Chapter 2: Methods for reconstructing Ice Age landscapes

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INTRODUCTION

The practice of Palaeolithic archaeology in the field is firstly about geology: the sediments and landscapes features that form the preservational context of archaeological remains. In nearly all instances (certainly for the Lower Palaeolithic), these preservational contexts have been deposited naturally and understanding their formation and spatial distribution is fundamental to a correct interpretation of the archaeological signatures found in them. Such an approach is therefore in essence about reconstructing Pleistocene geographies and palaeolandscapes (Butzer 1982) and using this information to inform our understanding of the Palaeolithic archaeology. As a discipline these interests can be traced into the mid-19th century when workers in northern France and southern England demonstrated an early human presence in geological deposits of great antiquity using collaboration between the earth sciences, zoology and archaeology (Trigger 1989; O'Connor 2007).

Today, those involved in undertaking, curating or designing schemes aimed at recovering or preserving Palaeolithic remains require a scaled understanding of the associated ancient palaeolandscapes. In other words, Pleistocene specialists of all flavours must turn their hand to the field of palaeogeography: the study and reconstruction of past landscapes. The study of palaeogeography entails the reconstruction of patterns of the earth's surface both at specific times and through time using a wide range of material evidence including geological, biological and archaeological information. In particular, it focuses on the ancient sedimentary environments and the contemporary ecological conditions that may allow us to fix the location of shorelines, position of rivers and source areas of raw material (ie for human use). Understanding such an approach is of particular importance in a discipline that is totally familiar to only a limited audience (ie specialist Palaeolithic archaeologists and Quaternary scientists) but where the informed lay-person (ie development control officer) might well be required to construct and oversee the implementation of an investigation framework for a site that contains a Palaeolithic interest. As such, it is important not only in enabling us to understand any excavated finds, but also for developing strategies to locate those places in the modern landscape where we may expect to find evidence for our earliest ancestors (Bates and Wenban-Smith 2011).

The adoption of a palaeogeographical approach was fundamental to many of the ALSF funded projects. This not only facilitated novel investigations of known and new archaeological sites, but also allowed the reconstruction of landscape contexts in situations where archaeological remains were absent but where important biological, geological or dating material was available. To those less familiar with the Palaeolithic archive and a palaeogeographic approach to Pleistocene deposits, it might be tempting to suggest that in the absence of direct archaeological evidence (ie a lack of artefacts) from a given area, a verdict of no archaeological interest can be given. However, by accepting that a palaeogeographic stance to the investigation of past landscapes is in fact the only logical approach to the Palaeolithic past – perhaps epitomised by Foley's (1981) argument of spatially continuous use of the landscape – areas devoid of apparent archaeological remains become an integral part of the broader archaeological (landscape) picture. They provide evidence for vegetation patterns, vertebrate and invertebrate faunas, climate and such like, which may be absent from archaeological sites themselves. They thus require investigation and are certainly legitimate objects of study within the context of both research and developer funded projects. In other words, artefacts or not, they are all part of the hominin landscape.

The processes involved in palaeogeographical reconstruction and the location and successful recovery of Palaeolithic archaeological remains include all aspects of palaeoenvironmental reconstruction (see Lowe and Walker 1997). However, success within the context of an archaeological project depends on an appreciation of scale. The scale of investigation needs to be considered in both spatial and temporal frameworks. In particular, approaches need to be scaled towards the nature of the archaeological question posed, which in part are directed by the resolution of the information available. Indeed, attempts to reconstruct past Pleistocene landscapes are often hampered by fragmentary evidence, incomplete sequences, poor dating control and an absence of evidence for the faunal and floral aspects of the landscapes. We are also often let down by a reticence to examine the success (or otherwise) of a project, and an inability to examine so-called 'failure' adequately in print following completion of a project. Indeed, there is a common perception that 'failure' equates to no recovered archaeology. However, as argued above, this perception is a function of an inadequate understanding of the Palaeolithic resource and what constitutes knowledge gain in the discipline, by practitioners with perhaps limited experience of working with the Palaeolithic record. Allied to the problems of investigating the past is the probability that Pleistocene landscapes and environments in the UK and elsewhere are unique and have no modern analogues. Consequently, in order to investigate this past a modified 'principle of uniformitarianism' needs to be adopted.

This chapter seeks to set out how we can investigate and enhance our understanding of the Palaeolithic past by looking at approaches to investigating these palaeogeographies that have been used within ALSF projects. It is not designed to be an exhaustive attempt to summarise all approaches to reconstructing past environments and landscapes (for this again see, for example, Lowe and Walker 2015) but simply to demonstrate how some of these approaches have been used within the context of furthering our understanding of the Palaeolithic record in Britain through this pioneering scheme. In order to do this we seek to outline the nature of the Pleistocene past and highlight some of the techniques that are available to us to reconstruct the past landscapes within which Palaeolithic peoples lived and acted out their day-to-day lives. Consequently in the next section, we consider the nature of the Pleistocene period and the frameworks in use, and examine some of the key methods we can use to investigate the remote period of human prehistory. Finally, we examine a range of case studies of landscapes at a variety of archaeological scales.

THE PLEISTOCENE PERIOD: FRAMEWORKS FOR PALAEOLITHIC ARCHAEOLOGY

Currently, the earliest evidence for human activity in the UK is recorded in East Anglia (Fig. 1.1; Parfitt *et al*. 2005; 2010), with the most recent work suggesting that this occupation dates to before 780,000 BP, perhaps as early as 980,000 BP (Parfitt *et al*. 2010). These discoveries represent the culmination of 30 years of re-evaluation and research into Palaeolithic archaeology, which have seen major changes in our understanding of the nature of this record (McNabb 2007; Pettitt and White 2012) and a near doubling of the length of time humans have been present in the UK (Parfitt *et al*. 2005; 2010). These changes have gone hand in hand with signif-

Table 2.2 Summary of Marine Isotope Stages (MIS) in relation to other aspects of the Palaeolithic record

Epoch	*Age kBP*	*MI stage*	*Traditional stage (Britain)*	*Climate*
Holocene	Present–10,000	1	Flandrian	Warm – full interglacial
Late Pleistocene	25,000	2	Devensian	Mainly cold; coldest in MIS 2 when Britain depopulated and maximum advance of Devensian ice sheets; occasional short-lived periods of relative warmth (`interstadial'), and more prolonged warmth in MIS 3
	50,000	3		
	70,000	4		
	110,000	5a-d		
	125,000	5e	Ipswichian	Warm – full interglacial
Middle Pleistocene	190,000	6	Wolstonian complex	Alternating periods of cold and warmth; recently recognised that this period includes more than one glacial - interglacial cycle; changes in faunal evolution and assemblage associations through the period help distinguish its different stages
	240,000	7		
	300,000	8		
	340,000	9		
	380,000	10		
	425,000	11	Hoxnian	Warm – full interglacial
	480,000	12	Anglian	Cold – maximum extent southward of glacial ice in Britain; may incorporate interstadials that have been confused with Cromerian complex interglacials
	620,000	13-16	Cromerian Complex III and IV	Cycles of cold and warmth; still poorly understood due to obliteration of sediments by subsequent events
	780,000	1-19	Cromerian Complex I and II	
Late Early Pleistocene	1,000,000	19-25	Bavelian complex	Cycles of cool and warm, but generally not sufficiently cold for glaciation in Britain

Table 2.1: Major component stages of the British Pleistocene as outlined by Roe (1981)

		Colder periods	*Warmer periods*
HOLOCENE			Flandrian (‘Postglacial’)
PLEISTOCENE			
	Upper	DEVENSIAN	
			Ipswichian
		WOLSTONIAN	
	Middle		Hoxnian
		ANGLIAN	
			Cromerian
		Beestonian	
			Pastonian
	Lower	Baventian	
			Antian
		Thurnian	
			Ludhamian
		Waltonian	
PLIOCENE			

icant developments in our understanding of the climates of the Pleistocene and in particular of the number, duration and nature of the alternating series of warm and cold episodes we commonly call glacials and interglacials (Lowe and Walker 2015).

Since the late 1960s, with the discovery that the oxygen isotope record (Box 2.1) from deep sea cores could be used as a proxy record for climate (Shackleton and Opdyke 1973) and sea-level change (Shackleton 1987), it became apparent that the long-held assumptions about the number of warm and cold periods associated with the Palaeolithic archaeological record in the UK (Table 2.1; eg Roe 1981) were outdated and required re-evaluation (Wymer 1988). Prior to this, Palaeolithic archaeology was tied to a framework for climate change established using only terrestrial geological and biological proxies (Mitchell *et al*. 1973), which resulted in a limited number of warm and cold stages (Table 2.1) defined against a series of type sites. With the adoption of the oxygen isotope record (Box 2.1) more than 60 climate cycles (Marine Isotope Stages or MIS) have been identified during the last 1.8 million years. This record is now the commonly accepted framework that Quaternary scientists and Palaeolithic archaeologists use to order and correlate evidence from a wide variety of sources and situations (Table 2.2).

The key to understanding the Pleistocene climate record as we now know it (Table 2.2) is that,

Feature of the Palaeolithic archaeological record	*Palaeogeographic features*
Possible overlap of occasional Late Neanderthal populations with early modern humans	
Occasional presence of Neanderthal populations in Britain	
Absence of humans from Britain	Island Britain during much of interglacial
Absence of humans from Britain?	
Occasional proliferations of Levallois expression?	
Occasional proliferations of Levallois expression	
Incipient Levalloisian techniques alongside handaxe manufacture	
Continuation of quite common handaxe-based occupation	
Re-settlement of Britain, quite abundant evidence, mostly handaxe-based	
Absence of hominins in Britain	Major glaciation, 'old' river patterns disrupted, ?Weald/Artois ridge broken
Various, archaeologically diverse occupations of Britain: Boxgrove (handaxes); High Lodge (worked flakes)	
Sporadic flake/core-¬based settlement (Pakefield)	
Sporadic flake/core¬-based settlement (Happisburgh 3)	

although the major oscillations in temperature vary between warm (peaks) and cold (troughs) conditions, the evidence from individual marine isotope stages suggests that *within* the individual warm/cold episodes considerable variation in climate may have been experienced by animals (including humans). For example, in the warm episode between *c* 240,000 and 190,000 BP (MIS 7; Fig. 2.1) interglacial conditions were interrupted by cold intervals and associated low sea-level. By comparison, conditions within the 'last glacial' period (MIS 5d-2, the Devensian; Fig. 2.2) varied from near present day climates to periods of intense cold when ice expanded across much of northern and western Britain (Lowe and Walker 2015). However, this period of ice expansion was restricted to a period of about 10,000 years, between 25,000 and 15,000 BP, and therefore only represents a small part of a complex period of time.

More recently, work on cores taken from the ice sheets (Steffensen *et al*. 2008) in both northern and southern hemispheres suggest even greater and more rapid fluctuations in climate may have impacted the UK in the last 250,000 years. At present it is difficult to ascertain precisely the impact of such changes on Palaeolithic peoples in the UK but suffice to say that considerable adaptability would be required by hominin populations to cope with such changes.

The varying climatic cycles (of both long and short duration) will have impacted not only on humans but on the plant and animal resources available to humans, and on the physical environment through which they moved. Thus sea-levels rose and fell by up to 130m, rivers shifted between periods of erosion and periods of deposition (of either coarse gravels or fine silts and sands), vegetation fluctuated between steppic grasslands and mixed oak forests, and associated suites of animals came and went. These changes would have conspired to make Britain more or less attractive and accessible to hominins and consequently patterns of human occupation and 'extinction' would have occurred in tandem with the changing environmental conditions (Pettitt and White 2012).

METHODS FOR INVESTIGATION

The last decade has seen significant advances in the methodologies that can be applied to investigations of Pleistocene sequences and Palaeolithic archaeology. Many of these have been trialled through ALSF projects. The techniques utilised in these projects were typically developed outside archaeology, and adopted, adapted and applied as appropriate. They can be broken down into those applied in field investigations and those for post-excavation laboratory analysis.

Selecting appropriate methodologies for supporting Palaeolithic field and laboratory projects is in many instances a case of trial and error, and the successful deployment of a battery of techniques in

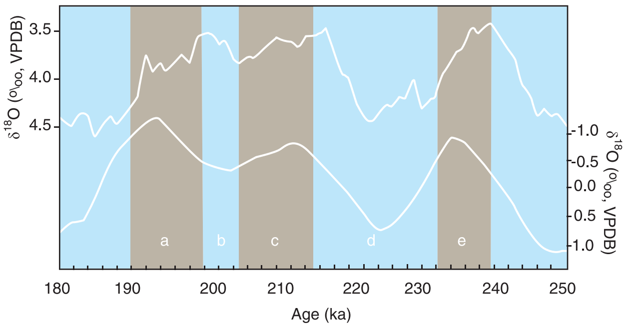


Fig. 2.1 Marine Isotope Stage 7 showing benthic $\delta^{18}O$ isotope stack (after Lisiecki and Raymo 2005) (upper curve) and orbitally tuned pelagic O isotope stack of Bassinot et al. *(1994) (lower curve). Note the fluctuations in these curves between warmer and cooler episodes, designated 7a-e*

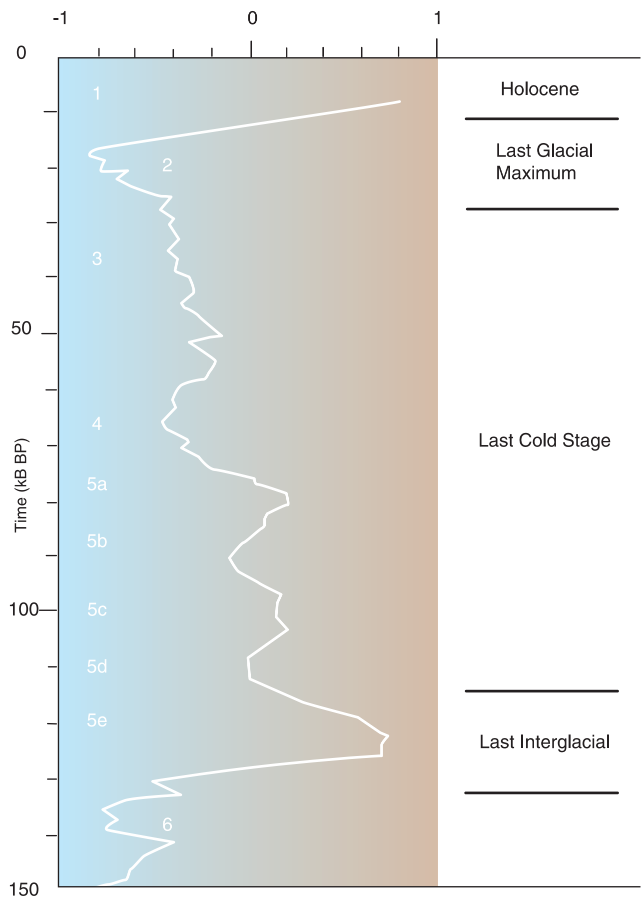
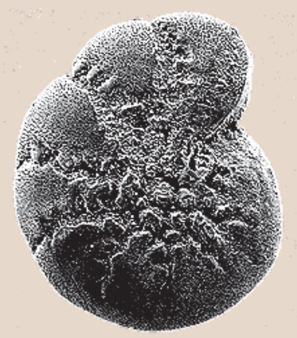


Fig. 2.2 The stacked marine oxygen isotope record for the last 130,000 years (after Martinson et al. *1987)*

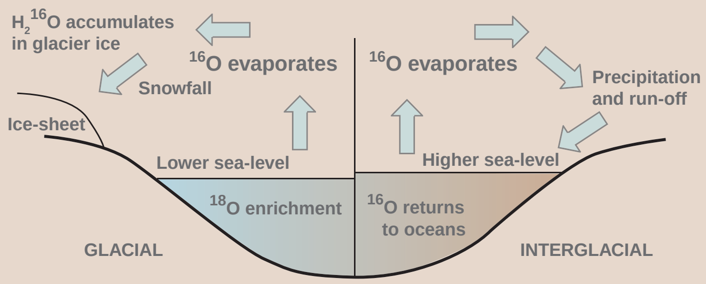
one project does not guarantee success in another. Indeed, individual projects are unique, and appropriate methods need to be selected in order to address the archaeological questions posed and to reflect variation in bedrock geologies, superficial sediment types, etc. Consequently, projects need to be developed within the context of the individual site/area and any methods selected should be

OXYGEN ISOTOPE STRATIGRAPHY BOX 2.1

The different isotopes of oxygen preserved in the tests ('shells') of foraminifera (Fig. 2.1.1) have been instrumental in developing a framework for global climate change. Foraminifera combine oxygen in the calcite in their shells, and this is present in two different forms: the atomically heavier ^{18}O and atomically lighter ^{16}O. The precise isotopic composition of the foram test reflects the isotopic concentrations in the water from which the oxygen is derived, and these concentrations vary according to changes in the global volume of ice. So, because it is lighter, ^{16}O is preferentially evaporated from the ocean surface during periods of cold and, as much of this is subsequently precipitated as snow and retained on land as ice, marine waters become enriched in isotopically heavy oxygen. During warm periods the opposite happens, when the isotopically light water returns to the oceans (Fig. 2.1.2). By analysing foraminifera from samples taken from long cores, a history of ice build-up and decay can be inferred, showing peaks and troughs of isotope ratios that reflect cold and warm periods respectively.

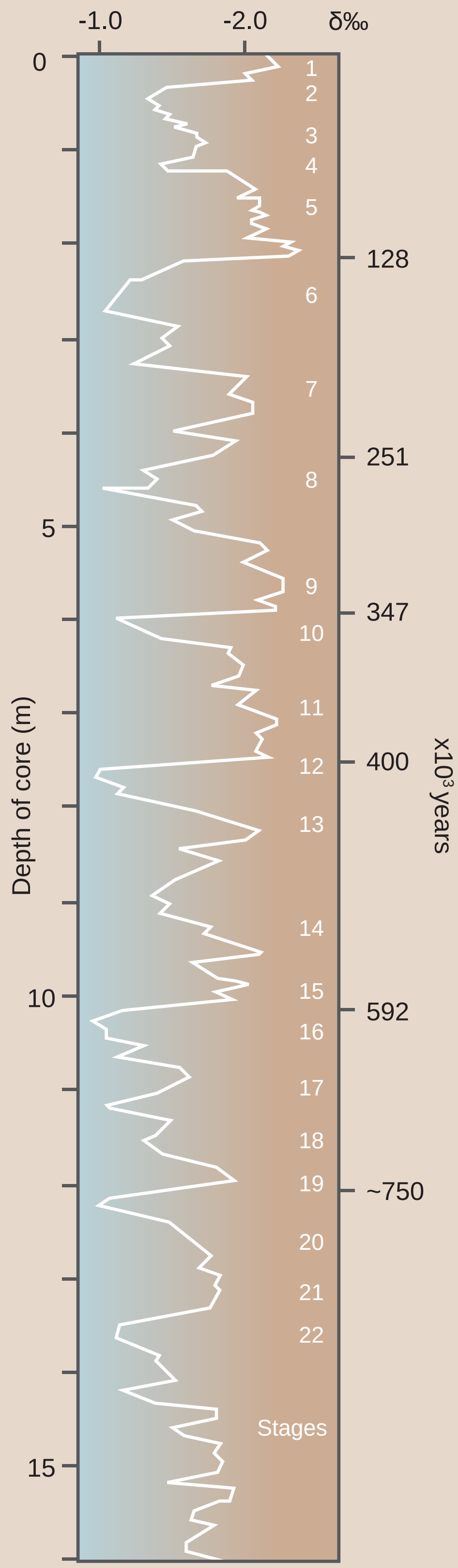


2.1.1 An example of a foraminifer: *Elphidium excavatum*



2.1.2 Effects of glacials and interglacials on the $^{18}O/^{16}O$ ratio of sea water

The first extensive application of this methodology was applied to a deep sea sediment core (V28-238) and the resulting graph of results showed that 23 peaks and troughs occurred in the last 800,000 years (Shackleton and Opdyke 1973). These periods have been numbered by counting back from the present-day interglacial or Holocene period (Marine Isotope Stage, MIS 1), with (usually) interglacial peaks (warm episodes) having odd numbers and glacial troughs (cold but not necessarily ice-dominated events) even numbers (Fig. 2.1.3).



