaneous presence. The majority of artefacts are derived into the MIS 8 terrace, leading to the conclusion that the bulk of the assemblages probably belong somewhere in the period MIS 11-8, even if the gravels that contain them are much younger.

As with its Palaeolithic archive, the Pleistocene fossil record of the Trent is similarly poorly known compared to equivalent records from the Thames and many of the East Anglian rivers. Much of this may be down to the acidic groundwater conditions of the East Midlands, which do not favour long-term preservation of bone and shell, although there are notable exceptions such as the Whitemoor Haye woolly rhino site (see below). In addition, the more recent commercial aggregate exploitation history of the Trent, when compared to the Thames, has been through mechanical excavation as opposed to hand-digging, so the scant palaeontological material present is likely to be destroyed, missed or simply not collected. As noted in Bridgland *et al.* (2014), the mechanisation of aggregate extraction in the Trent has also created a bias against all but the largest vertebrate remains being collected by a sharp-eyed machine operator or emerging onto the reject piles of over-sized material at the processing plant and hopefully picked up by collectors.

The TVPP undertook a complete review of the palaeoenvironmental evidence, including the compilation of a gazetteer of the most significant collection of Pleistocene vertebrates from the Trent valley, the Brandon collection, now housed in the National Museum of Scotland in Edinburgh and the University Museum of Zoology, Cambridge. This collection comprises *c* 2000 bones, teeth and antlers from a number of localities between Newark and Lincoln. Additional assemblages of molluscs, pollen, plant macrofossils and insects were also generated through sampling at field sites, thereby adding substantially to the body of palaeoenvironmental knowledge from the Trent system. With the exception of localities such as Waverley Wood (Shotton *et al.* 1993), Brandon (Maddy *et al.* 1994) and Brooksby (Stephens *et al.* 2008), little is known of pre-Anglian palaeoenvironments in the Midlands, the vast majority of sites yielding palaeobiological proxies are from MIS 7 and later. Of particular note from the TVPP are the discovery of

an important new MIS 7 site at Norton Bottoms in Lincolnshire (White *et al.* 2007b) and re-evaluation of the rich MIS 7-6 vertebrate assemblages from the Balderton terrace (Bridgland *et al.* 2014). The integration of the available palaeobiological datasets not only provides important contextual information for the archaeological assemblages but also assists, from a biostratigraphical perspective, in constraining the terrace age model proposed.

MICRO-SCALE: NEW SITE-SPECIFIC INFORMATION FROM THE FLUVIAL RECORD

As well as the landscape-scale fluvial studies described above, which occasionally revealed opportunities for more detailed investigation of individual sites, a number of ALSF projects focussed exclusively on single localities, either where archaeological evidence was discovered in association with palaeoenvironmental proxies, or where artefacts were absent but where other sources potentially provided valuable contextual climatic, environmental, biochronological or geographical information related to hominin occupation. With respect to the latter, it is important to recognise here the input of funding from a second ALSF provider, namely English Nature (now Natural England), since investigation of purely palaeontological sites fell more comfortably within their geodiversity remit. Almost without exception, every one of these investigations was undertaken as a rescue excavation in active quarries, where short-lived opportunities existed to salvage exceptional material at short notice.

Norton Subcourse

English Nature was able to fund a number of important projects, including rescue excavation at Norton Subcourse Quarry, Norfolk, led by Queen Mary, University of London. The site lies within the Crag Basin, which contains Early and early Middle Pleistocene marine sediments of the Norwich Crag and Wroxham Crag Formations, overlain by an extensive deposit of fossiliferous organic muds (the Cromer Forest-bed Formation, of early Middle Pleistocene age) and fluvial gravels of the Bytham River, the whole capped by Anglian glacial deposits. Although purely palaeoenvironmental in focus, the site is broadly coeval with some of the oldest evidence for hominin occupation in Britain, such as that at Pakefield, Suffolk (Parfitt *et al.* 2005), and as such can provide significant new information on early human environments and the landscapes of the early Middle Pleistocene in Britain. The pollen spectra indicate a temperate climate, spanning at least half of an interglacial. Molluscs, ostracods, fish and rare bird remains were also recovered, together with small mammals including an extinct water vole (*Mimomys savini*), extinct horse (*Equus altidens*), a cluster of large hyaena coprolites and remains of hippopotamus

(Lewis *et al.* 2004). The combined evidence appears to indicate that the site reflects a previously unrecognised temperate episode in the British early Middle Pleistocene. This obviously offers a prime example of sites where archaeology may be absent, but where the potential for understanding the landscapes of human presence and absence is immense (see Chapter 2).

Aylesford Gravel Pit

ALSF rescue investigations were also carried out on deposits of the Second Medway Terrace at Aylesford Gravel Pit SSSI (Kent) by the Kent RIGS (Regionally Important Geological and Geomorphological Sites) Group. A component of the project included the appraisal of the Aylesford vertebrate assemblage housed in Maidstone Museum (Schreve unpubl.), which complemented the stratigraphical, geochronological and archaeological investigations undertaken by the MVPP described above. The faunal analysis revealed a predominantly cold-climate (but taphonomically mixed) assemblage dominated by woolly rhinoceros (*Coelodonta antiquitatis*) with smaller numbers of woolly mammoth (*Mammuthus primigenius*), wild horse (*Equus ferus*), wild boar (*Sus scrofa*), giant deer (*Megaloceros giganteus*), red deer (*Cervus elaphus*) and large bovid. Pits in the Aylesford area have also produced a relatively rich but evidently derived Lower Palaeolithic handaxe assemblage, as well as some Middle Palaeolithic Levalloisian material that may or may not be contemporary with the faunal material. The age of the Aylesford Gravel Pit SSSI deposits remains inconclusive. The deposits were OSL dated to *c.* 250,000–270,000 BP as part of the ALSF project (E Jarzembowski pers. comm., in Wenban-Smith 2007a). However, the presence of younger terrace deposits in the southern side of the quarry and of extensive solifluction gravels capping the fluvial sediments (Wenban-Smith *et al.* 2007a) potentially obscures the relationship of the date to the faunal assemblage, little of which bears any stratigraphical information. An additional complicating factor is the presence of both a lower and upper gravel member in the Aylesford terrace, separated by an interglacial 'brickearth' (the Kingsnorth Member) attributed to MIS 5e by Bates *et al.* (2002) although the attribution has yet to be confirmed on biostratigraphical or geochronological grounds (Bridgland 2003). The Aylesford gravel deposits appear to 'sandwich' these interglacial sediments and thus apparently cover both a pre-Ipswichian period of cold climate conditions, equated with MIS 6 and parts of the Devensian (last glaciations). It is not known from which part of the Aylesford Gravel Formation (ie pre- or post- the Kingsnorth interglacial Member) the fossil mammal remains come, and certainly, on the basis of the limited stratigraphical data preserved on the specimens, they could easily come from both.

Welton-le-Wold

Similar chronological issues were faced by the project *Towards an Understanding of the Ice Age at Welton-le-Wold*, undertaken by the Heritage Trust for Lincolnshire (Aram *et al.* 2004). This site, near Louth in Lincolnshire, exposes a complex glacial sequence, including up to 13m of glacial tills overlying *c.* 10m of silts, sands and flint-rich gravels. Three distinctive till units (Welton Till, Calcethorpe Till and the Marsh Till, the last of Devensian age) are visible in the quarry, although in no place do all occur in stratigraphical superposition and the dating of the lower two tills has long been controversial. The importance of the site lies in the fact that it was for many years considered to provide evidence in support of a 'Wolstonian' glaciation in eastern England, stemming from the presence of mammalian remains and Palaeolithic artefacts in gravels underlying two generations of till, the younger of which was attributed to the Devensian (Alabaster and Straw 1976; Wymer and Straw 1977; Straw 2005). In the 1970s, prior to the widespread recognition of pre-Anglian hominin settlement in Britain, the artefacts and fauna were generally regarded as being of Hoxnian (late Middle Pleistocene) age. The ALSF project undertook a re-evaluation of artefact and faunal assemblage to gather fresh information about the date and context of the material, a programme of borehole survey to re-assess the stratigraphical context of the 1960s finds, and examination of the entirety of the Pleistocene sedimentary sequence. At the same time, a parallel series of outreach activities was designed to enhance immediate and long-term intellectual access to the geological and archaeological resource (Aram *et al.* 2004).