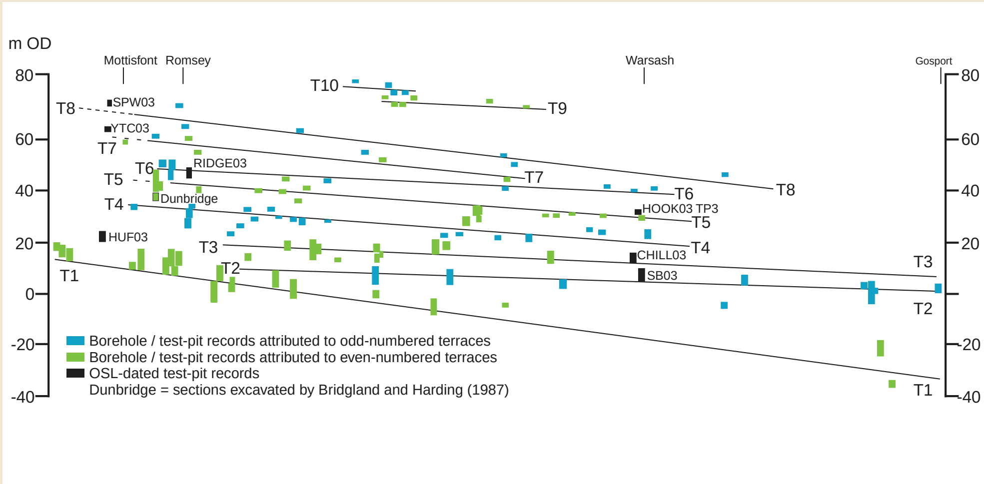
2.1.3 Marine oxygen isotope trace from deep-sea sediment core V28-238 (after Shackleton and Opdyke 1973)

USE OF BOREHOLES: TERRACES AND RAISED BEACHES

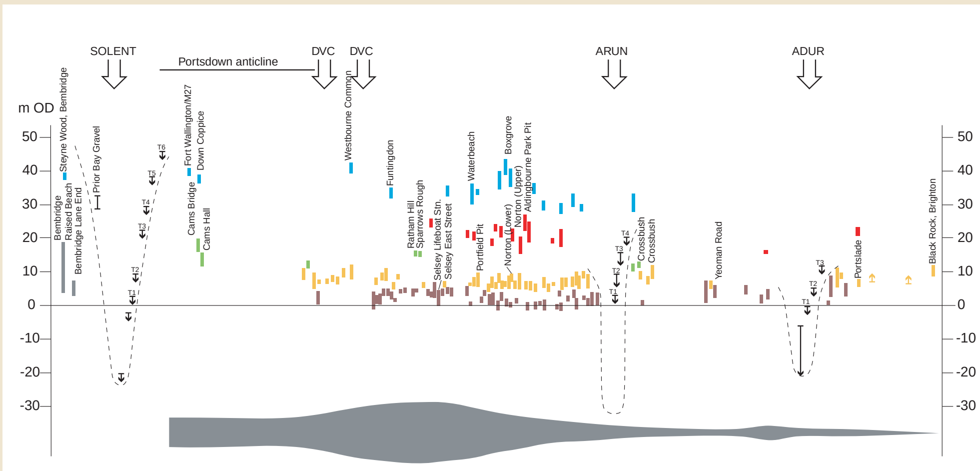
The work undertaken as part of the PASHCC project (*Palaeolithic Archaeology of the Sussex Hampshire Coastal Plain*) used a combination of extant borehole data from a wide variety of sources, coupled with purposive boreholes and test pits excavated to recover samples for palaeoenvironmental reconstruction and dating. The work was undertaken in order to provide the basis for a robust correlation for the river terraces of the Solent system (Briant *et al.* 2006; 2012) and to link the terraces with the marine raised beach sequences of the West Sussex Coastal Plain (Bates *et al.* 2010). Dating of these fluvial and marine terraces was achieved through OSL dating (Bates *et al.* 2004; 2007a; 2010; Briant *et al.* 2006; 2012).

River terraces are formed as a result of rivers downcutting through former floodplains in areas where uplift is ocurring. They are particularly important in providing a framework for understanding the Palaeolithic archaeological record and associated patterns of human occupation of the landscape (Bridgland 1996; 2006; Bridgland *et al.* 2006). Unfortunately the deposits remaining in the landscape today are fragments of these former floodplains and consequently the records are typically difficult to correlate up and downstream. Usually these remnants mirror the original geometry of the floodplain and dip in a downstream direction. By contrast, raised beaches usually form as spreads of sands and gravels at the inner margin of the former high sea-level event and form broadly horizontal sheets dissected by erosion.

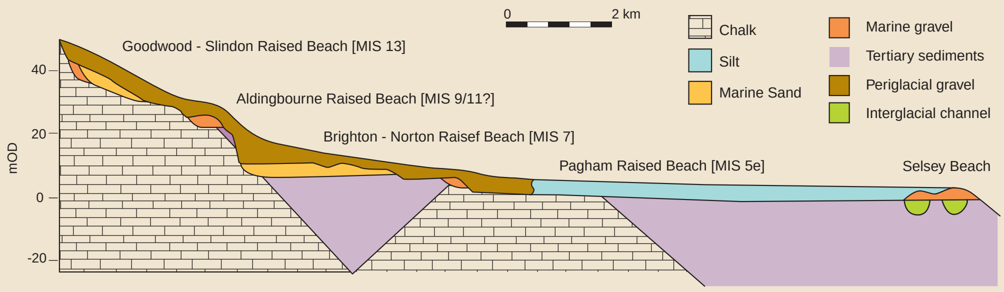
In the PASHCC project a reconsideration of the previous mapping of the terraces of the Solent was undertaken (Fig. 2.2.1) and borehole data was inputted into a geological software system (Rockworks) to facilitate the plotting and correlation of fragments of former river systems. By contrast, marine sediments on the West Sussex Coastal Plain (Fig. 2.2.3) exhibit broadly horizontal distributions that allow a staircase of raised beaches to be reconstructed (Fig. 2.2.5).



2.2.2 Long profiles of the eastern Solent terraces using the PASHCC scheme (from Briant *et al.* 2012)

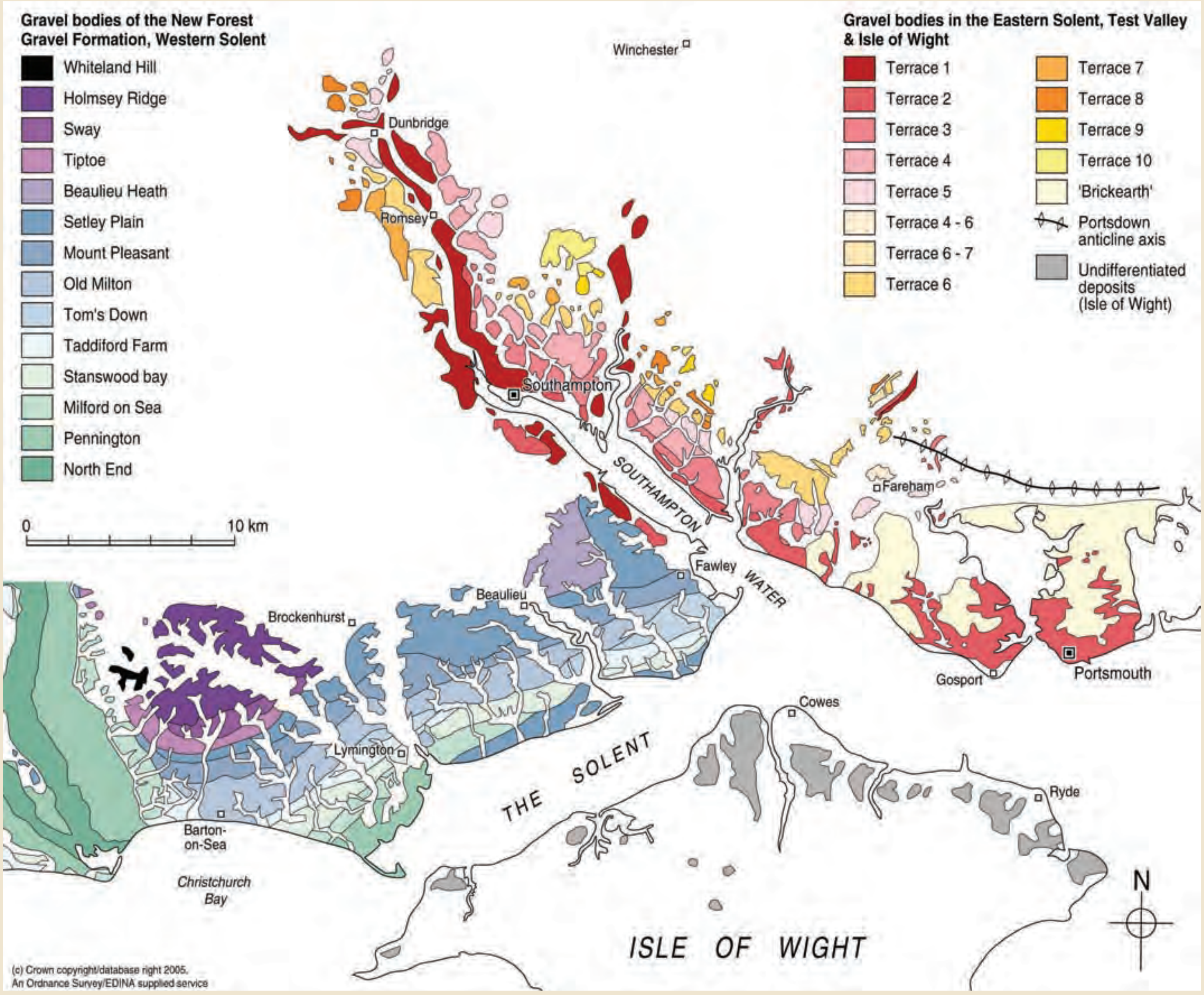


2.2.4 Elevation of marine sediments from selected sites in the PASHCC coastal plain study area (from Bates *et al.* 2010). Colour key: blue = Goodwood/Slindon Raised Beach; red = Aldingbourne Raised Beach; green = unknown; yellow = Brighton/Norton Raised Beach; brown = Pagham Raised Beach



2.2.5 Schematic section through the West Sussex Coastal Plain showing the main stratigraphic units recognised today from integrated studies of boreholes and published records (from Bates *et al.* 2010)

BOX 2.2



2.2.1 Distribution of gravel bodies in the eastern and western Solent (from Briant *et al.* 2012)

2.2.3 Distribution of marine and fluvial sediments in the PASHCC study area trialled and deployed carefully. In most cases this is best achieved through the cooperation of specialists who are familiar with the nature of the Pleistocene record in that area. This combination of expertise and judicial selection of appropriate methods in the development of field projects is well illustrated by the success of the ALSF funded projects. Examples can be seen at the landscape scale – as shown by the *Trent Valley Palaeolithic Project* (TVPP: Bridgland *et al*. 2015) and *The Palaeolithic Archaeology of the Sussex/Hampshire Coastal Corridor* (PASHCC: Bates *et al*. 2004; 2007a; 2010; Briant *et al*. 2006; 2012) – to the site level, as seen at Lynford and the Valdoe (Boismier *et al*. 2012; Pope *et al*. 2009).

Field investigations

Field investigation of areas containing thick and complex sequences of Quaternary sediments – such as the Pleistocene river terrace sequence of the Thames (Bridgland 1994; Gibbard 1985; 1994) or raised beach and river gravels on southern England's coastal plains (Bates *et al*. 1997; 2003; 2010) – typically commences with the examination of published literature (both archaeological and geological) and extant borehole data (Box 2.2). This might be followed by field investigation involving mapping the surface expression of the deposits (Brown *et al*. 2008) and the recording and sampling of sequences exposed in quarry exposures, cliff sections etc (Box 2.3). Such an approach is often augmented by purposive boreholes and/or test pits in areas known or thought to include sequences likely to contain geological or biological data required for palaeoenvironmental reconstruction, correlation or dating.

The application of geophysical survey (Box 2.4) at this stage in a project may also be considered. Projects constructed in this fashion might address a number of issues. Firstly, where large quantities of extant material exist in archive collections such projects might usefully provide a context for that material enabling more to be made of historic collections – for example TVPP, PASHCC, *Medway Valley Palaeolithic Project* (MVPP: Wenban-Smith *et al*. 2007a and b), *Palaeolithic Rivers of Southwest Britain* (PRoSWeB: Brown *et al*. 2008). Alternatively, projects of this kind may be the precursor to searching for hitherto unknown Palaeolithic sites and are useful to facilitate development control within the HERs – for example the PASHCC project (Bates *et al.* 2007a), MVPP (Wenban-Smith *et al*. 2007 and b), and the *Middle Thames Northern Tributaries* project (MTNT: Bates and Heppell 2007).

As mentioned in Chapter 1, most of the sites we now think of as providing the key to our understanding the Palaeolithic human occupation of Britain are those that were found during quarrying

Fig. 2.3 Gravel quarrying in 19th/early 20th century; Galley Hill Pit. Note worker on left with shovel and barrow for aggregate removal.

in the late 19th and early to mid-20th centuries, when quarrying was undertaken by hand and artefacts were relatively easy to see during aggregate extraction and grading processes (Fig. 2.3). Sites such as Hoxne (Singer *et al*. 1993; Ashton *et al*. 2008), High Lodge (Ashton *et al*. 1992), Swanscombe (Conway *et al*. 1996), Clacton (Bridgland *et al*. 1999), Beeches Pit (Gowlett *et al*. 1998; 2005; Preece *et al*. 2006) and Barnham (Ashton *et al*. 1998) have been known for a century or more and have been re-excavated on a number of occasions following developments in methodologies as well as changes in accepted paradigms (see Fig. 1.1 for site locations). Typically these excavations have been undertaken by teams constituted from research-active scientists in the employment of universities or state-funded museums. By contrast, relatively few large, previously unknown sites have been found by prospecting in the last 20 years (Pettitt and White 2012). Those sites that have been discovered and excavated since the early 1980s, such as Boxgrove (Roberts and Parfitt 1999), Harnham (Whittaker *et al*. 2004), Southfleet Road (Wenban-Smith *et al*. 2006, Wenban-Smith 2013), Lynford (Boismier *et al*. 2012), Pakefield (Parfitt *et al*. 2005) and Happisburgh (Parfitt *et al*. 2010), have all been discovered either during investigation for later prehistoric archaeology or by chance.

Elsewhere, purposive strategies for locating Palaeolithic remains within sites of known archaeological potential have been successful at the Valdoe site (Pope *et al*. 2009), at Cuxton (Wenban-Smith *et al*. 2007a) and in Eastern Quarry, Swanscombe (Wenban-Smith pers. comm). Other projects that have set out to investigate landscapes for the specific purpose of locating Palaeolithic archaeology have met with spatially localised success; although not an ALSF project, a good example is the work in advance of construction of Ebbsfleet International Station in Kent (Wenban-Smith 2013). To the authors' knowledge only in one instance has purposive test pitting in an area of unknown archaeological potential produced artefacts and in this case, at Dartford in Kent, only a few, albeit potentially significant, artefacts were located (Wenban-Smith *et al*. 2010).

In the light of this discussion, we should, therefore, firstly note that in none of the ALSF projects were objectives set to find new Palaeolithic sites. Secondly, we should also take the time to consider why it is that so few projects have discovered Palaeolithic archaeology during their implementation and why we remain largely trusting to luck and chance to discover our new Palaeolithic archaeological sites. Because nearly all major Palaeolithic ALSF projects focused on better understanding of known archaeological occurrences, they concentrated on the application of new methodologies, the contextualisation of past finds within the landscape or the development of databases suitable for supplementing HER records and aiding development control. None of the projects focused on examining landscapes with the specified aims of locating new sites. For us, this is largely because:

- Opportunities to investigate new sites at the intensity needed to discover buried archaeology have been limited by changes within the terrestrial aggregates industry (relative to the late 19th and early 20th century). Therefore access to a large number of sites containing Pleistocene sands and gravels and associated archaeology was not possible
- Methods of investigation deployed through the projects include both direct observation of sequences through open sections, test pits, trenches and boreholes as well as indirect observations through geophysical surveys. These are either incapable of identifying artefact presence or are unlikely to do so where direct access to sediments is not possible (eg because trenches are shored), except in exceptional circumstances
- The significance of single reworked artefacts or single mint-condition artefacts in a test pit remains equivocal and experts in the discipline remain divided on the significance to be placed on such finds. This is particularly important in deposits that span the apparent lacunae in human occupation (cf Lewis *et al.* 2011). Even though individual finds in these sediments (eg Wenban-Smith *et al.* 2010) are rightly met with caution (eg Pettitt and White 2012), off-hand dismissals will only preserve the status quo and advance the discipline not a bit. Indeed, it is just as important, and at times more so, that such sediments are investigated as fully as areas that have already produced thousands of archaeological remains (see Chapter 1)

Therefore, it can be argued that the palaeogeographic approach to the Palaeolithic archive was adopted (knowingly or not) in projects where the combination of methods and approaches was to:

- Record sediment bodies that may contain archaeological remains
- Sample sediment bodies that are known to contain geologically important sequences (ie with faunal, floral, geochronological or archaeological properties)
- Recover artefacts from the sediment bodies (if possible)
- Sample sequences thought to be 'characteristic' of a mappable sediment body

Employing boreholes

The use of boreholes within Quaternary science and archaeology is well documented by Bates *et al.* (2000), and borehole data is routinely used to trace terrace long-profiles in river valleys such as the Thames (Gibbard 1985; 1994) and the Solent (Allen

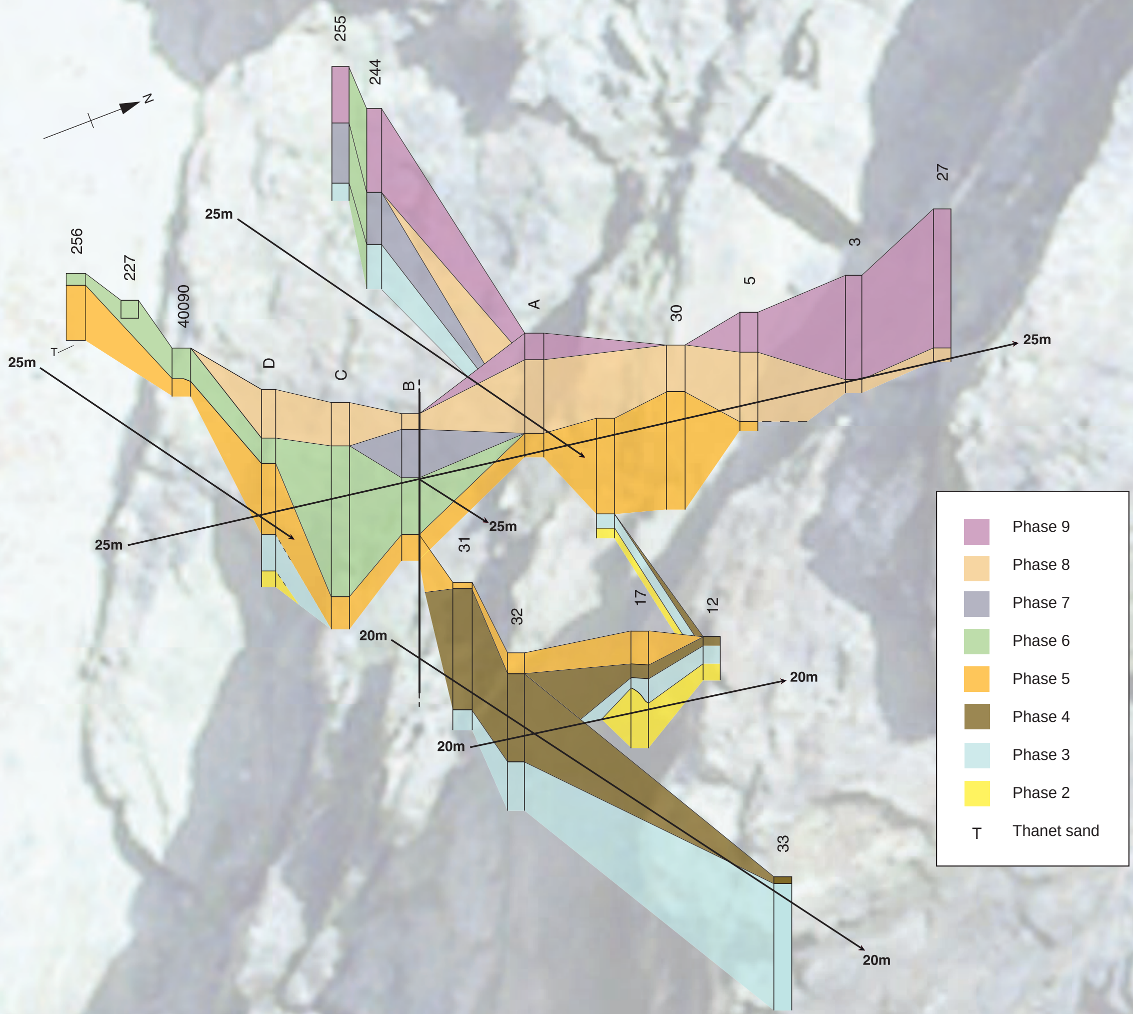
QUARRY FACE RECORDING

Recording quarry exposures and sequences associated with Palaeolithic excavations can be time consuming and complex, particularly where sequences are laterally variable and where sections may run over tens of metres (Fig. 2.3.1). In such cases traditional approaches to recording are frequently utilised (Fig. 2.3.2) to produce long profiles and fence diagrams (Fig. 2.3.3). Today, however, new technology allows some of this time consuming work to be undertaken by laser scanning to produce accurate archives of the quarry faces and sedimentary successions at successive intervals in the quarry history.

Upper right 2.3.1 Long profile cut through a variety of sediments, Southfleet Road, north Kent

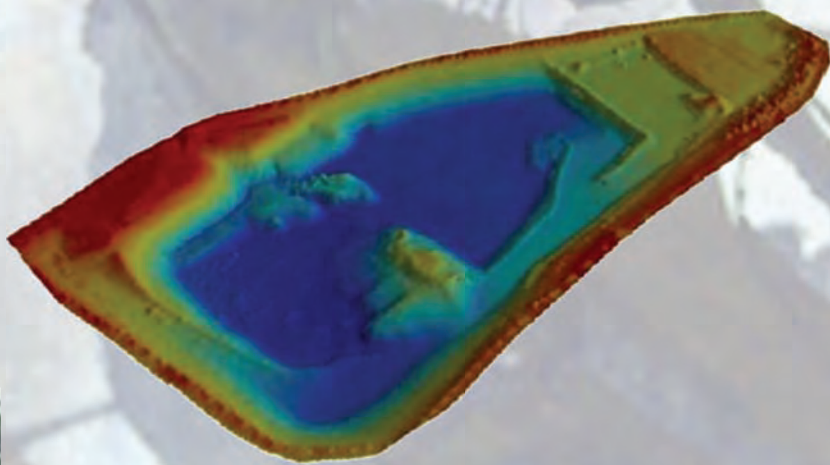
Right 2.3.2 Preparing section for traditional recording by drawing, Southfleet Road, north Kent

Below 2.3.3 Fence diagram showing deposit phases, Southfleet Road, north Kent (from Wenban-Smith 2013)



BOX 2.3

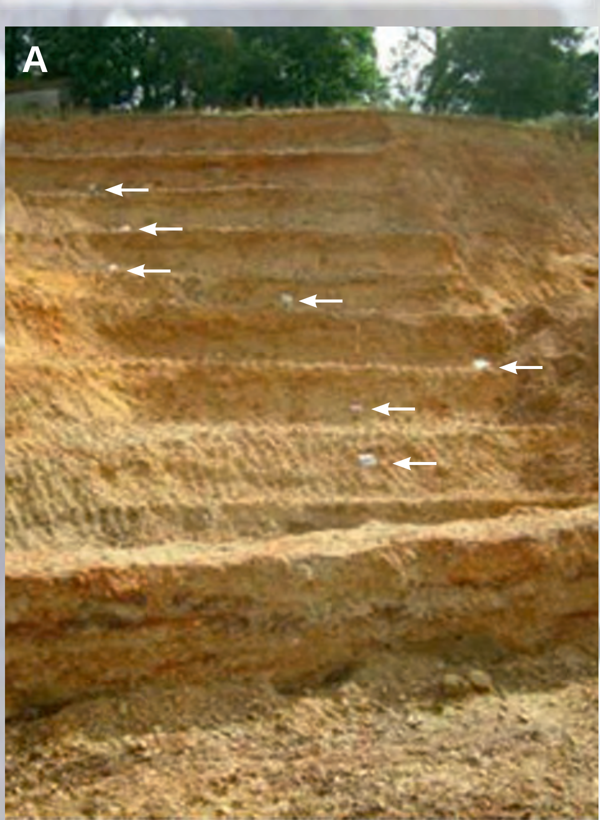
At Chard Junction terrestrial laser scanning (TLS; Fig. 2.3.4) has been used to rapidly record sections and is the first application of this approach to aggregate quarries. The data gathered during the survey has produced a 3D model (Fig. 2.3.5) of the quarry that allows both the finds and OSL dates to be displayed within a 3D volumetric model of the quarry (Fig. 2.3.6). Such approaches not only facilitate the long term recording of the site but help in planning, site monitoring and management.

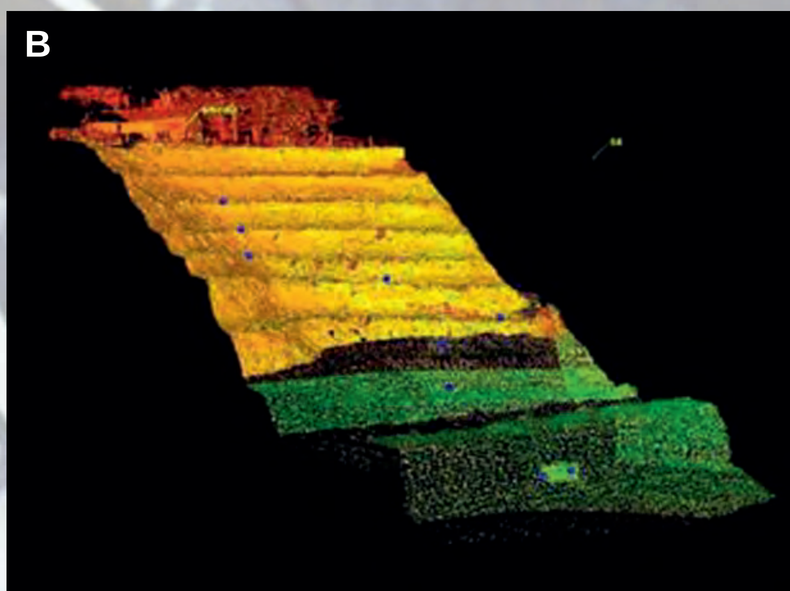


Upper right 2.3.4 Terrestrial laser survey at Hodge Ditch (from Brown 2012)

Right 2.3.5 Hodge Ditch 1, 2 and 3 point data interpolated in ArcMap 10 using inverse distance weighting and displayed in ArcScene in 3D using height values. Red=high and blue = low (from Brown 2012)

Below 2.3.6 A. Photograph of stepped face of Hodge Ditch I used for dating – note position of samples (arrows). B. Laser scanned image of stepped face in A (from Brown 2012)





ELECTRICAL GEOPHYSICS

Electrical techniques are used in terrestrial geophysics to record changes in the conductivity or resistance of the ground to electrical currents. Because different materials (solid rock, gravels, clays etc) show different responses to an electrical current these changes map differences in sediments beneath the ground. In general, sequences with high clay contents show higher conductivity. Conversely, sequences with low clay content, sands and gravel or bedrock such as limestones and chalks, show low conductivity or high resistivity.

Two techniques have been used in the work of the PASHCC (Palaeolithic Archaeology of the Sussex Hampshire Coastal Corridor) and the MVPP (Medway Valley Palaeolithic Project):

- Direct current resistivity where an electrical current is put into the ground (Fig. 2.4.1)
- Electromagnetic techniques where an electrical current is induced in the ground by creating an electromagnetic field in a coil of wire located at the surface (Fig. 2.4.2)

Typical survey results for DC survey are electrical sections (Fig. 2.4.3), while for electromagnetic surveys they are contour maps of conductivity (Fig. 2.4.4). In the ALSF surveys these techniques have been applied to the sectioning of some of the intertidal channels beneath beach sands on the foreshore at West Wittering (Fig. 2.4.3) and mapping the extent of a channel at West Street, Selsey (Bates et al. 2004; 2009) (Figs 2.4.4 and 2.4.5) as well as Holocene and Pleistocene stratigraphies at the mouth of the Medway Estuary (Fig 2.4.6; Bates et al. 2007b; Wenban-Smith et al. 2007a).

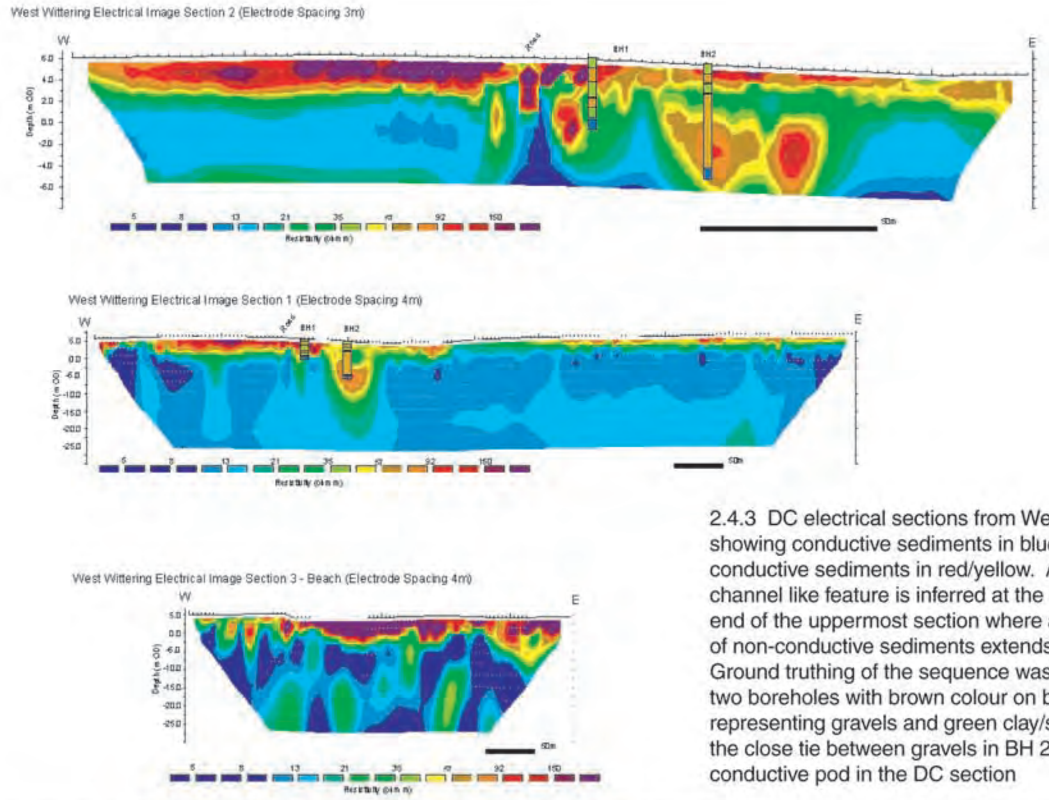
The advantage of deploying such survey techniques is that they are rapid to undertake, can cover large areas and are useful in helping to site purposive test pits and trenches in areas deemed to be of high archaeological or palaeoenvironmental potential. They provide a flexibility in survey methodology and can be incorporated into project design where informed decisions are made in a step-wise fashion regarding the appropriate method and scale of investigation to be deployed (Bates and Stafford 2013).

2.4.1 DC electrical survey equipment laid out along a transect at West Wittering, Sussex

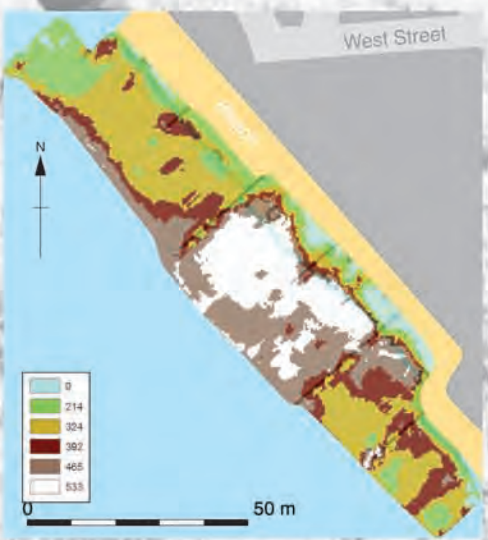
2.4.2 EM31 electromagnetic survey at Allhallows in the Medway Estuary, Kent

2.4.5 Excavated edge of West Street, Selsey Channel as predicted from the EM31 conductivity survey

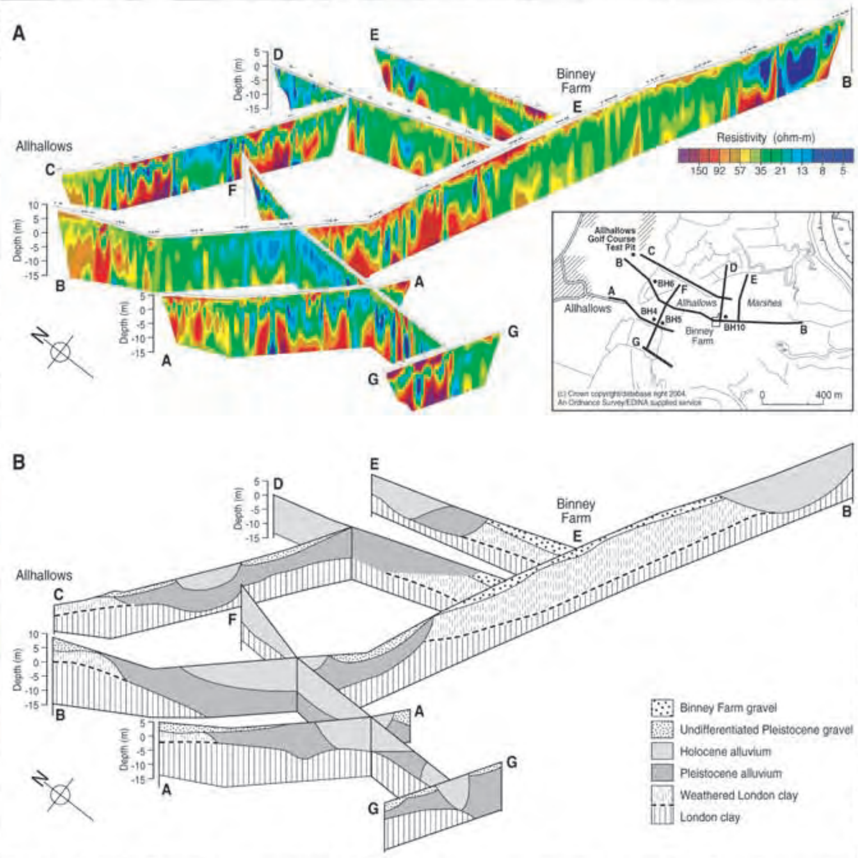
BOX 2.4



2.4.3 DC electrical sections from West Wittering showing conductive sediments in blue and non-conductive sediments in red/yellow. A large channel like feature is inferred at the right hand end of the uppermost section where a large pod of non-conductive sediments extends downwards. Ground truthing of the sequence was achieved by two boreholes with brown colour on borehole logs representing gravels and green clay/silt units. Note the close tie between gravels in BH 2 and the non-conductive pod in the DC section



2.4.4 EM31 electromagnetic survey results from West Street, Selsey. Contour plot of conductivity values indicate a highly conductive zone equivalent with the position of the channel (Bates *et al.* 2009)



2.4.6 A. Electrical pseudo-section fence diagram. B. Inferred stratigraphy from Allhallows study area and Gibbard 1993; Briant *et al.* 2006; 2012). Boreholes provide information on the lithology of sequences below ground that may be beyond the reach of conventional test pitting or where access to the site is limited, as is often the case in modern urban areas. Information from boreholes is often available in geotechnical reports and can provide data suitable for deriving predictions relevant to understanding the 3-D geometry of buried sediment bodies. However, it should be remembered that in the case of boreholes collected in advance of construction, for example, the distribution of the data across a given site (as well as the methods and techniques used) is typically dependent upon the type of structure and construction methods rather than any consideration relating to reconstructing the Quaternary geology.

A range of equipment is available for investigation of subsurface contexts from unpowered manually driven devices such as Hiller borers and

Fig. 2.4 Shell and auger drill rig at West Wittering, West Sussex

Fig. 2.5 Core samples from West Wittering. Cores are split to show stratigraphy. Fine grained sediments are estuarine deposits sandwiched between two cold stage gravels

Fig. 2.6 Section cleaning of a gravel quarry face at Badminston Farm Quarry, Hampshire

Fig. 2.7 Excavation of palaeolandsurface at CH2 Boxgrove, West Sussex in the mid 1980s

Fig. 2.8 Sampling at Corfe Mullen in a trench opened into the former quarry face

Russian (D-section) corers, which retrieve variably undisturbed sediment cores, to powered mechanical corers with a number of interchangeable coring heads (eg Eijkelkamp system), and small portable drill rigs including the Terrier 2000 self-propelled drill rig with a windowless liner sampling system and wireline percussive drilling (Figs 2.4 and 2.5; Bates *et al.* 2000; Clayton *et al.* 1995). Selection of appropriate drilling equipment varies depending on a number of factors including costs, site ground conditions, nature of the overburden (made ground), the type of sediment likely to be encountered in the subsurface, and the nature of the samples required for analysis.

Good examples of the use of large datasets in the construction of subsurface models include the work of Chen *et al*. (1996) on the North China Plain; Allen (2001) in the Severn Estuary; Berendsen and Stouthamer (2001) in the Rhine-Meuse delta region; Weerts *et al.* (2005) in the Netherlands; Culshaw (2005) in Manchester and the Neath/Swansea area of south Wales; and Hijma *et al.* (2012) in the southern North Sea. Within the ALSF projects extensive use of borehole data has been made in the PASHCC project (Box 2.2; Bates *et al.* 2004; 2007a).

Using trenches, test pits and quarry faces

To many archaeologists, quarries are intimately associated with the Palaeolithic, and images of section cleaning down quarry face exposures (Fig. 2.6; Box 2.3) or excavations in the base of quarries

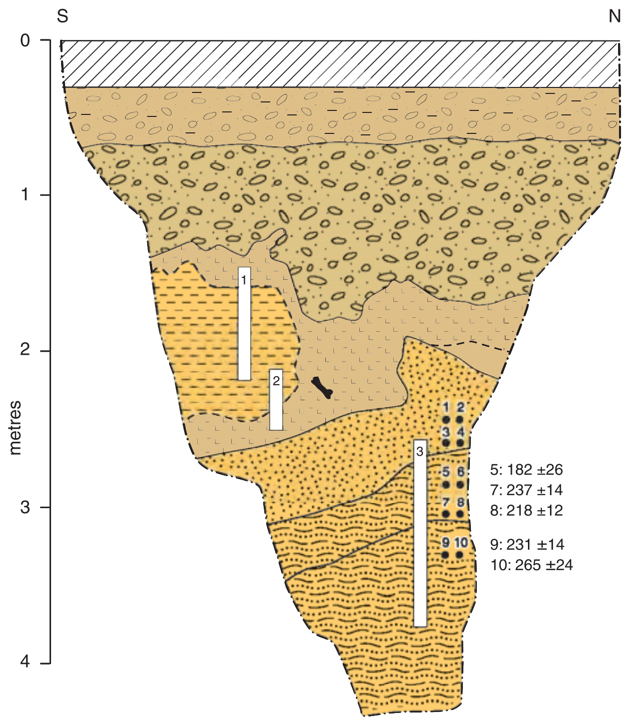
Fig. 2.9 Stepped trench at Northfleet Sewage Works during investigation of Devensian colluvial sediments

Fig. 2.10 Excavation of a test pit during the PASHCC fieldwork in the Solent system

Fig. 2.11 Long trench excavated in a stepped fashion through Devensian slope deposits at Dartford A2/A282 crossing

Fig. 2.12 Example of excavated test pit through gravels of the river Medina at Great Pan Farm, Isle of Wight

Fig. 2.13 Sieving sediment recovered from a test pit for artefacts



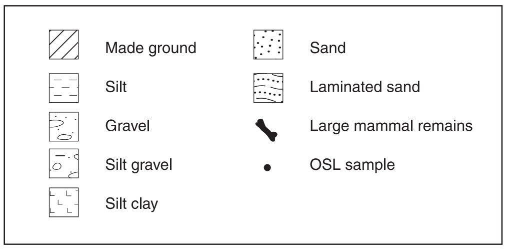


Fig. 2.14 Example of a stratigraphic profile and OSL sample points from Norton Farm in West Sussex. Boxes 1, 2, and 3 show the locations of monolith-tin samples; dates are ka BP (from Bates et al. *2010)*

(Fig. 2.7) are common to many. Indeed, most of the key sites that form our basic framework for the Palaeolithic are quarry sites (see Fig. 1.1), and access to sections is relatively easy even in quarries that have been abandoned for many years (Fig. 2.8), unless of course they have subsequently been infilled and developed. Consequently, the cleaning of faces, stepped where of excessive height (Fig. 2.9), the digging of test pits to evaluate stratigraphy (Fig. 2.10) and larger trenches for sampling and excavation (Fig. 2.11) are now common practices.