Re-examination of the limited faunal assemblage by Schreve (in Aram *et al.* 2004) confirmed the presence of a minimum number of two straight-tusked elephants (*Palaeoloxodon antiquus*), a single individual each of horse (*Equus* sp.) and red deer, as well as two large bovids, previously misidentified as giant deer (Alabaster and Straw 1976). The assemblage can be subdivided into two parts: a derived component (horse, red deer and large bovid) and a relatively fresh component (straight-tusked elephant). The former is not diagnostic of any particular climatic conditions, although the presence of horse indicates the availability of open grassland habitats. Equally, age determination is difficult, other than the fact that the occurrence of horse precludes a date within the Last Interglacial and the Early Devensian. The derived component may therefore represent any interstadial, interglacial or period of cold climate prior to the Last Interglacial. The fresh component consists only of straight-tusked elephant, an animal found solely in association with temperate-climate episodes during the Pleistocene. Although it is not age-diagnostic (occurring from the early Middle Pleistocene until the Last Interglacial in the UK), its presence



Fig. 4.14 The Whitemoor Haye woolly rhinoceros shortly after its discovery (photo @ Birmingham Archaeology)

indicates that the sands and gravels were laid down during an interstadial or interglacial episode. New OSL age-estimates undertaken by Aram *et al.* (2004) place the entire sequence between MIS 10 and 6. However, this is challenged by the findings of the TVPP described above, which assert that at least one of the two lowermost tills could be Anglian (if not both), making the faunal and archaeological assemblage not only pre-Anglian in age but if true, the most northerly evidence of pre-Anglian occupation in Britain yet discovered. The artefacts from Welton are discussed further in Chapter 5 (Box 5.2).

Whitemoor Haye Quarry

One of the most spectacular palaeontological finds to be made during the course of the ALSF lifetime was the recovery of the front half of a skeleton of woolly rhinoceros from deposits of the River Tame (a Trent tributary) at Whitemoor Haye Quarry, near Alrewas in Staffordshire. Follow-up investigations led by the University of Birmingham (project number IW/2002/127; Buteux *et al.* 2003) were funded by English Nature, following the chance find in a single scoop of a machine operator's bucket (Fig. 4.14). The bones were in excellent condition and represent the finest example of a woolly rhino found in Britain this century, and one of the most important finds of a Pleistocene fossil mammal skeleton made in the UK in the last 100 years. The full results of the project are reported in Schreve *et al.* (2013). Thirty-three separate skeletal elements of the rhinoceros were recovered, predominantly associated elements, including a magnificent cranium with complete dentition (Fig. 4.15),

strongly suggesting that these were originally in articulated (or near-articulated) position in the ground. Based upon additional material collected, the remains of at least four adult woolly rhinoceroses are preserved at the site (the most abundant species within the vertebrate assemblage), together with reindeer (*Rangifer tarandus*), woolly mammoth, horse, bison (*Bison priscus*) and wolf (*Canis lupus*). Preservation of Pleistocene vertebrate remains is extremely unusual in this part of the Midlands, given the absence of calcareous groundwaters. However, the undulating surface of the Mercia Mudstone bedrock would have provided opportunities for localised ponding and stagnation of water and organic debris, leading to a near-neutral pH and a reducing environment more favourable to bone preservation. Analysis of pollen, plant macrofossil and arthropod (beetle, chironomid and caddisfly) remains suggests that the rhinoceros was rapidly buried on a braided river floodplain surrounded by a predominantly treeless, herb-rich grassland. Comparative calculations of coleopteran and chironomid palaeotemperatures suggest a mean July temperature of 8–11° C and a mean December temperature of between -22° C and -16° C. Radiocarbon age estimates on skeletal material, supported by OSL ages from surrounding sediments, indicate that the rhinoceros lived at around 41,000–43,000 BP (Schreve *et al.* 2013).