The varying approaches to the excavation of test pits, trenches etc dictates the type of information it is possible to retrieve from them. Single bucket-width test pits allow the stratigraphy to be recorded from the top, and where careful control of the excavation machine is possible spits 0.2m thick may

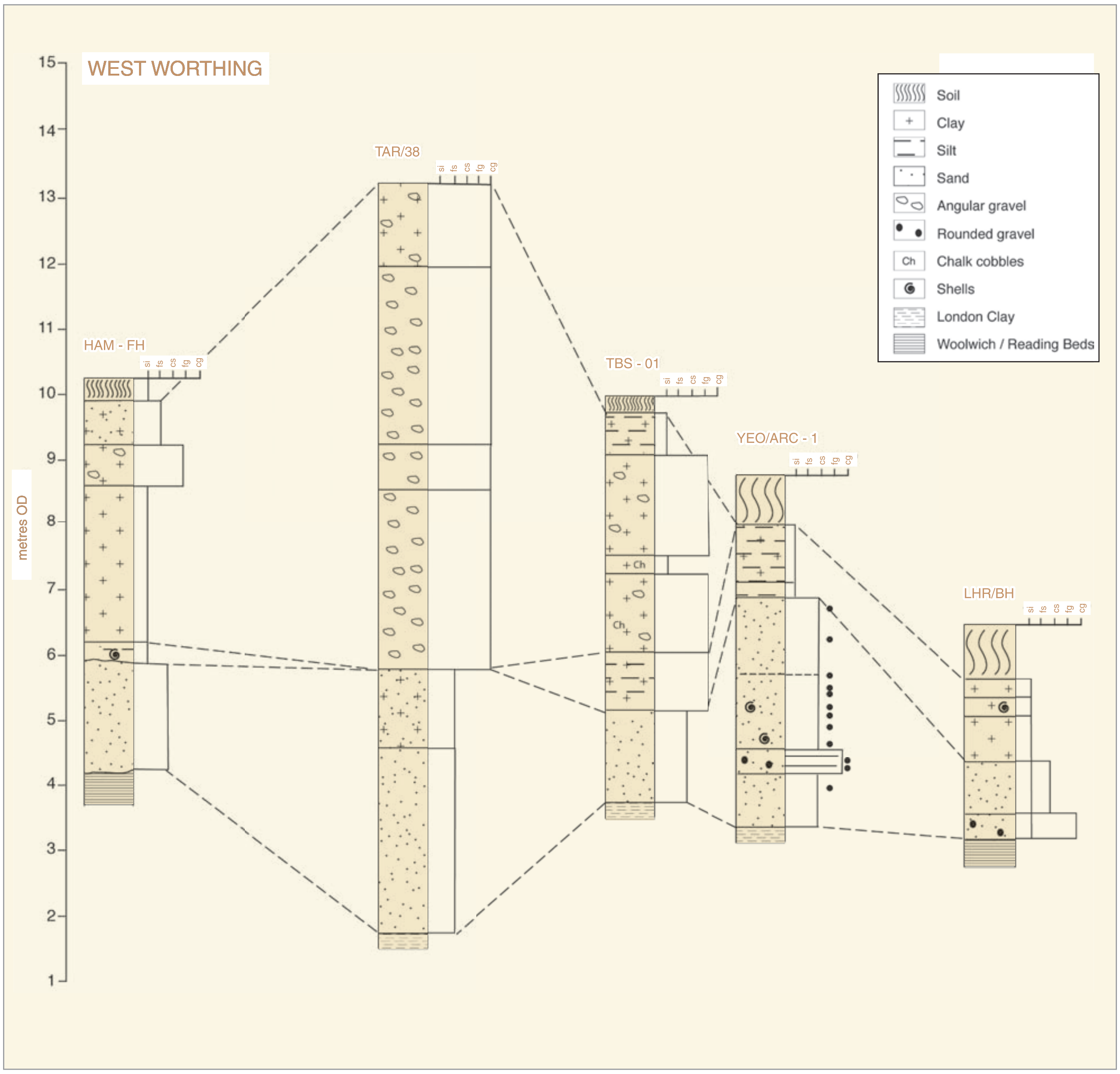


Fig. 2.15 Stratigraphic logs from boreholes and test pits used to form a site wide outline of sequences from the West Sussex Coastal Plain (after Bates et al. *2004, 2007a)*

be excavated and sampled for sieving for artefacts or palaeoenvironmental data (Figs 2.12-2.14). Such exercises can provide information on the broad stratigraphic framework at a site (Fig. 2.15), yet in order to fully understand the sequences, and in particular the context of any recovered Palaeolithic artefacts, larger trenches in which long profiles can be examined, drawn and sampled are a necessity (Fig. 2.16).

One of the hardest issues to deal with in Palaeolithic archaeological site evaluation is addressing the question, at an early stage in the project, of the number and location of interventions (be it test pits, trenches etc) to be used. In conventional archaeological evaluations, figures of 2-5% of total site area are considered appropriate to assess the archaeological potential of the site. In Palaeolithic archaeology it is rare for anywhere near that figure to be approached. Although no specific ALSF project tackled this issue directly, the problem was highlighted in the MVPP (Wenban-Smith *et al.* 2007a) where an intensive test pitting and sieving operation was undertaken at Roke Manor Farm, Romsey in the Test Valley in Hampshire. The site was chosen because of its proximity to the important Palaeolithic site at Dunbridge (Harding *et al.* 2012). More than 40 test pits, each 3m by 2m, were dug by Wenban-Smith *et al.* (2007a) on a closely spaced grid across 8 hectares (Fig. 2.17). The key aims of this project were to investigate the spatial concentration and vertical distribution of Palaeolithic remains within the

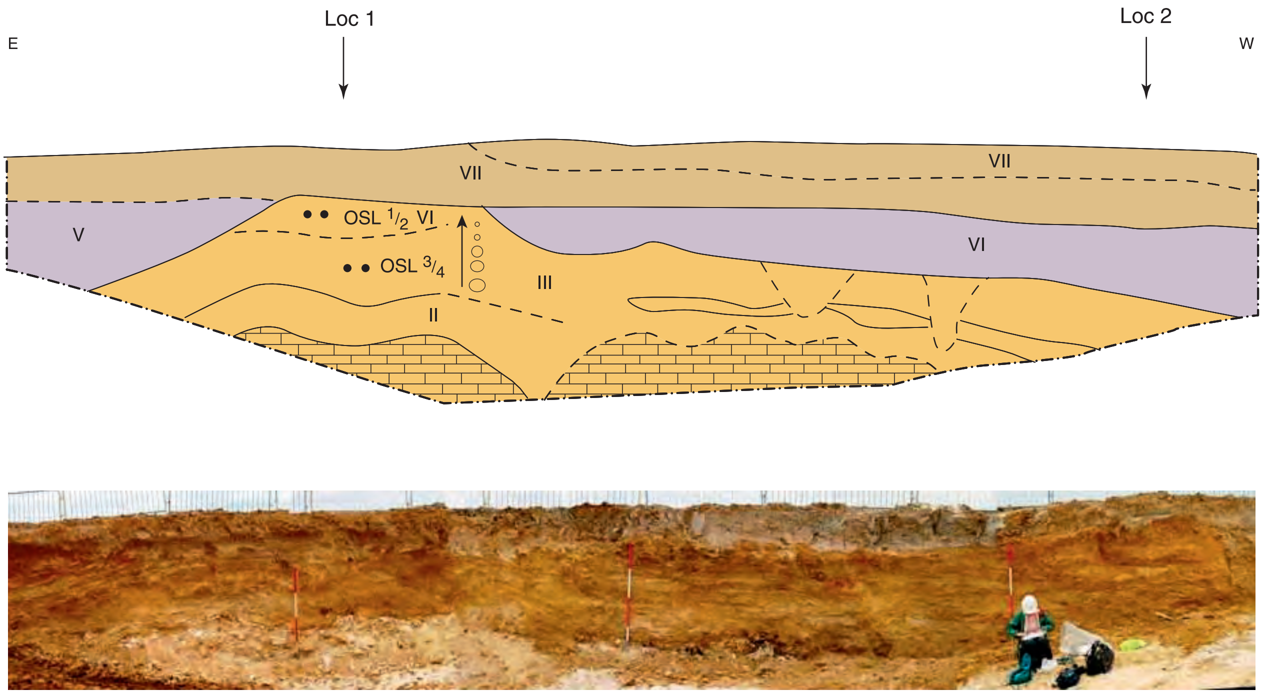


Fig. 2.16 Long profile from Pear Tree Knap site, West Sussex showing drawn and photographed section (after Bates et al. *2010, fig 5a)*

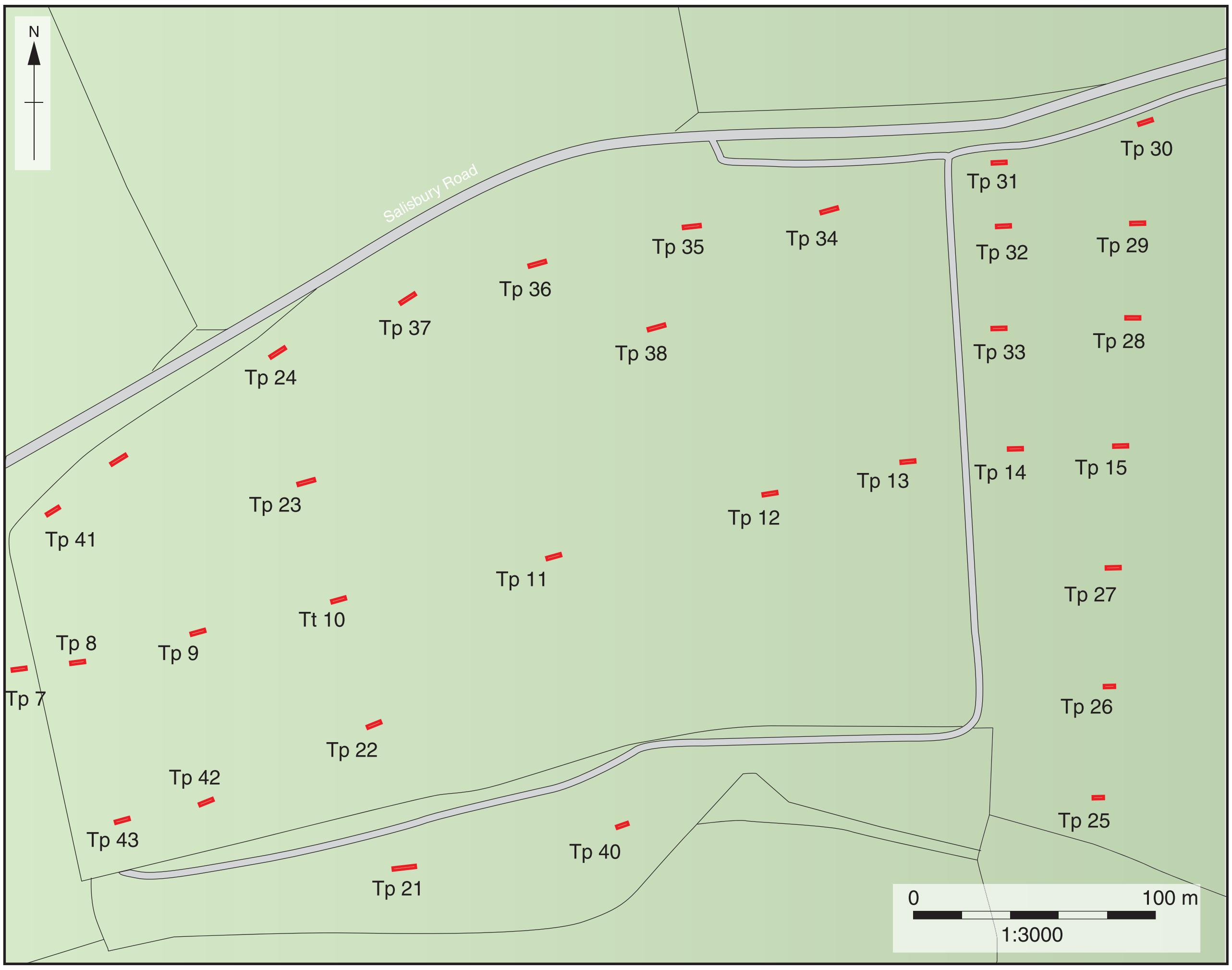


Fig. 2.17 Distribution of test pits at Roke Manor Farm, Romsey on a grid based pattern (after Bates et al. *2004, 2007a)*

Fig. 2.18 Excavations at Cuxton (courtesy of Francis Wenban-Smith)

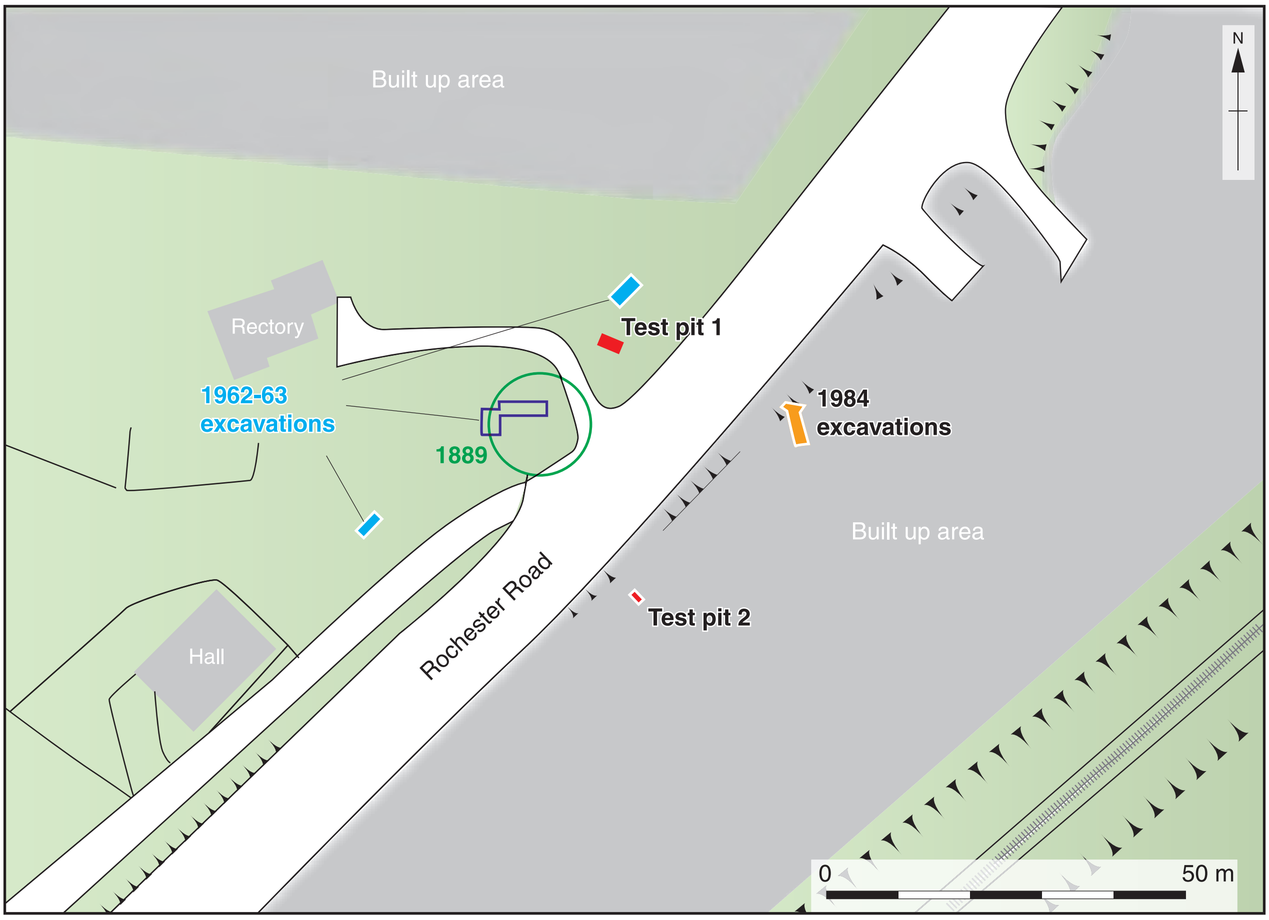


Fig. 2.19 Site location plan for past and recent work at Cuxton, with dates the trench was excavated (from Wenban-Smith et al. *2007)*

Fig. 2.20 Test pit excavated at Cuxton (Wenban-Smith et al. *2007a) showing fluvial gravels over Chalk bedrock*

gravel body, and to establish the most appropriate sampling volumes and test pit density for field evaluation and artefact recovery. The test pits were dug along the main east–west axis of the site, with a series of north–south transects (Fig. 2.17). Unfortunately, few artefacts were found in the sieved samples from the gravel deposits, despite two handaxes being found on the surface in one part of the site. The result of this investigation highlighted the difficulty of locating artefacts through test pitting even in proximity to sites of known potential.

By contrast, test pitting at Cuxton was spectacularly successful MVPP (Wenban-Smith *et al.* 2007a). Previous work at Cuxton indicated a site of considerable potential. For example, Tester (1965) recovered 210 handaxes from a thin seam of river gravel in three small test pits. Work on the

Fig. 2.21 Large ficron and cleaver recovered from excavations at Cuxton (photo courtesy of F. Wenban-Smith)

MVPP excavated a single test pit through a garden in Rochester Road that revealed a sequence of river gravels and a series of handaxes including a majestic ficron, a cleaver, cores, flakes and flake tools (Figs 2.18-2.21). The results of the work of the Medway Valley Project certainly suggest that the development of detailed methodologies and investigation strategies that are statistically significant depend on further work designed to address issues of sampling strategies and artefact taphonomy throughout Pleistocene landscapes.

Watching briefs

The use of watching briefs within the framework of Palaeolithic archaeology is well demonstrated by the works at Lynford (Boismier *et al.* 2012) and Dunbridge (Harding *et al.* 2012). The successful application of a watching brief will, of course, be dependent on the constraints set on the frequency of monitoring of the site as well as the nature of the impact and the experience of the monitors. Typically, where extraction of gravel from a relatively uniform, well-understood aggregate site is taking place, a

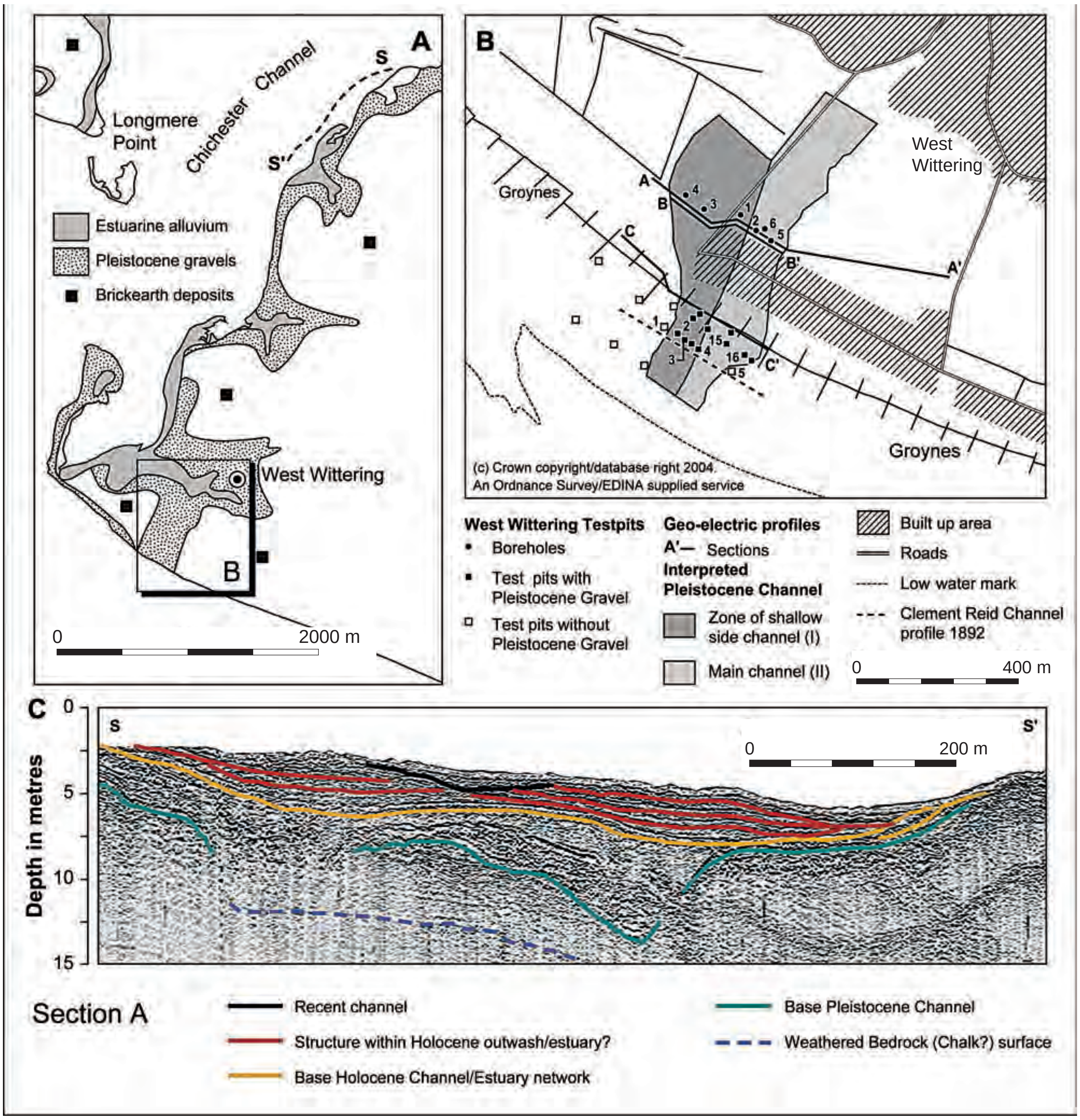


Fig. 2.22 West Wittering, West Sussex. A: site location plan for marine and terrestrial geophysics. B: West Wittering channel – terrestrial investigation and geophysics. C: sub-bottom profile data and interpretation from submerged channel in Chichester Harbour (from Bates et al. *2007c, fig 9)*

watching brief can usually be undertaken with a degree of precision provided that monitors are familiar with Quaternary geology and Palaeolithic archaeology. In the case of both Dunbridge and Lynford this was the case (Harding *et al.* 2012; Boismeir *et al.* 2012). The use of novel techniques for rapidly surveying and recording such as the terrestrial laser scanning (TLS) used at Chard Junction (Box 2.3) would significantly help in such processes.

In other situations, watching briefs are likely to be far more problematic. For example where Quaternary sediments at the margins of fluvial systems or in lacustrine contexts are being monitored, lateral variation in sediment types and consequently depositional context is likely and this may well be reflected in rapidly varying Palaeolithic archaeological potential. In such situations a considerably enhanced presence on site may be required in order to adequately monitor impact. Additionally, where gravel extraction is not the main aim access to sequences may also be problematic (for example, where narrow excavations are being undertaken for drainage).

Geophysics

The use of geophysics in Quaternary science has been increasing in recent years and although seismic profiling is commonly undertaken in the marine sector (Fig. 2.22), advances in radar and electromagnetic/electrical techniques have substantially enhanced our ability on land to see beneath the surface (Box 2.4). Marine geophysical survey was also undertaken as part of the ALSF in the English Channel area (Gupta *et al.* 2004) and in the southern North Sea (Wessex Archaeology 2008), which utilised a combination of seabed mapping techniques (Swath bathymetry) and sub-seabed mapping (seismic survey) to investigate the nature of the submerged landscapes in these areas (Fig. 2.23).