Lynford Quarry

The final example illustrated in this section can be described as a flagship site for our understanding of Middle Palaeolithic technology and Neanderthal

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Fig. 4.15 Skull with complete dentition of the Whitmoor Haye woolly rhinoceros *Coelodonta antiquitatis* (scale bar in cm)

environments in Britain. This is the site of Lynford, in the valley of the River Wissey in Norfolk, which was discovered during active quarrying in 2002 and subsequently excavated, with support from the ALSF, by the Norfolk Archaeological Unit and associated specialists. During quarrying, a palaeochannel containing *in situ* faunal remains and a rich associated Mousterian flint assemblage was revealed (Boismier 2003; Schreve 2006; Boismier *et*

al. 2012; see also Chapter 2, Figs 2.28 and 2.29 and Box 5.8). With the exception of a handful of mammalian remains from gravels underlying the palaeochannel, all of the fauna comes from the palaeochannel itself (Fig. 4.16), and is thought to represent an accumulation within a former meander cut-off. The age of the site was established by geochronology and biostratigraphy. Radiocarbon dating of woolly mammoth bone and molar



Fig. 4.16 Excavation of the Lynford site (courtesy of the Norfolk Museums Service)

KILLING THE MAMMOTH

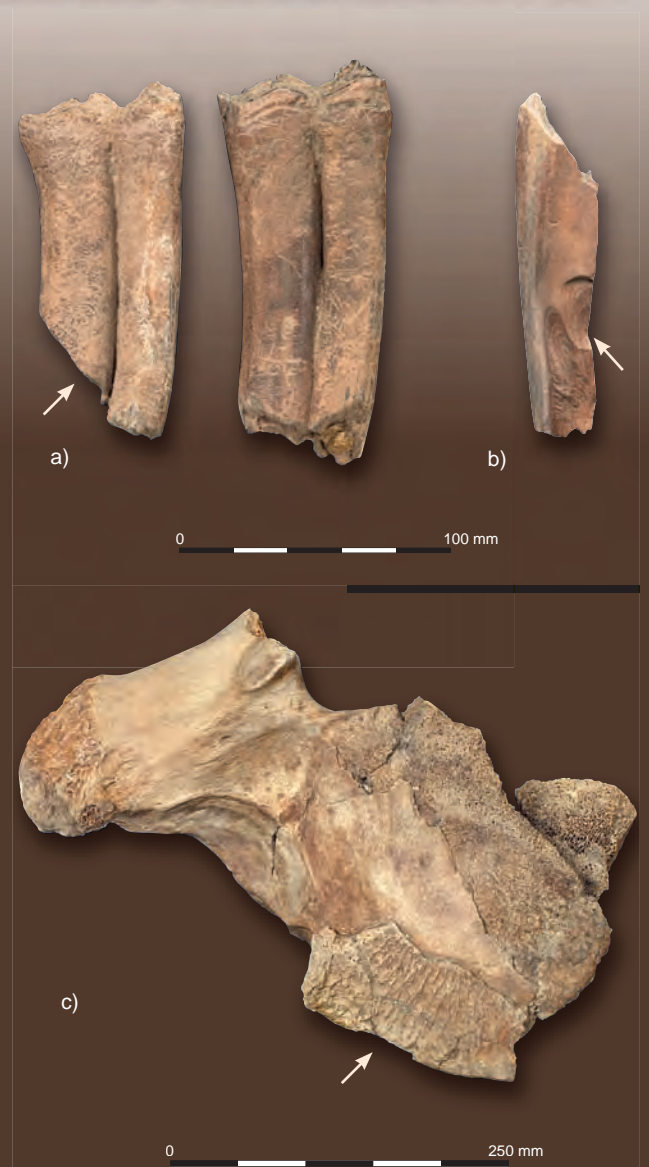
BOX 4.2



The Lynford vertebrate assemblage not only sheds light on Middle Devensian palaeoenvironments and mammalian faunal history in Britain but also contributes to our understanding of Neanderthal diet and subsistence behaviour in a marginal environment. The richness of the faunal vertebrate assemblage is mirrored by that of the archaeological assemblage, including more than 2700 artefacts, of which 47 are handaxes, mostly in mint-fresh condition (White, in Boismier *et al.* 2012). The faunal assemblages represent a palimpsest of material, with some specimens deposited rapidly under very still water conditions, and others laying on the land surface for variable amounts of time before being incorporated into the channel fill through debris flows, bank collapse or overbank flooding, over a period of perhaps tens of years. Although there is abundant evidence of fragmentation, particularly of mammoth crania and tusks (probably the result of trampling), the general lack of abrasion, root-etching and evidence of fluvial winnowing on the fauna, together with the presence of refitting lithic pieces, suggests that the assemblages can be interpreted as a coherent whole.

Direct evidence of faunal exploitation comes from horse, reindeer and woolly rhinoceros teeth and bones that appear to have been deliberately smashed during marrow extraction activities.

Evidence for mammoth utilization is harder to establish, although the predominance of prime individuals, the absence of the meatiest limb bones (despite other large elements being present), the paucity of carnivore gnaw marks and evidence for tool resharpening and damage on the tips of the handaxes collectively support the view that Neanderthals were coming to the site deliberately to exploit, if not to hunt, mammoth. The site itself presents certain advantages for this endeavour, since Neanderthals could have actively 'shepherded' mammoths into the swampy channel, tiring them out before moving in for the kill, a strategy developed by early hominins in Britain as long ago as 500,000 years BP. Interestingly, the Lynford mammoth remains also present an exceptional number of pathologies, much higher than has been seen in other mammoth assemblages where occasional damage is usually the result of inter-specific fighting. Here, the pathologies are clustered in key, vital areas of the body, leading to speculation that they may result from previous, failed hunting attempts. Clear evidence for the exploitation of large and dangerous megafauna by Neanderthals exists elsewhere in Europe; there is no reason to suspect that British populations were any less proficient.



4.2.1 Modified bones from Lynford

- a) Horse molars broken during extraction of marrow from the mandibular cavity (arrow)
- b) Reindeer tibia fragment showing impact scars from marrow extraction (arrow)
- c) Partial mammoth vertebra showing attached fragment of adjacent vertebra (arrow), broken while being prised apart

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fragments from the main channel yielded age estimates of $53,700 \pm 3100$ BP (OxA-11571) and $> 49,700$ BP (OxA-11572), indicating an age for the site in excess of 50,000 years, whereas OSL ages of $64,000 \pm 5000$ and $67,000 \pm 5000$ BP place the deposition of the channel sediments at the transition from MIS 4 to 3. In terms of its species composition, the Lynford mammalian assemblage is typical of the Middle Devensian in Britain, correlated with MIS 3 (Currant and Jacobi 2001). This period overall represents a modest climatic amelioration but is characterised by numerous abrupt climatic oscillations occurring on a submillennial scale.

The vertebrate faunal assemblage comprised just over 2000 individually-numbered large mammal finds (1300 of which could be identified to species, genus or Family level), together with over 2000 microvertebrate remains and other fragments from wet-sieved bulk samples taken for palaeoenvironmental analysis. In addition, one quarter of all excavated spoil was sieved for the recovery of faunal remains, yielding over 26,400 specimens from dry-sieved soil residues and over 17,400 from wet-sieved spoil residues. Twelve mammalian taxa (including *Homo*, represented on the basis of the artefacts), four fish taxa, one amphibian taxon and one bird taxon were recorded. The mammal assemblage is dominated by remains of eleven woolly mammoths (Fig. 4.17), all prime adults apart from a single calf and mostly male where determinable, followed by reindeer, woolly rhino, bison, horse, wolf, red fox (*Vulpes vulpes*), brown bear (*Ursus arctos*), spotted hyaena (*Crocuta crocuta*), ground squirrel (*Spermophilus* sp.) and narrow-skulled vole (*Microtus gregalis*). The remaining vertebrates