Discussion

There are problems when considering appropriate strategies for examining the Palaeolithic archive using these approaches. As previously noted, very few examples of direct discovery of a totally unknown Palaeolithic archaeological site have been made through an applied strategy of borehole/test pit investigation. The examples described in the MVPP (see above) illustrate the difficulties in investigating sites for Palaeolithic archaeological content by comparison with later prehistoric/historic archaeological investigations. Additionally, it is rare for investigations to adequately consider the impact that investigation strategy had on the

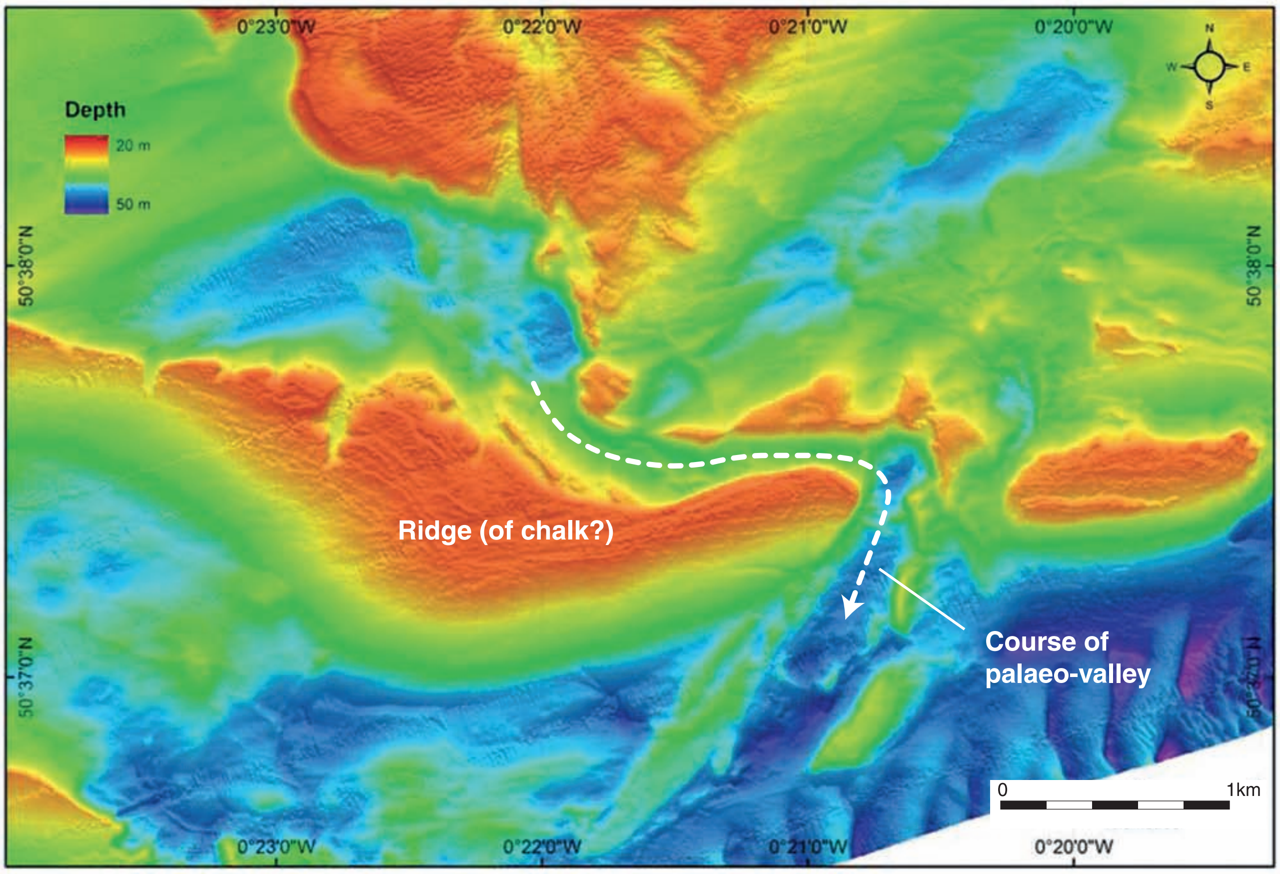


Fig. 2.23 Multibeam bathymetry for the lower segment of the submerged Arun valley displayed as a composite depth coloured and shaded relief image. Sun-illumination is from the north-west at an elevation of 45° (from Gupta et al. *2004)*

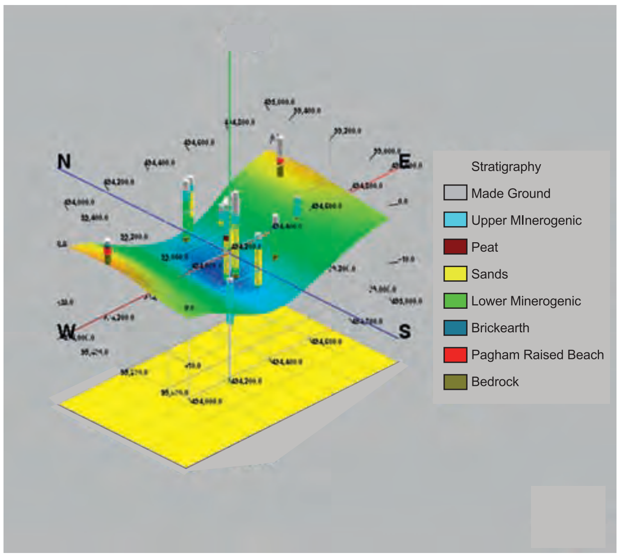


Fig. 2.24 Borehole logs and contoured bedrock surface from Bognor Regis, West Sussex illustrated through the Rockworks Software system

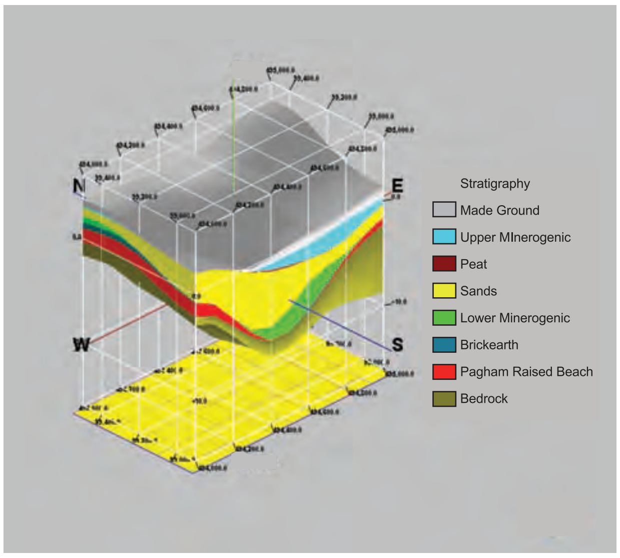


Fig. 2.25 Block model of major stratigraphic units from the boreholes at Bognor Regis, West Sussex

results of the project and the discovery, or not, of archaeological remains.

The rationale for the use of quarry section, borehole and test pit data (point specific data) recovered from regional terrestrial surveys (Barham and Bates 1994; Bates *et al.* 2000) as well as geophysical data (Bates *et al.* 2007c) is that such information may be used to model and understand the geometry and topography of these subsurface sediment bodies (ie reconstruct palaeogeographies within which the Palaeolithic archaeology resides). This means that the geometry and nature of the deposits themselves are being inferred mainly from the point-specific (ie borehole/test pit) data linked together by assumptions about litho- or chronostratigraphic correlations (Chew 1995).

Today, it is increasingly common to visualise these bodies using computerised geological modelling systems that provide the user (and reader) with pictorial images of the subsurface (Fig. 2.24; Culshaw 2005). The 3D geological models consist of a structural framework of 2D surfaces representing stratigraphic boundaries, chronostratigraphic horizons etc (Fig. 2.25). Such systems aim to produce a pseudo three-dimensional block model representation of subsurface deposits allowing the researcher the opportunity to investigate the relationships between deposits, and the ability to predict sequence occurrence away from known data positions (Jones 1992).

These are commonly used in developer-funded projects to understand the geoarchaeology of a site prior to investigation. However, the images produced from the models imply a robustness with respect to the 'hardness' of the surfaces being modelled, as well as the reliability of the relationship between data points. In many cases, the fact is that our understanding of these surfaces and correlations is based upon inadequate sampling intervals (of boreholes) and the use of facies models coupled with the understanding of the surface expression of the sediment bodies to make sense of our stratigraphies.

That said, one of the major outcomes of subsurface modelling is that the 2D/3D surfaces may be used to reconstruct palaeogeographies that subsequently form the basis for predictions and projections regarding Palaeolithic archaeological potential. This perspective is significant because when we adopt such an approach, information from both 'sites' (ie places at which artefacts have been recovered) and 'non-sites' (at which no artefacts but other sources of information may be present) become important to the archaeological picture as a whole at the landscape scale (see below). By comparison, marine data exists in the form of continuous profiles of seismic data that is only rarely ground truthed by point specific data (boreholes). Thus, direct comparison of marine and terrestrial data sets is impossible without interpretation of the results. Furthermore, no direct links between the terrestrial evidence and that from the marine sector exist in the British context, and nowhere can continuous profiles currently be demonstrated across the transition zone between marine and terrestrial domains (Fig. 2.26; Bates *et al.* 2007c). An attempt was made to understand the problems of such an approach through the Transition Zone Mapping Project (Bates *et al.* 2009) and attempts are now being made at Happisburgh.

Ultimately, an integrated approach to archaeological investigation using a range of geological, geomorphological and palaeoenvironmental perspectives derived from direct and indirect observations of subsurface stratigraphies is desirable, prior to developing a conceptual model containing palaeosurface information whether terrestrially or

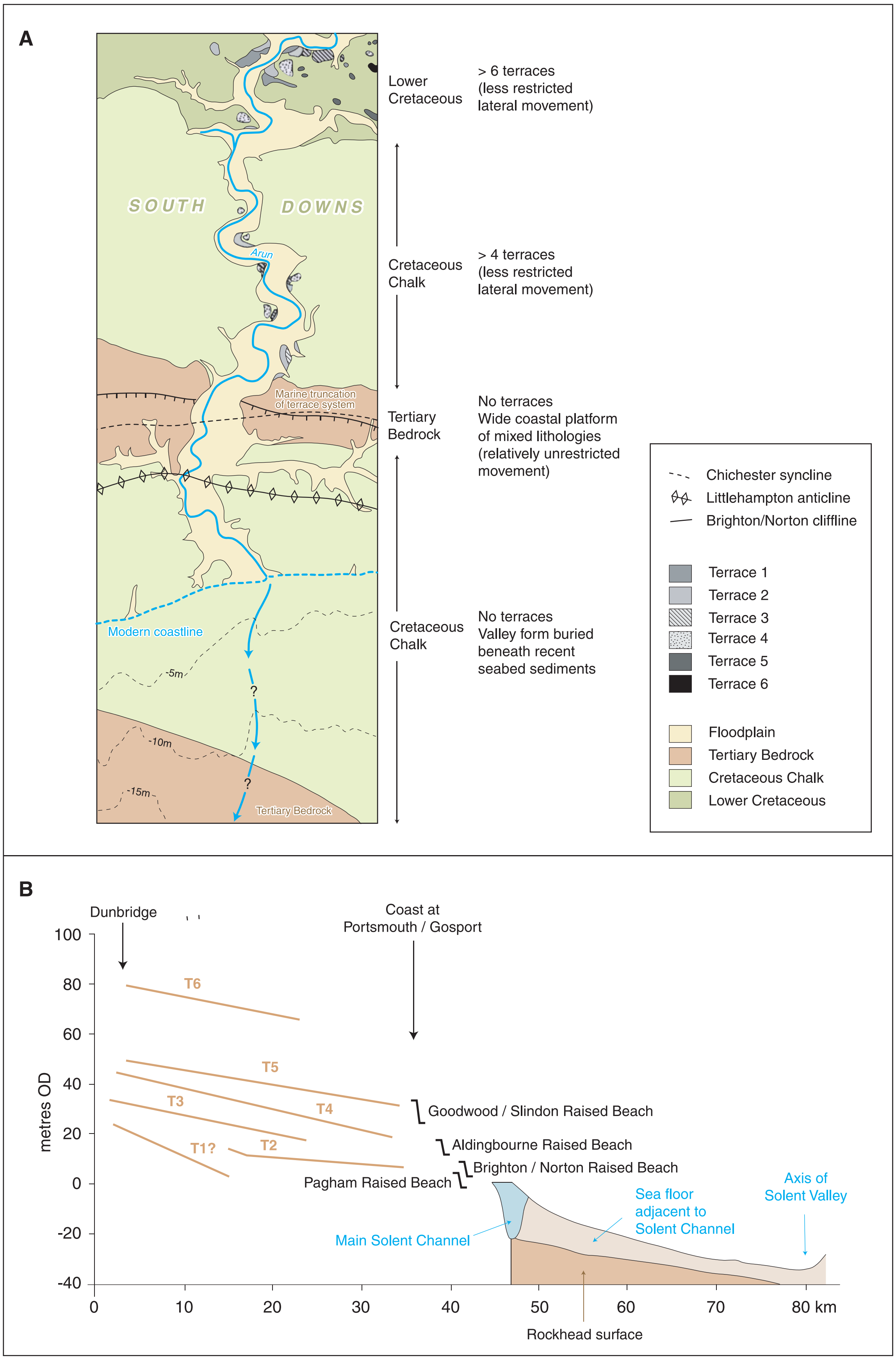


Fig. 2.26 A: On-shore to off-shore Arun Valley showing distribution of main geomorphological features. B: Terraces of the eastern Solent and Solent sea bed showing discontinuity between on- and off-shore sequences (from Bates et al. *2007c, fig 4)*

OSL DATING

BOX 2.5

OPTICALLY STIMULATED LUMINESCENCE

2.5.1 OSL sampling and measurement of radiation from the surrounding environment from a raised beach at St Clement, Jersey

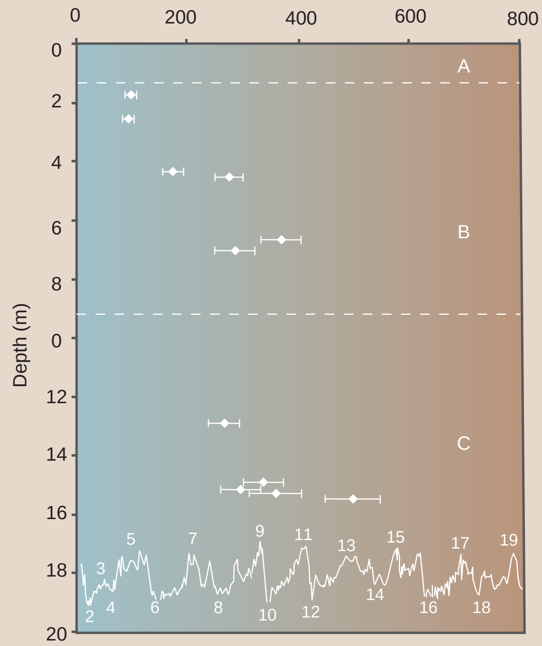
Luminescence dating is a chronological method that can be applied to a wide range of materials (sediment, burnt flint, pottery) that contain quartz or similar materials (Duller 2008). It is based on the emission of light (luminescence) by commonly occurring minerals, principally quartz. For ceramics and burnt flints the event being dated is the last heating while for sediments it is the last exposure of the mineral grains to daylight. The age range over which the methods can be applied is from a few to 300,000 years.

A simple analogy for luminescence is a rechargable battery, with the battery representing the mineral grains. Exposing mineral grains to light or heat will release the battery's energy so that when the mineral (battery) is incorporated into sediment it has no energy. The battery then begins to be recharged by exposure to radiation from the natural environment and over time the stored energy levels increase. A sample collected and measured in the laboratory releases the stored energy and light is created – the luminescence signal. The amount of energy in the battery being related to the brightness of the luminescence signal. Calculating the rate at which the battery was recharged (dose rate) from the radiation in the environment means we can determine how long it was recharging and thus the time since it was last emptied.

A

Sample	Depth	De(Gy)	Dose rate (Gy.ka^{-1})	Age (ka)
GL06012	1.70	193.7 ± 11.0	1.97 ± 0.11	98 ± 8
GL06011	2.50	90.2 ± 6.8	0.96 ± 0.05	94 ± 9
GL06010	4.30	268.5 ± 22.0	1.54 ± 0.10	174 ± 18
GL06013	4.50	298.6 ± 19.2	1.09 ± 0.07	274 ± 25
GL06057	6.70	375.3 ± 24.6	1.02 ± 0.07	367 ± 35
GL06058	7.00	318.3 ± 33.3	1.12 ± 0.08	284 ± 36
GL08045	12.90	332.7 ± 23.8	1.26 ± 0.10	264 ± 28
GL08046	15.00	521.4 ± 41.5	1.56 ± 0.11	334 ± 36
GL08044	15.20	477.2 ± 45.1	1.63 ± 0.13	292 ± 37
GL08043	15.30	284.9 ± 31.9	0.80 ± 0.06	335+47
GL08047	15.50	736.8 ± 51.7	1.49 ± 0.10	494 ± 50

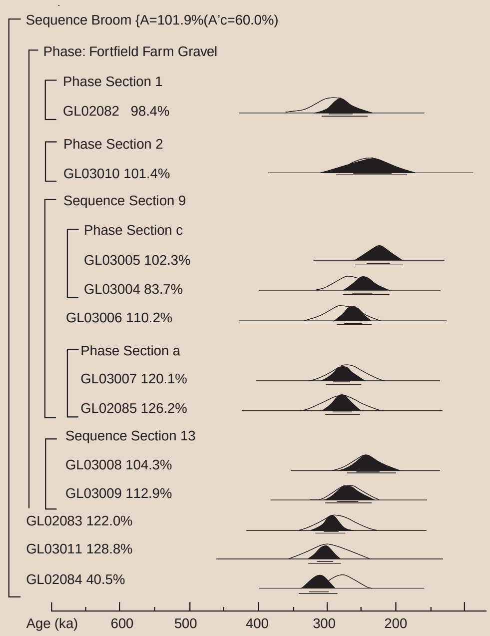
B



2.5.2 A: OSL age estimates from Hodge Ditch I, Chard Junction, listed in stratigraphic order (Basell *et al.* 2011). B. Age-depth plot for Hodge Ditch I Optical dating samples, Chard Junction. MIS curve from ODP 677 (Shackleton *et al.* 1990)

The most common used method for releasing the electrons stored within minerals is by exposing them to light. A stimulating light causes luminescence to be emitted by mineral grains and continues until the trapped electrons are emptied and the signal decreases – this is termed optically stimulated luminescence (OSL). Thermoluminescence produces a signal by heating a sample.

Luminescence dating in now widespread in Palaeolithic archaeology for dating artefacts (Preece et al 2006), artifact-bearing deposits (Hosfield et al 2011; Hosfield and Green 2013) and providing a chronology for landscape development (Bridgland et al 2014)



2.5.3 Bayesian modelling of accepted optical age estimates within the Broom Sand and Silt Bed (from Hosfield *et al.* 2011)

AMINO ACID RACEMIZATION

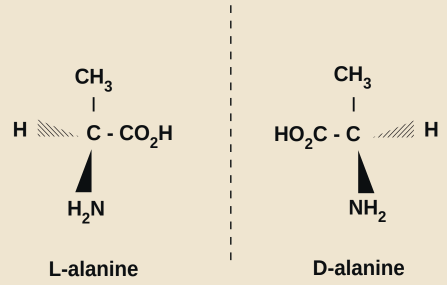
Amino acid racemization (AAR) has been applied to the correlation of Pleistocene sediments in the UK and NW Europe for some time (Bowen *et al.* 1989; Bates 1993) but for a variety of reasons (McCarroll 2002) has only recently been accepted as a routinely used approach for correlating Quaternary sediments (Penkman *et al.* 2011).

The technique relies on the fact that proteins are formed from 20 different types of amino acids, the majority of which can exist in different forms known as stereoisomers (Fig. 2.6.1). Most amino acids have two stereoisomers (an L-amino acid and a D-amino acid). The technique measures the extent of protein decomposition within shell material from material extracted from key geological or archaeological units. Because of metabolic reactions in living organisms only the L-amino acid is present in live specimens. After death, as the protein decomposes, the amino acids change and undergo isomerization (racemization) to produce a mixture of D-and L-amino acids that ultimately form an equilibrium. Samples are selected from material from sediment samples that have been washed through a sieve and picked from residues that have been air-dried.

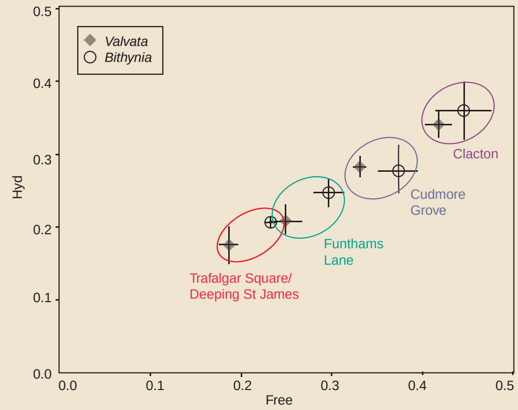
From an early stage in the use of AAR in geochronology it was recognised that the rate of racemization varied between species (Fig. 2.6.2) and this species effect therefore limits the use of the technique. Samples can only be directly compared to other samples of the same species, so an aminostratigraphic framework must be developed for each species studied. Furthermore, changes in the ambient temperature that the samples have experienced since death also impact on the rate of racemization (increasing the temperature at which the samples have been kept since death will increase the rate at which racemization occurs). Consequently, equilibrium will be reached sooner where samples have been subject to higher temperatures. Thus comparison can only be made between samples for which it is likely that temperatures since death have been similar. In practice this means that samples can only be compared from geographical regions where temperatures are similar across the region.

Today, a principal focus of study is made on the amino acids obtained from the remains of the opercula from the freshwater gastropod *Bithynia tentaculata* (Penkman *et al.* 2011). Study has shown that analysis of D/L values of a range of amino acids from the chemically protected organic matter within the biominerals of the opercula provide a robust method of high reliability (Penkman *et al.* 2008). A combination of approaches including Reverse-Phase High Pressure Liquid Chromatography and bleach treatment has established a method that is now fulfilling the hopes of early researchers.

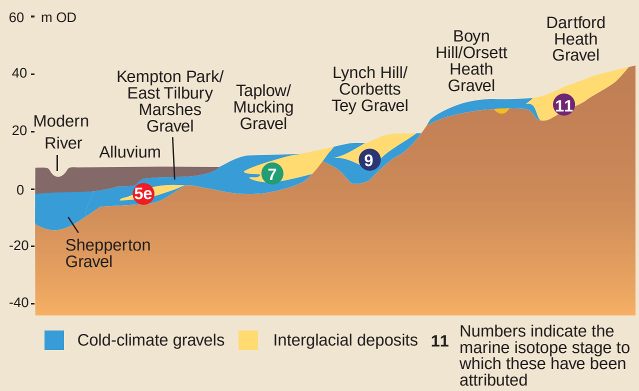
The results of Penkman's work on *Bithynia* opercula enables us to construct a chronological framework from different aggregate deposits in England that can be related to the marine oxygen isotope record, thereby independently validating the stratigraphic frameworks derived from terrace stratigraphy, mammalian palaeontology etc (Penkman *et al.* 2011; for example, compare the aminostratigraphy with the Thames terrace model: Fig. 2.6.3).



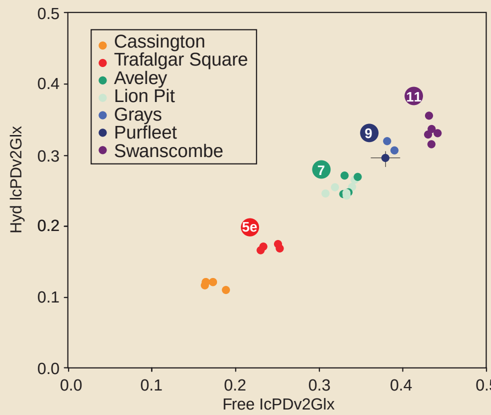
2.6.1 L- and D-amino acid structure (from Penkman *et al.* 2008)



2.6.2 Plot of IcPD hydrolyzed vs IcPD free mean values, with 1 standard deviation, for shells of *Bithynia tentaculata* and *Valvata piscinalis* (from Penkman *et al.* 2008)



2.6.3 A. Lower Thames terrace stratigraphy (after Bridgland 1994)



2.6.3 B. Hyd IcPD vs Free IcPD for the Thames aminostratigraphic sequence. Each point represents the overall extent of intra-crystalline protein decomposition from an individual *Bithynia tentaculata* opercula sample (from Penkman *et al.* 2008) marine based. In some cases this information can then be used to place the archaeological site/area of investigation within a (pre)historical context as well as defining areas in which evidence of *in situ* activity by past human groups / environments may occur. In each case the mixed method approach needs to be structured in order to address the needs of the site/problem. An important element of the investigation is the clear articulation and discussion of the methodologies used, the limitations of the sampling approaches and the impact that that approach may have on the interpretation derived (in other words, the confidence limits that may be placed on the conclusions of the investigation that relate to the location of sample points and correlations made between sample points). Discussion of the sampling strategy utilised in a study as part of routine procedures practiced by Quaternary scientists is rarely documented in the published literature, although this is particularly important (in Quaternary science) where frameworks for site and sequence correlations may be based on individual classes of data (such as small mammals). In many cases complex frameworks may be erected on relatively few sites, and it is only rarely that the details of the sampling strategy (at a regional rather than site level) are considered in the discussion of the data and the confidence placed in the conclusions drawn from that information.

POST-EXCAVATION ANALYSIS

Analysis in the laboratory is one of the major cost factors in conducting Palaeolithic archaeological investigations where time-consuming and expensive investigations are necessary to tease out evidence about the past. These include palaeontological investigation of contained biological materials (Preece and Parfitt 2012), technological investigation of artefacts through refitting (Pope 2002), chemical and sedimentological investigation of sequences (Lewis in Boismier *et al.* 2012) and the dating of samples (Penkman *et al.* 2008; 2011). While traditional palaeontological investigations are now augmented by sophisticated investigations of isotopic signatures of the biological material, or study of DNA, key developments that aid field investigations have largely focused on dating and correlation with the marine isotope chronology (and through this between terrestrial sites).

Significant developments in the post-excavation analysis of field data have been made in the last 10 years through the application of new, or modified, dating techniques to enable more reliable and robust correlation to be made between sites and sequences (Walker 2005). These developments are most noticeable in the fields of radiometric dating where advances in the application of Optically Stimulated Luminescence (OSL) dating to fluvial and marine sediments in southern England have enabled hitherto undatable sequences to be ascribed ages (for examples see PASHCC, MVPP and TVVP and Box 2.5). Major advances have also been made in the application of Amino Acid Racemization (AAR) to the opercula of the freshwater species of mollusc *Bithynia tentaculata* (Penkman *et al.* 2008; 2011). This relative dating technique now provides a framework for comparing sites across the full time depth of the Palaeolithic record (Box 2.6).

APPROACHES TO LANDSCAPE AT A VARIETY OF SCALES

The range of projects undertaken in the ALSF include site-specific investigations such as the Valdoe (Pope *et al.* 2009), Lynford (Boismier *et al.* 2012) and Chard Junction Quarry (Brown *et al.* 2008; Basell *et al.* 2011) through to large-scale regional surveys (PASHCC, MVPP and TVPP). These projects reflect a wide range of scales, encompassing multiple drainage basins, single drainage basins and coastal plains, and spanning at least 500,000 years through the Middle and Upper Pleistocene. Selection of the appropriate scale of investigation is dictated by the nature of the questions being addressed by the archaeological team and, in the case of developer-funded investigation, the size of the area being impacted. Ultimately the scale of investigation will determine the sort of questions being asked of the project and the nature of the investigation strategy used to recover the information required in the project. Some of these issues have recently been considered by Bates and Wenban-Smith (2011).

Macro-scale

At this scale, issues such as palimpsest palaeogeography, ancestral rivers, the Channel link between Britain and Europe and the impact of glaciation are key issues (Box 2.7). In order to address big-picture questions regarding the likely migration routes into Britain, the impact of changing sea-levels on the ability of humans to colonise Britain, and possible reasons for human presence/absence in Britain at various times in the last 800,000 years, large scale palaeogeographies need to be examined. While no ALSF projects attempted to address such issues directly, work in a number of projects has indirectly addressed these problems – for example PASHCC (Bates *et al.* 2004; 2007a), the *Submerged Landscapes of the English Channel* (Gupta *et al.* 2004) and the *Pakefield/Happisburgh Marine Survey* (Wessex Archaeology 2008). Most recently these issues have been more directly addressed through the work of the *Ancient Human Occupation of Britain Project* (AHOB: Preece and Parfitt 2012) as well as the *North Sea Prehistory Research and Management Framework* (NSPRMF: Peeters *et al.* 2009; Cohen *et al.* 2012; Hijma *et al.* 2012). Of relevance here is the recognition that Palaeolithic investigation of a range of sites, at different scales of investigation, can provide relevant information for big picture questions even when the 'no result' scenario is attained during a site

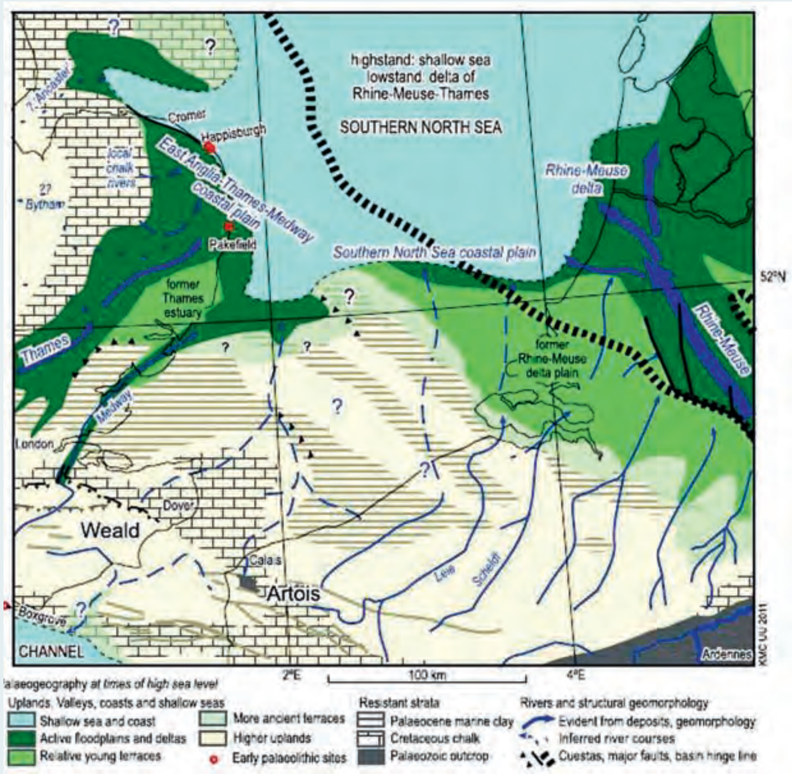
MACRO-SCALE INVESTIGATIONS BOX 2.7

The earliest human occupation of the British landmass (MIS 21-13) occurred during a period in the Pleistocene associated with a physical geography very different to that of the present (Fig. 2.7.1). Efforts to reconstruct the palaeogeography associated with this earliest phase of human occupation (Rose 2009) have focused on modelling the distribution of the contemporary river channels and the nature of the land bridge connecting southern Britain to the continent (Hijma *et al.* 2012). It should be noted that this model (Fig. 2.7.1) represents a combined period of time of nearly 500,000 years and consequently considerable variation (at the meso and micro scales) will have occurred throughout this time; this may be termed a palimpsest-palaeogeography. However, such coarse representations are useful not only for interpreting the local landscape setting of particular finds, but also in evaluating migration routes and associated sequences within which additional evidence for human activity may be preserved (Bates and Wenban-Smith 2011).

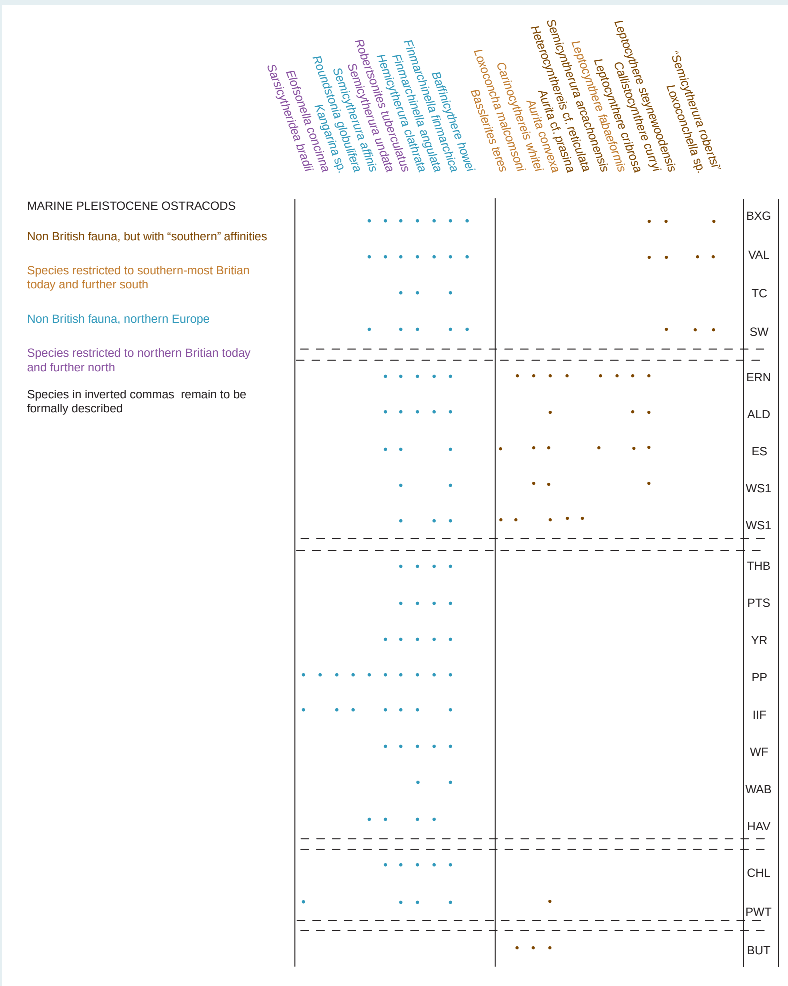
This earlier Middle Pleistocene geography, dominated by eastward or north-eastward draining major river channels originating in the Midlands and flowing across the area now occupied by the Fenland basin towards eastern Norfolk, lay north of a landbridge at the eastern end of the English Channel which formed a large embayment that included the embayment containing the important Palaeolithic site at Boxgrove (Roberts and Parfitt 1999). Disruption of this landscape is generally accepted as having occurred as a result of the advance of ice to the north London area around 450,000 years ago. This had a considerable impact on the geographical structure of the landscape resulting in major remodelling of the major drainage basins such as the Thames (Gibbard 1985), the loss of some systems (eg the Bytham River) and the creation of new rivers and basins (eg the Severn and Fen; Rose 1994). This event (or series of events) resulted in the destruction of much of the landscape associated with the earliest phases of human activity (Wymer 2001) and ALSF work in the English Channel (Gupta *et al.* 2004) provided some of the evidence used to suggest a two stage model for the erosion and loss of the old landbridge (Gupta *et al.* 2007).

The impact of creating the breach between southern England and northern France across the Straits of Dover would have been felt on human and animal access to Britain resulting from the intermittent flooding of this former land bridge (Gibbard 1995; White and Schreve 2000). The impact of these changes, at a regional level, has been examined in the PASHCC project (Bates *et al*. 2007a) which investigated how changes in the composition of foraminifera and ostracod assemblages from the different beaches reflect differences in regional palaeogeography related to open and closed channel geographies (Fig. 2.7.2).

Archaeologically, these landscapes operating at large scales (both temporally and spatially) are useful when attempting to understand the broad patterns of human movement across the landscape as well as temporal patterns at scales of 100,000 years (where perhaps crude changes in frequencies of occupation and technology may be mapped, Bates and Wenban-Smith 2011).



2.7.1 Palaeogeographic map for an interglacial during the early Middle Pleistocene between 0.5 and 1 million years ago (from Hijma *et al.* 2012)

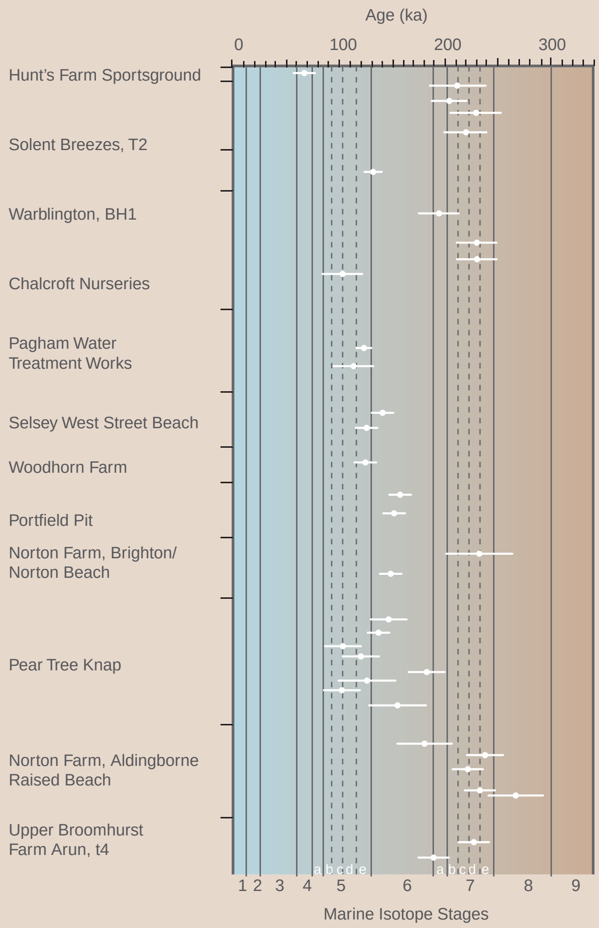


2.7.2 Ostracod range chart from the West Sussex Coastal Plain illustrating the main indicator species and their distributions

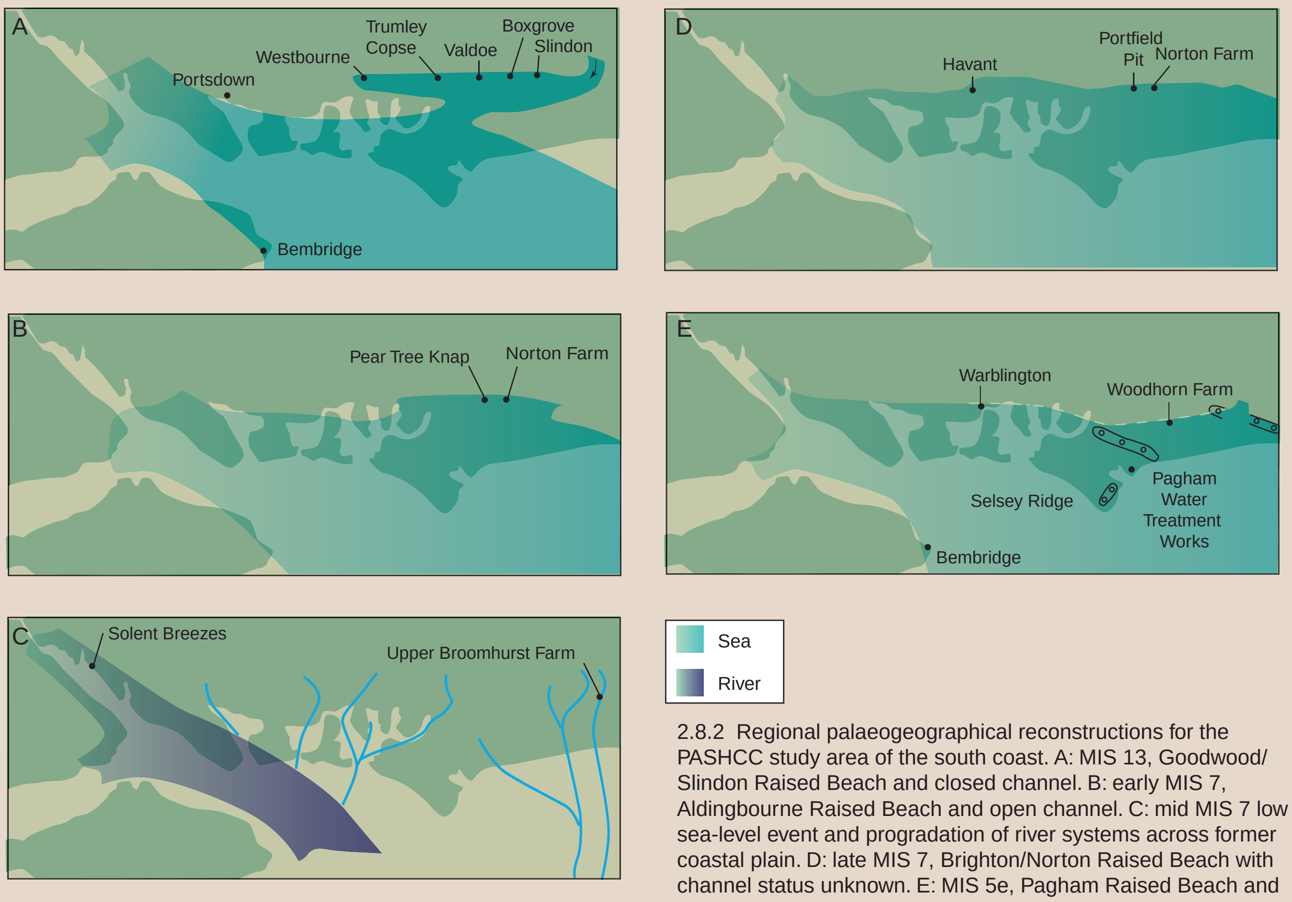
MESO-SCALE INVESTIGATIONS

Palaeolithic archaeology within the West Sussex area is best known for the important site at Boxgrove (Fig. 2.2.3; Roberts and Parfitt 1999). However, this site is associated with more extensive marine deposits at the northern end of a major coastal plain preserving sediments ranging in date from nearly 500,000 years old to recent Holocene deposits (Fig. 2.2.5) that were extensively studied in the PASHCC project (Bates *et al.* 2004; 2007; 2010). Understanding the distribution of potential sites and determining their age is significant in order to adequately address issues of probability and importance related to finds in the region.