comprise pike (*Esox lucius*), three-spined stickleback (*Gasterosteus aculeatus*), a member of the carp family (Cyprinidae sp.) and perch (*Perca fluviatilis*), together with crake (*Porzana* sp.) and common frog (*Rana temporaria*). The combined palaeoenvironmental evidence from plant remains, pollen, molluscs, insects and vertebrates indicates open conditions dominated by grasses, sedges and low-growing herbaceous communities with small stands of birch or scrub, acid heath or wetlands, adjacent to a source of slow-flowing permanent water. Beetle remains suggest that the mean temperature of the warmest month (July) lay somewhere between 14°C and 12°C , with the mean temperature of the coldest months (January/February) at or below -15°C (Boismier *et al.* 2012). The implications of the faunal assemblage in terms of interpreting Neanderthal subsistence behaviour are discussed in Box 4.2.

WIDER ENGAGEMENT

One of the most important roles of the ALSF involved the raising of awareness and strengthening of contacts between those working in the aggregate extraction environment. These include quarry companies, planning authorities, geologists, archaeologists, Quaternary scientists, other specialists and members of the public whose local landscape has been impacted by past or present quarrying. With this in mind, ALSF funding was directed towards a major public exhibition that highlighted the Palaeolithic and Pleistocene record and emphasised the role of aggregate extraction in enhancing our knowledge of early prehistory. The



Fig. 4.17 Associated upper molars of *Mammuthus primigenius* from Lynford, Norfolk (scale bar in cm)

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Museum of London's 'London Before London' gallery tells the story of the Lower Thames Valley from the arrival of the earliest hominins during the Middle Pleistocene to the founding of Roman Londinium in the mid 1st century AD. The gallery provided a unique opportunity in the UK to engage the public by showing off over 1500 specimens of superb fossil and artefactual material, many of them from excavations associated with gravel extraction.

Dissemination of Palaeolithic and Pleistocene research findings in Britain was also promoted through the funding of a major monograph publication, 'The Thames Through Time' Volume 1, by Morigi *et al.* (2011), which formed the first of a four-part series coordinated by Oxford Archaeology. The monograph series focussed on the archaeology of the Pleistocene gravel terraces of the Upper and Middle Thames Valley, which were intensively worked for gravel extraction during the 19th and 20th centuries. The region remains a major focus for aggregate operations today, with primary extraction set to continue at a high level for the foreseeable future engendering some of the most intensive archaeological activity in England in recent years. The series was particularly devised to facilitate intellectual access to excavation results for professional practitioners (benefitting heritage management and curation, informing professional practice, advancing the regional research agenda, and

supporting the teaching of archaeology) as well as being tailored for the informed non-specialist reader, including especially the voluntary archaeological sector and a diverse range of non-archaeological organisations with convergent interests in the protection and management of the river and its surrounding landscape.

Several of the meso-scale projects described above contained elements of public engagement, such as the provision of public information leaflets and talks to specialist interest societies. In many of the regions outside East Anglia and the South-East, however, where historically interest in the Palaeolithic has been comparatively limited, the importance of building networks between stakeholders, and of regional 'champions', becomes all the more important. In this respect, the Shotton Project: a Midlands Palaeolithic Network led by Birmingham University identified the key role played by the late Professor Frederick Shotton, who for more than fifty years maintained a regional network of local enthusiasts who worked with quarry companies to discover and record the Pleistocene geology and archaeology of the Midlands. With the death of Professor Shotton in 1990, much of the research momentum was lost. The ALSF-funded *Shotton Project* (based in the counties of Herefordshire, Leicestershire, Rutland, Shropshire, Staffordshire, Warwickshire and Worcestershire) was therefore designed to forge new links between aggregates



Fig. 4.18 Palaeolithic geoaerchaeology walk at Ottery St Mary (Devon), 2006, by PRoSWeB

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Fig. 4.19 Montage of images from the Royal Holloway 'Day In the Ice Age' (19a-d), showing flint knapping, pollen analysis, demonstration of vertebrate fossils and spear-making and cave painting activities for children

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companies and their employees, archaeologists, palaeontologists, geologists, local societies, museums and schools, in order to recreate a network dedicated to systematic and regular monitoring of sand and gravel workings for finds and deposits of significance, while investigating and promoting interest in the Palaeolithic. The PROSWeB project in south-west Britain was equally successful in developing new networks to promote Palaeolithic and Pleistocene research in the region, including (amongst other activities) the provision of geoarchaeology walks (Fig. 4.18), schools activity days and teaching resource boxes, containing replica Palaeolithic stone tools and resource cards, thereby ensuring a maintainable resource that could continue to promote interest in the Palaeolithic archaeology and Pleistocene geology of the south-west region beyond the lifetime of the project.