Amongst the findings of the project was a significant revision of the age of the main raised beach sequences in the area. Traditionally (Roberts and Parfitt 1999) the Aldingbourne Beach (Fig. 2.2.5) has been assigned to the interglacial immediately following that of the Boxgrove sequences (ie MIS 11/Hoxnian). Artefacts are likely to be abundant in sediments of this age (Ashton and Lewis 2002), although in reality only relatively few, rolled artefacts have been recovered from this beach (Bates *et al.* 2004; 2007a). However, OSL dating and a reconsideration of other lines of evidence (Bates *et al.* 2004; 2007a; 2010) have suggested that



2.8.1 OSL dates from the West Sussex Coastal Plain area plotted against Marine Isotope Stages

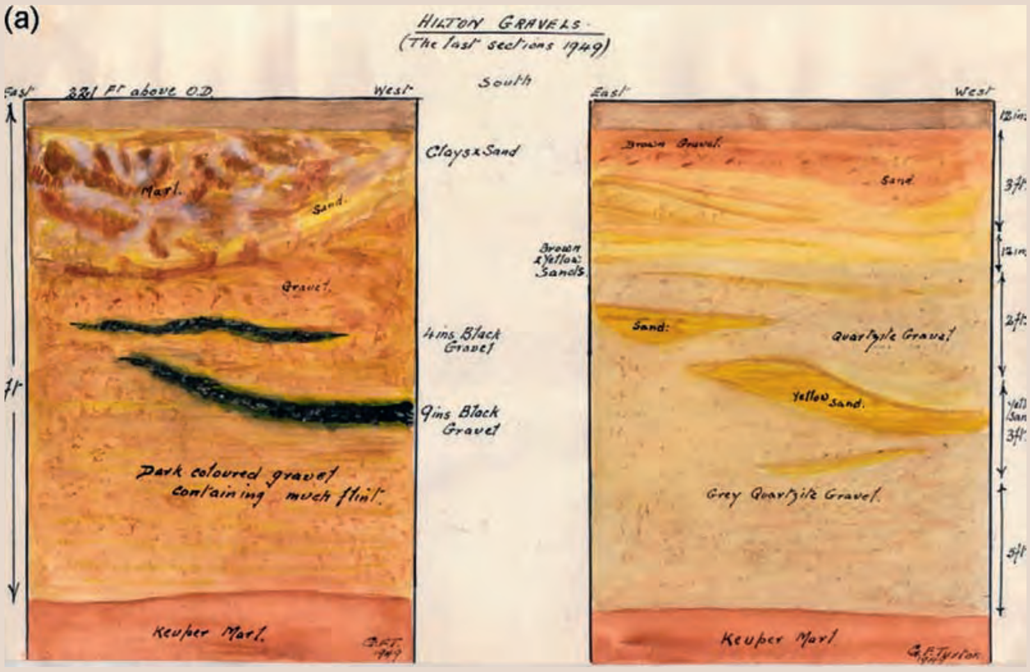


2.8.2 Regional palaeogeographical reconstructions for the PASHCC study area of the south coast. A: MIS 13, Goodwood/ Slindon Raised Beach and closed channel. B: early MIS 7, Aldingbourne Raised Beach and open channel. C: mid MIS 7 low sea-level event and progradation of river systems across former coastal plain. D: late MIS 7, Brighton/Norton Raised Beach with channel status unknown. E: MIS 5e, Pagham Raised Beach and channel open

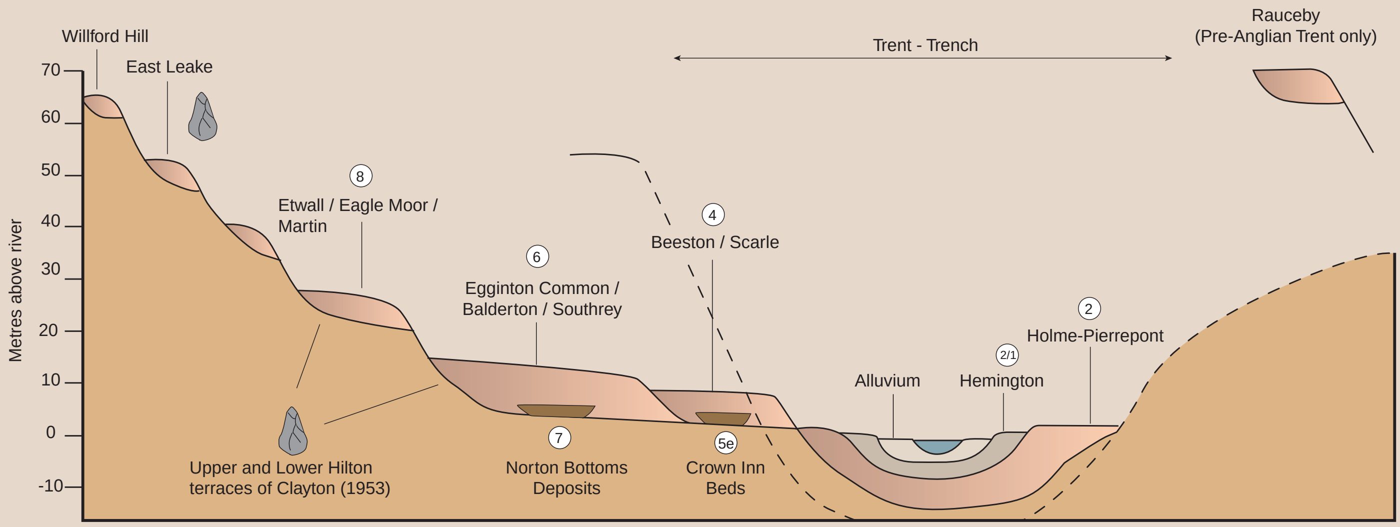
BOX 2.8

the beach might be more likely to belong to the beginning of MIS 7 (Fig. 2.8.1). As Palaeolithic artefacts are likely to be much rarer in deposits of MIS 7 age (Ashton and Lewis 2002) this explains the relative paucity of artefacts recovered from the Aldingbourne Beach. Furthermore, it suggests (perhaps for reasons of local geography; Fig. 2.8.2) that sediments belonging to MIS 9 and 11 are going to be rare or absent in the area of the West Sussex Coastal Plain. This has significant implications for development control issues in the region (see below).

Elsewhere, regional projects such as the TVPP (White *et al.* 2009; Bridgland *et al.* in press) and the MVPP (Wenban-Smith *et al.* 2007 a and b) have played an important part in assessing and synthesising a regional record of archaeological and geological data. For example, in the Trent, survey of unpublished records (Fig. 2.8.3) was linked to a synthesis of the geological and chronological information from the river terraces to produce an integrated model of Palaeolithic distribution by terrace (Fig. 2.8.4).



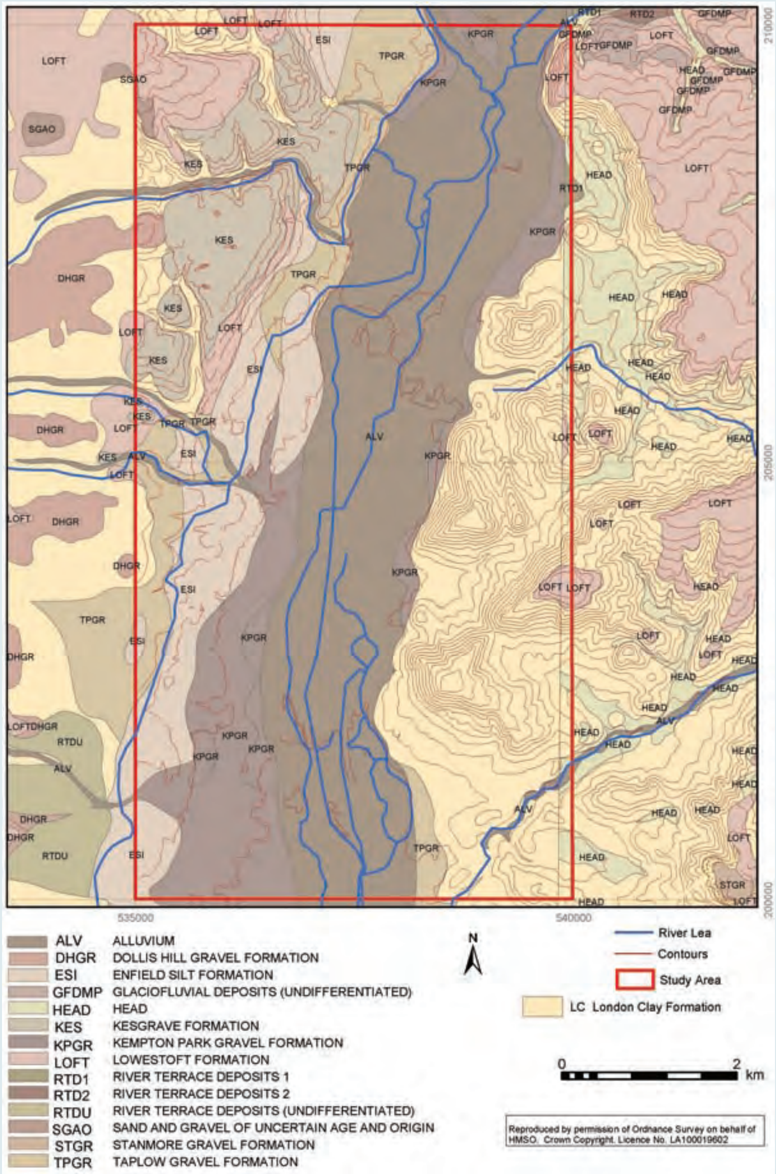
2.8.3 Mr George Turton's section drawing of the gravel deposits at Hilton, Derbyshire (reproduced courtesy of Derby Museum and Art Gallery)

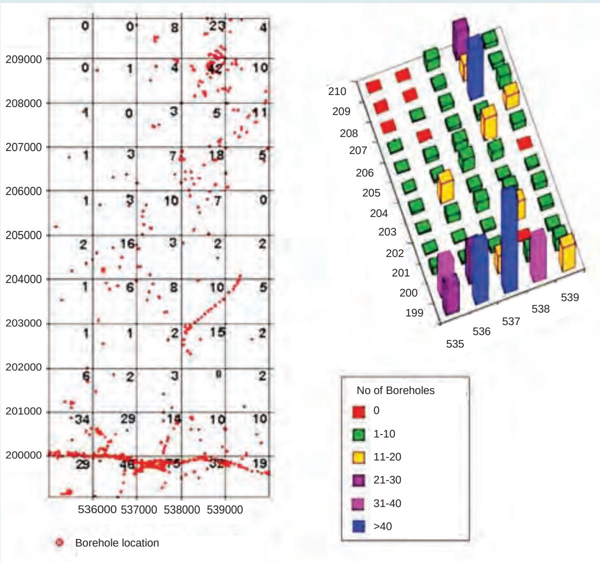


2.8.4 Modified transverse section through the terraces of the Middle Trent based on TVPP work showing the distribution of artefacts by terrace (White *et al.* 2009)

DATA FOR THE HISTORIC ENVIRONMENT

Because of the nature of the Palaeolithic, and in particular the problematic status of 'sites' in the Palaeolithic record, evidence recorded within the Historic Environment Record can be limited, and typically reflects only certain categories of information. Allied to this is the sometimes problematic nature of the baseline British Geological Survey mapping of superficial deposits at a scale reflecting that of the likely archaeological investigations (ie mapped boundaries of geological units may only be accurate to 50m or 100m, while smaller patches of Quaternary sediments may not be recorded at all). In order to address these issues and provide information suitable for incorporation into the HER and supporting GIS systems, a number of ALSF projects directly tackled these issues. Work on the TVPP (White *et al.* 2009; Bridgland *et al.* 2014) and PRoSWeB (Brown *et al.* 2008) provided detailed investigations of the study areas and supplied new and enhanced records for the HER.

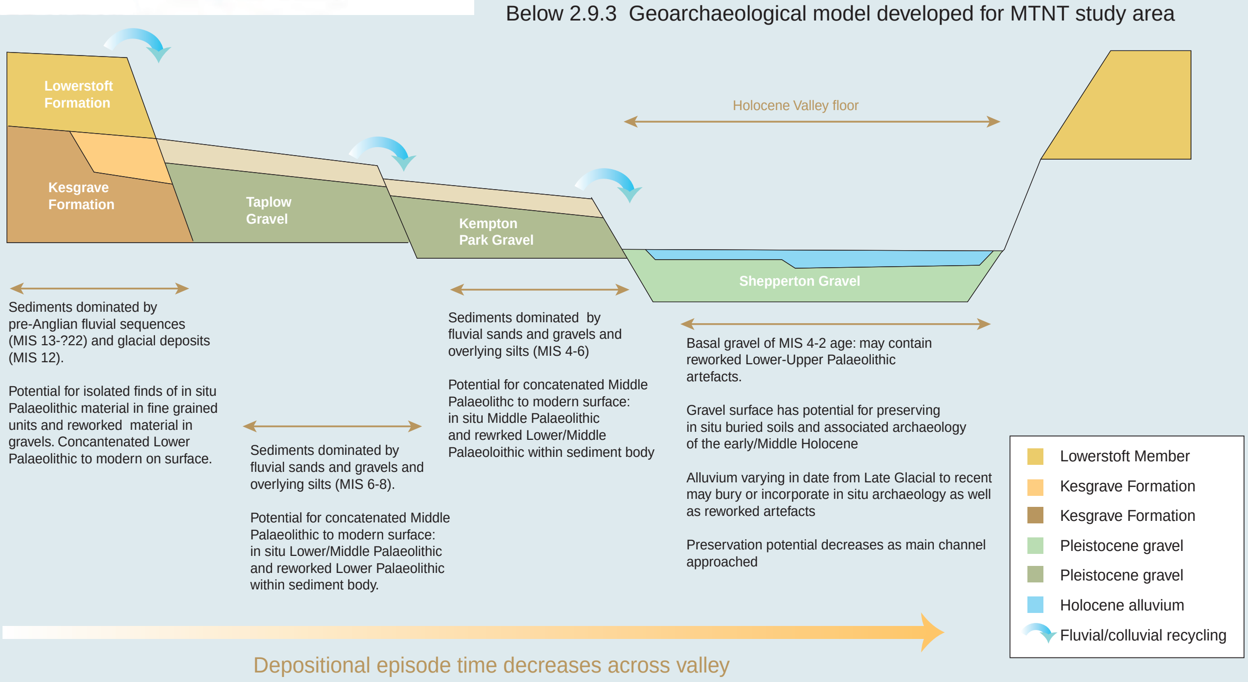




Above 2.9.1 GIS screenshot, superficial geology for the MTNT study area in the Lea Valley

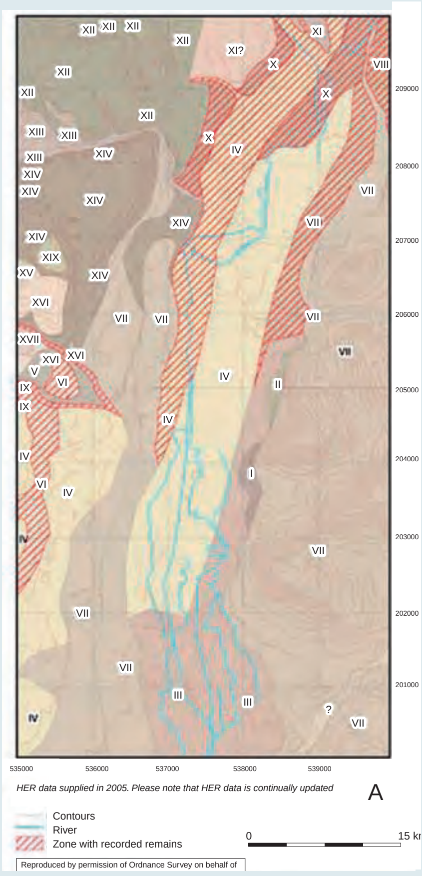
Left 2.9.2 Distribution of boreholes across the MTNT study area

Below 2.9.3 Geoarchaeological model developed for MTNT study area



By contrast, the MVPP (Wenban-Smith *et al.* 2007a and b), PASHCC (Bates *et al.* 2007a) and the MTNT (Bates and Heppell 2007) have all used field and desktop investigations to zone the landscape into differing zones of geoarchaeology/Palaeolithic archaeological potential. This is most clearly illustrated by the MTNT (Bates and Heppell 2007). Starting with the mapped superficial geology for the study area in the Lea Valley (Fig. 2.9.1) and a large data set of extant boreholes (Fig. 2.9.2), a framework geoarchaeological model relating bedrock and superficial geology to archaeology was articulated (Fig. 2.9.3). This enabled the study area to be divided into a series of zones of different potential (Fig. 2.9.4) with each zone supported by a table of data characterising that zone. Similar methods and results were obtained for both the PASHCC and Medway (Fig. 2.9.5) study areas.

Note: See Table 1.1 for project acronyms

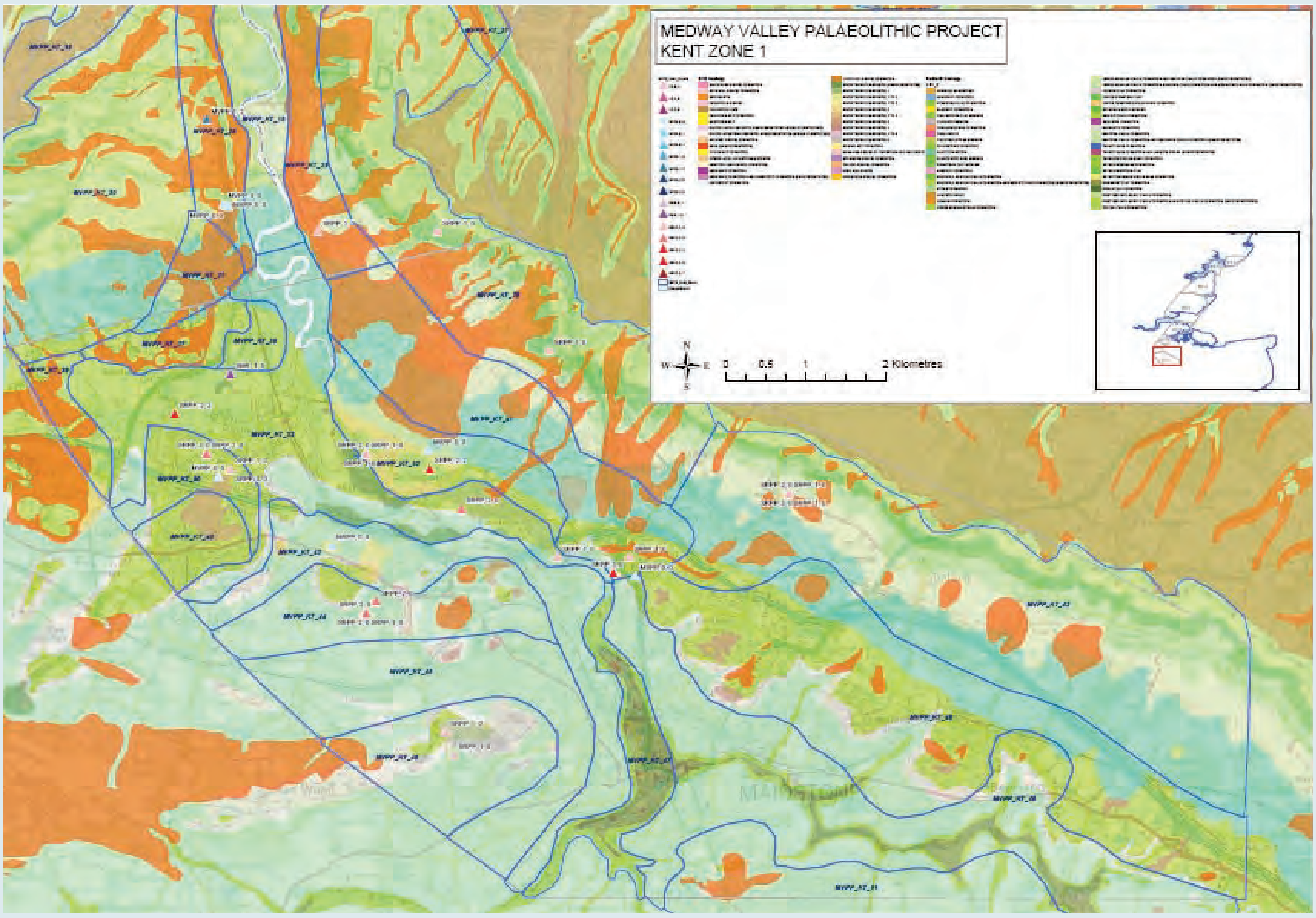


B

Zone descriptor	VI				
Total area of zone	3.79	Area of zone lost to quarrying:	km^2 / %	0.64 / 16.9	
Bedrock geology (defined)	London Clay				
Bedrock geology (description)					
Superficial geology (defined)	Enfield Silt Formation. Mid to Late Devensian silt probably overlying older gravels of the Kempton Park Gravel Formation				
Superficial geology (description)	Fine grained clays-silts.				
Geomorphological situation	Valley side, low lying topography (<3°)				
Age range of sediments	Early Devensian (c.90,000) to recent				
Number of boreholes in zone	54				
Number of palaeoenvironmental sites in zone					
Number of recorded sites in zone					
Paleolithic	1	*Mesolithic*	2	*Neolithic*	
Bronze Age	3	*Iron Age*	1	*Prehistoric*	
Roman		*Saxon*		*Medieval*	9
Post Medieval	5	*Modern*	1	*Unknown*	
Comments	Paleolithic (Levallois) artifact from Rikoff's pit Two Mesolithic occupation sites (C14 dates of 9350 BP +/-120 and 6895BP +/-75) Bronze age entries refer to artifacts with possible uncertain provenance Medieval sites include Rye House moated site and associated entries, Cheshunt nunnery, a leper hospital and a derr park. Post medieval entries refer to the river and canal, a corn mill and a watercress bed				
Key research questions					
Investigation strategies					

Above 2.9.4 GIS screenshot of the MTNT study area subdivided into different Palaeolithic archaeological zones and example of supporting data table for the HER.