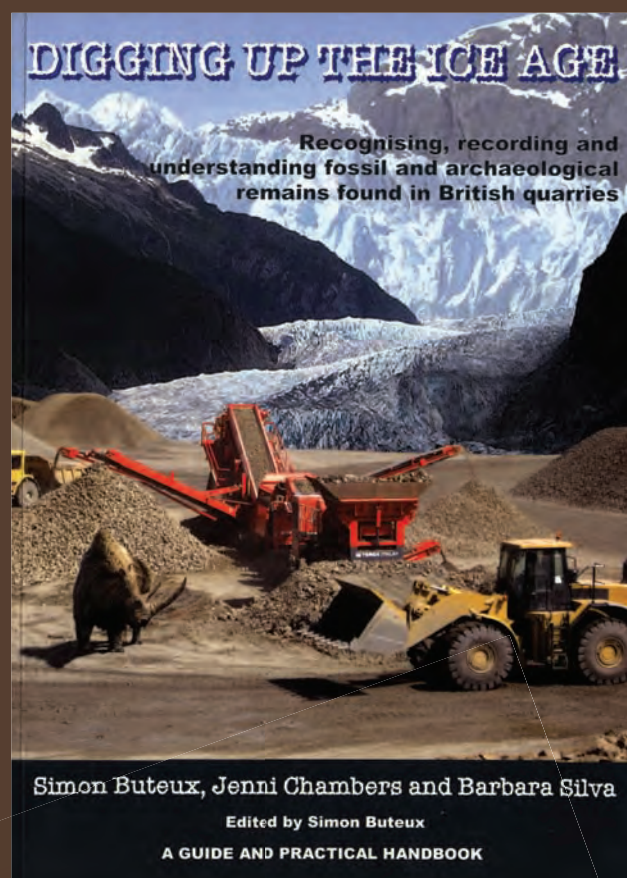
Following on from the success of the Shotton Project in the Midlands, this integrated approach was extended to the macro-scale through the flagship *National Ice Age Network* (NIAN) project, operating from four regional centres based in the Universities of Birmingham, Royal Holloway University of London, Southampton and Leicester and uniquely co-funded through the ALSF by



SHEDDING LIGHT ON THE DARK ARTS

BOX 4.3

One of the most successful examples of public engagement came from the National Ice Age Network project (NIAN) which designed and distributed a series of four bespoke 'recognition sheets', covering stone tools, sediments, vertebrate fossils, and molluscs, insects and plant remains. The leaflets were pitched in such a manner that they would appeal and be of interest to as wide an audience as possible, including but not limited to quarry personnel, commercial archaeologists and the general public. Distribution was widespread, including collaboration through the PRoSWeB project and downloads through the NIAN website, as well as an invitation from the Council for British Archaeology to supply 7500 packs of the four recognition sheets in the February 2007 edition of *British Archaeology* magazine. Their widespread distribution has brought information regarding Ice Age evidence to a huge audience. At the time of writing, over 42,500 stone tool recognition sheets and 32,000 copies of the other three sheets have been distributed and distribution is still ongoing. Sheets have been used by Finds Liaison Officers, for AS Level and undergraduate teaching and by the general public to help spot and identify Ice Age remains and artefacts. The project further worked closely with museums across England, reviewing the Palaeolithic and Pleistocene collections and developing a travelling display of museum panels, tailored for the individual regions, and produced a handbook for the recognition and recording of remains in quarries (Buteux *et al.* 2009).



4.3.1 National Ice Age Network project's "Digging up the Ice Age"



4.3.2 National Ice Age Network project "Recognition sheets" Download recognition sheets from http://archaeologydataservice.ac.uk/archives/view/nian_eh_2010/downloads.cfm

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English Heritage (now Historic England) and English Nature (now Natural England). The overarching goals of the project were threefold:

- To develop a national network of stakeholders and other interested participants to raise awareness of Palaeolithic archaeology and Pleistocene geology
- To undertake a detailed programme of outreach and dissemination activities
- To create an infrastructure throughout England to promote the regular and systematic monitoring of sand and gravel workings in order to assess their potential for providing Palaeolithic and Pleistocene finds that can be used to reconstruct past environments.

Through the NIAN project website, a database of nearly 1100 participants was established, including museum staff, local government archaeologists, academic departments and researchers, local archaeological and geological societies and members of the public. This network later performed an important consultation role when NIAN coordinated preparation of English Heritage's National Research Framework for the Palaeolithic/Pleistocene. Over 100 outreach events were carried out, including public lectures, society presentations and hands-on training sessions, as well as major 'Day In the Ice Age' public events in the four regional centres (Fig. 4.19). Twenty five thousand copies of an A4 colour duplex leaflet on the Ice Age were produced and distributed to museums, commercial archaeologists, academic departments, local societies and relevant conferences, together with a number of 'recognition sheets' for the identification of different remains (Fig. 4.20; Box 4.3).

Dealing appropriately with significant Ice Age remains uncovered during sand and gravel quarrying is a very important aspect of environmentally sustainable aggregate extraction. Although quarrying provides the opportunity to bring such remains to light, because of its ultimately destructive nature, there are no second chances. It was a premise of the NIAN project that these issues were not sufficiently appreciated both by those in the aggregates industry and by those in charge of regulating the industry – the minerals planners and their advisors. For this reason, the NIAN project was funded to tackle an issue that goes to the heart of sustainability and the aims of the ALSF.

However, the extent to which the importance of Palaeolithic and Pleistocene remains uncovered during quarrying was not appreciated was underestimated at the outset of the project. This was compounded by widespread misapprehension on the part of some quarry companies that the

recording and recovery of significant remains would entail significant disruption to aggregates extraction, a view heavily coloured by their experiences with developer-funded surface archaeology preservation by record. As well as the outreach aspects of the NIAN project, a significant element was to have been a field-based survey of all active quarries in England to assess their potential to yield significant Ice Age remains, combined with GIS modelling of this potential. In this respect, NIAN adopted the same methodology as projects described above but sought to apply it at a national level, in the hope of developing a 'light touch' procedure for future monitoring, agreed in collaboration with the aggregates industry. Very many in the industry were sympathetic to and supportive of this aim, which built on a long tradition of voluntary collaboration between the industry, geologists and amateur collectors. Unfortunately, in the course of negotiations with the larger companies in the industry, ultimately at the request of the quarry companies through the Quarry Products Association (QPA, now the Mineral Products Association), a consensus developed that such collaboration was not currently in the interests of the QPA's members and would not be until required by future legislation.

The QPA expressed concerns that Pleistocene remains uncovered within and beneath the 'aggregate body' was a new responsibility for the industry to assume, presenting the possibility of significant disruption to extraction, health and safety concerns, and the possibility of further planning constraints in the future. The argument that the long tradition of successful collaboration between quarry companies and researchers at the local level showed that this was not the case, was not accepted. Despite support from English Nature and English Heritage in these negotiations, the proposed national audit of the 'Pleistocene potential' of active quarries had to be largely abandoned. Many aggregates companies fully appreciate that taking responsibility for the significant Ice Age remains uncovered during quarrying is something that, in their goal of achieving environmentally-responsible extraction, they should be concerned with. The door was left open to continue negotiations on the matter once other pressing matters facing the industry, including the increasing costs of archaeological mitigation, had been satisfactorily resolved. Such renewed negotiations could not take place within the duration of the project, however, and remain a matter for the future. The hope is that these negotiations have laid a foundation for a more positive approach to be developed in due course. Revealing the mysteries of our distant ancestors and past environments through quarrying has major potential benefits for science and society, but the industry as a whole needs to capitalise on this.