Below 2.9.5 GIS screenshot, zoned space in Kent for the MVPP



investigation. Thus sites that have been investigated and found to contain the Rhenish mollusc fauna (eg Bridgland *et al.* 2004) not only imply an age for that site in MIS 11 but also link to large scale palaeogeographic scenarios between the Thames and the Rhine (Bates and Wenban-Smith 2011).

Archaeologically, these temporally and spatially large-scale landscapes are useful when attempting to understand the broad patterns of human movement across the landscape as well as temporal patterns at scales of 100,000 years (where perhaps crude changes in frequencies of occupation and technology may be mapped).

Meso-scale

At this scale, ALSF projects (Box 2.8) have focused on discrete geomorphological systems such as the Chard Junction Quarry Project (Brown *et al.* 2008), the TVPP (Bridgland *et al.* in press), the offshore Arun (Gupta *et al.* 2004), the MVPP (Wenban-Smith *et al.* 2007a and b) and the PASHCC project (Bates *et al.* 2004; 2007a-c; 2010; Briant 2006; 2012). Typically these projects have attempted to:

- Contextualise extant collections of artefacts (eg the TVPP and PASHCC projects)
- Track and map individual bodies of sediment likely to contain archaeology or to provide marker horizons to help to date and correlate other sediments stratigraphically removed from these deposits (ie above or below the marker horizons). Examples of marker horizons within project study areas are the buried land surfaces associated with the Goodwood/Slindon and Brighton/Norton Raised Beaches in West Sussex (Fig. 2.27A/B). Sometimes the marker horizons or units can subsequently be dated directly (through OSL) or indirectly (through biostratigraphy or relative dating techniques such as AAR).

Understanding these palaeogeographical changes helps explain the distribution of the archaeological resource, and allows us to make predictions regarding the location of sequences that elsewhere contain Palaeolithic archaeological remains. This scale of investigation is particularly useful for development control officers responsible for maintaining the HER or implementing strategies in advance of construction. This approach was pioneered in the PASHCC (Bates *et al.* 2004; 2007), MVPP (Wenban-Smith *et al.* 2007a and b), MTNT (Bates and Heppell 2007) and the *Fenland Rivers of Cambridgeshire Palaeolithic Project* (FRCPP: White *et al.* 2008a). These are projects where the ultimate goal was to provide the HER with additional information to aid the planning process (Box 2.9).

Fig. 2.27 A: Buried landsurface of the Goodwood/Slindon Raised Beach

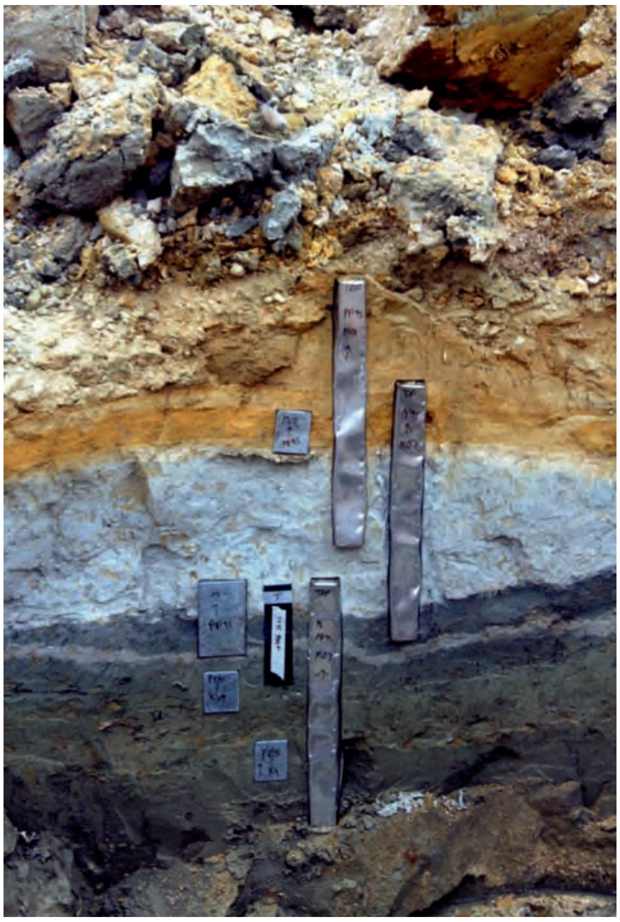


Fig. 2.27 B: Buried landsurface of the Brighton/Norton Raised Beach

MICRO-SCALE INVESTIGATIONS BOX 2.10

The Valdoe Quarry (Fig. 2.10.1) lies on the Goodwood Estate, near Chichester in West Sussex. Topographically, it occupies an almost identical position in the landscapes to the original Boxgrove site some 6km to the east, and it had been established that deposits of a similar nature existed in the pit. In 2006 a project, funded directly through the ALSF was established to assess the archaeological potential of areas of ongoing quarry expansion. The project developed an intensive and scaled approach to the assessment allowing for staged survey, geological mapping and targeted archaeological excavation as an understanding of the site developed. At the core of the project was the need to identity, isolate and excavate areas of an intact ancient landsurface (designated Unit 4c) identified at Boxgrove and known to extend more widely in the mapped palaeolandscape. This landsurface and its equivalent deposits preserved the highest resolution archaeology and associated hominin remains at Boxgrove.

2.10.1 A view of the Valdoe Quarry

2.10.2 Drilling on the Upper Coastal Plain

2.10.3 Excavated landsurface, Valdoe Quarry

The project also examined the wider distribution of the palaeolandsurface across the Goodwood Estate and into the Lavant Valley. This part of the county has produced a large quantity of Palaeolithic surface finds which may have largely derived from subcrops of the Slindon Formation.

Through geological mapping by percussion borehole (Fig. 2.10.2) the ancient landsurface was identified across the northern portion of the quarry site (Fig. 2.10.3) and test pits were dug to allow for hand excavation of its surface. The excavations recovered small scatters of handaxe sharpening flakes and, closer to the old cliff line, large flakes from the early stages of handaxe manufacture (Fig. 2.10.4).

The project produced the first clear evidence for *in-situ* archaeology within the wider Boxgrove palaeolandscape outside of the main Boxgrove site. In addition excellent palaeoenvironmental evidence was recovered, of a higher quality even to those preserved at the main Boxgrove site, allowing for nuanced reconstruction of ancient environments and landscape change at the Valdoe locality.

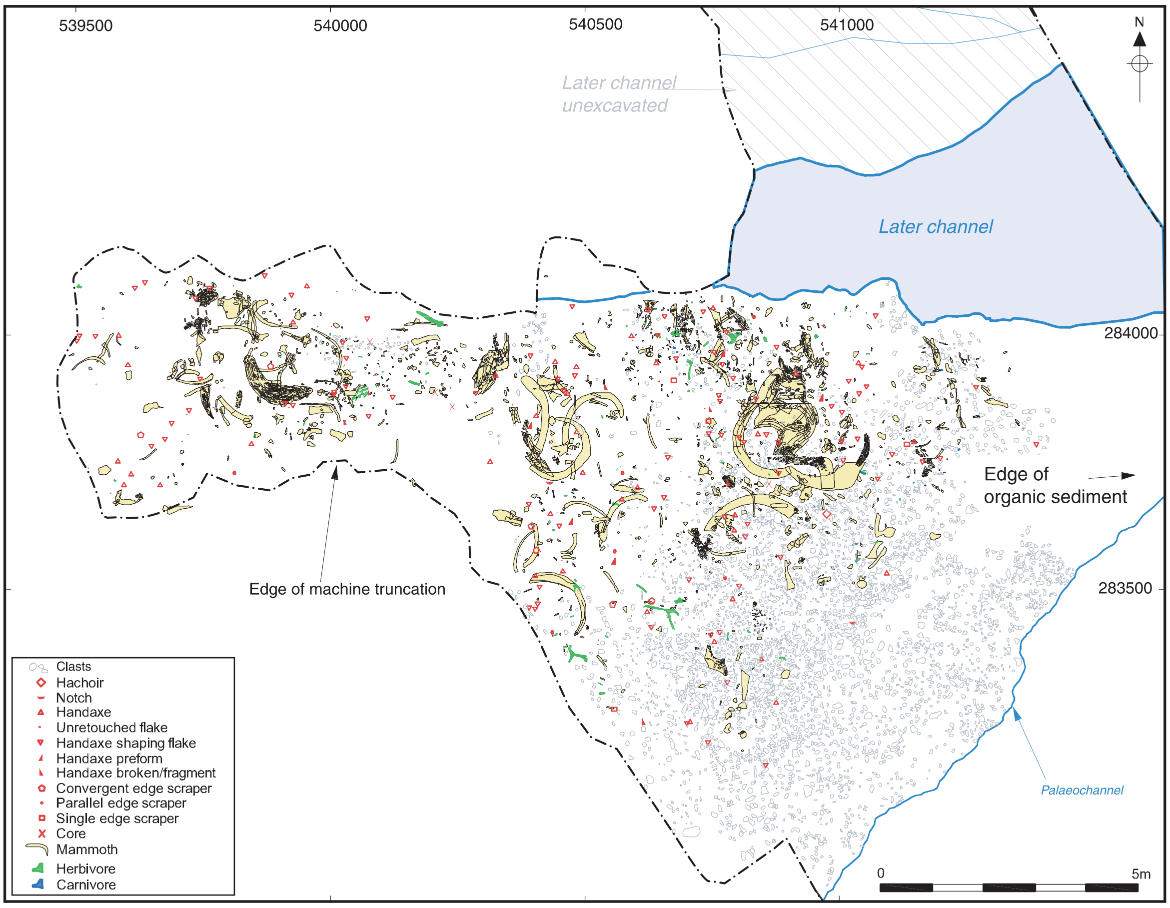
The project provides an example of how targeted funding through the ALSF worked alongside the aggregates industry to provide efficient evaluation and investigation methodology, taking a wider understanding of sedimentary context and ancient human behaviour to zero in on microscales of investigation within relatively extended landscapes.

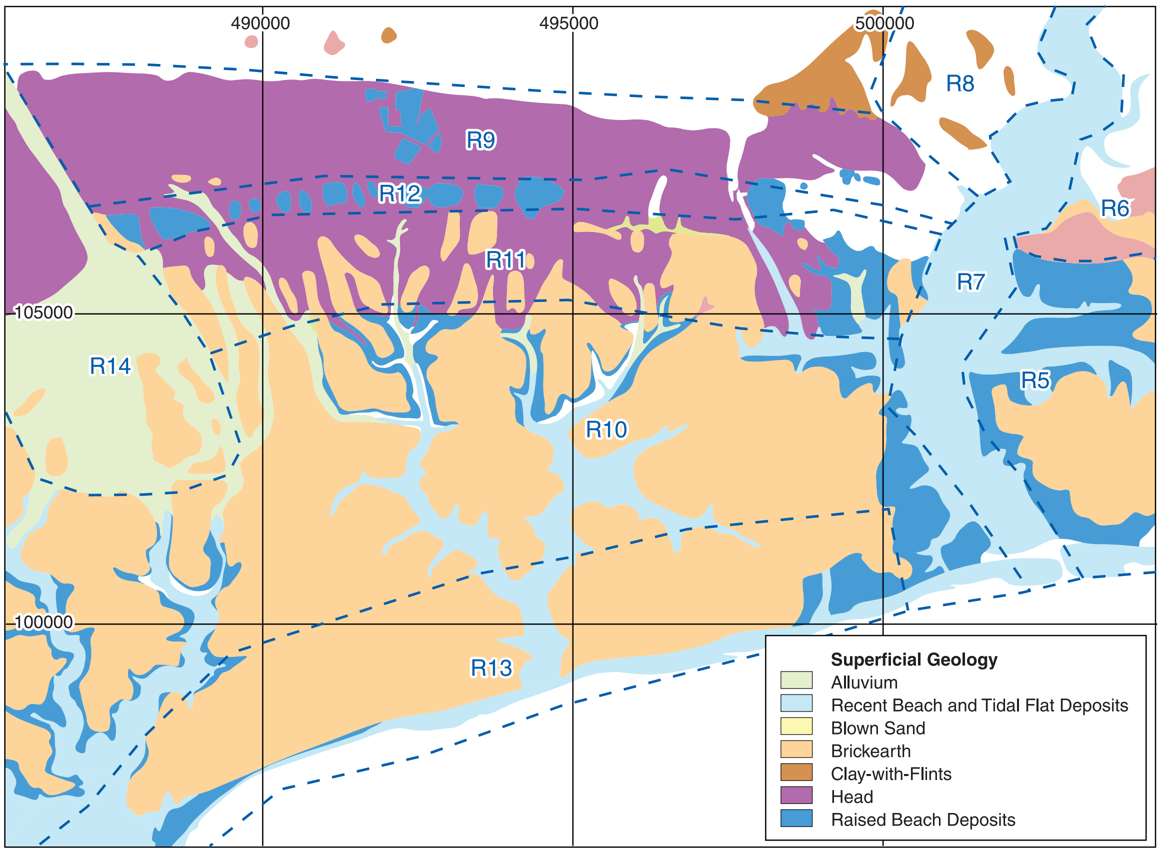
2.10.4 Finds under excavation at the Valdoe Quarry

Table 2.3 Description of zones of Palaeolithic potential as defined in the PASHCC project for part of West Sussex Coastal Plain (see Fig. 2.29)

Zone	*Geomorphological context*	*Bedrock (as mapped by BGS)*	*Superficial sediments (as mapped by BGS)*
R5	Adur Valley floodplain floor	Upper and Middle Chalk	Alluvium with elements of Head, Raised Beach Deposits (1) and Storm Gravel Beach Deposits
R6	Lower coastal plain backing against steeply rising slopes of South Downs. Dry valleys enter from South Downs	Upper and Middle Chalk, Woolwich and Reading Beds and London Clay to southwest	Head, Raised Beach Deposits (1) and Alluvium
R7	Lower coastal plain.	Upper and Middle Chalk, Woolwich and Reading Beds and London Clay	Brickearth, Raised Beach Deposits (1), Alluvium
R8	Modern Storm beach coastal fringing strip	Upper and Middle Chalk	Storm Gravel Beach Deposits
R9	Lower coastal plain backing against steeply rising slopes of South Downs. Dry valleys enter from South Downs	Upper and Middle Chalk	Brickearth, Raised Beach Deposits (1), Alluvium
R10	Upper part of Lower coastal plain backing mouth of Arun Valley	Upper and Middle Chalk, Woolwich and Reading Beds and London Clay	Brickearth, Raised Beach Deposits (1), Alluvium
R11	Lower valley sides (east) of Arun Valley	Upper and Middle Chalk, Woolwich and Reading Beds and London Clay	Arun terraces 2/3/4
R12	Arun Valley/Upper Coastal Plain confluence	London Clay	Raised Storm Beach 2
R13	Arun Valley floodplain	Upper and Middle Chalk, Woolwich and Reading Beds and London Clay	Alluvium with elements of Head, Raised Beach Deposits (1, 2), Raised Storm Beach Deposits (1, 2) and Storm Gravel Beach Deposits
R14	Lower valley sides (west) of Arun Valley	Upper and Middle Chalk, Woolwich and Reading Beds and London Clay	Arun terraces 2/3/4

Superficial sediments (as mapped/ identified by PASHCC)	*Summary of Palaeolithic artefactual and zoological remains*	*Geological periods*
(may contain evidence of buried gravels of the Adur beneath alluvium)	Biological material expected in Holocene alluvium (pollen, plant macrofossils, insects, molluscs, foraminifera/ostracoda)	Mainly Holocene – some Devensian at depth. If elements of Raised Beach 1 present Saalian also
Chalky head deposits with a mixture of chalk and flint rich gravels overlying high energy storm beach gravels close to cliff. Away from cliff extensive sand sequences overlain by fine grained silts. Silts seal intact buried landsurface in places some evidence for palaeosols in Head deposits	Large, small mammal remains, molluscs, foraminifera/ostracoda reported from sands, silts and overlying chalky head	Saalian Devensian, Recent
Extensive sand sequences overlain by fine grained silts. Silts seal intact buried land-surface in places some evidence for palaeosols in Head deposits	Large, small mammal remains, molluscs, foraminifera/ostracoda reported from sands, silts and overlying chalky head	Saalian Devensian, Recent
–	None known	Recent Holocene
Chalky head deposits with a mixture of chalk and flint rich gravels overlying high energy storm beach gravels close to cliff. Away from cliff extensive sand sequences overlain by fine grained silts. Silts seal intact buried landsurface in places some evidence for palaeosols in Head deposits. High energy beach gravels replace sand in places in south of zone	Large, small mammal remains, molluscs, foraminifera/ostracoda reported from sands, silts and overlying chalky head	Saalian Devensian, Recent
Head deposits overlying high energy storm beach gravels close to cliff. Away from cliff extensive sand sequences overlain by fine grained silts. Silts seal intact buried landsurface in places some evidence for palaeosols in Head deposits	Large, small mammal remains, molluscs, foraminifera/ostracoda reported from sands, silts and overlying chalky head	Saalian Devensian, Recent
Fluvial gravel overlain by Periglacial Head/ slope wash deposits	Occasional large mammal bone preservation	?Saalian/Devensian
Marine gravels over bedrock	None known	Saalian
(may contain evidence of buried gravels of the Arun beneath alluvium)	Biological material expected in Holocene alluvium (pollen, plant macrofossils, insects, molluscs, foraminifera/ostracoda)	Mainly Holocene – some Devensian at depth. If elements of Raised Beach 1 present Saalian also
Fluvial gravel overlain by Periglacial Head/ slope wash deposits	Occasional large mammal bone preservation	?Saalian/Devensian


539500
540000
540500
541000
N
Later channel
unexcavated
Later channel
284000
Edge of
organic sediment
283500
Edge of machine truncation
Palaeochannel
0
5m
Clasts
Hachoir
Notch
Handaxe
Unretouched flake
Handaxe shaping flake
Handaxe preform
Handaxe broken/fragment
Convergent edge scraper
Parallel edge scraper
Single edge scraper
Core
Mammoth
Herbivore
Carnivore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Superficial Geology
Alluvium
Recent Beach and Tidal Flat Deposits
Blown Sand
Brickearth
Clay-with-Flints
Head
Raised Beach Deposits

Micro-scale

At this scale, examining the nature of the archaeology within a known site and in ideal situations addressing questions related to technology, mobility, and 'ethnographical' style hominin practices may be the focus of the investigation. Examples funded by the ALSF include the excavations at Lynford (Boismier *et al.* 2012) and the Valdoe (Box 2.10; Pope *et al.* 2009).

The excavations at the site of Lynford (Bosimier *et al.* 2012) demonstrate the problems often faced by Palaeolithic archaeologists even on sites where evidence of human activity and palaeoenvironmental data are recovered from the same deposits. Here, organic silts and sands filling a palaeochannel were found to contain a cold-stage mammalian assemblage rich in mammoth remains, and an associated Mousterian flint industry of some 2,720 pieces (Fig 2.28). The OSL dates place the filling of the channel at between 65,000 and 57,000 BP, at the transition between Marine Isotope Stages (MIS) 4 and 3. Unfortunately, there is no 'smoking gun' and the absence of cut-marks on the mammoth bones means that their relationship with human activity at the site remains circumstantial. There are, however, typically human patterns of breakage on the bones of horse and woolly rhinoceros; and given that the location was a still or slow-flowing backwater, at times stagnant and often boggy, one might reasonably argue that the Neanderthals were only there to exploit the carcasses of mammoths and other animals that had become trapped in the mire (through whatever agency).

DISCUSSION

The wide range of project types that have been undertaken in the guise of the ALSF have consistently attempted to contextualise sites and findings as well as to test new methods of investigation. The outcomes of the projects have been new or developed methodologies or novel applications of approaches used elsewhere but not previously applied in Palaeolithic archaeology. Most significantly, the projects all reflect the realistic application of techniques to problems that could, and should, be applied more widely. The approaches developed and illustrated by the ALSF projects do not reflect 'state-of-the-art' high-cost scientific techniques that may be applicable in one or two instances but are either limited in application or too expensive to routinely use. Rather, they are approaches that offer pragmatic methods to tackle the problems of our Palaeolithic past within a time and budget framework that is both practical and realistic.

The long term success and legacy of the Palaeolithic projects undertaken as part of the spectrum of ALSF funded works will ultimately be judged on their ability to inform non-specialist readers for whom the role of the Palaeolithic within development control is something of a 'dark art', practised by a few, and kept secret through the use of jargon and inaccessible terminology. It can be deemed to have been successful if, as a result of the projects that are synthesised in this volume, future Palaeolithic projects within the commercial sector take forward the findings and methods described and utilise them within the context for which they have been developed.

This educative process is perhaps best considered in the context of a better understanding of the fact that a 'no-return' on finding Palaeolithic artefacts does not negate the importance of a site – it simply modifies the information obtained from the study. Ultimately, Palaeolithic archaeology is not just about excavating the evidence for human behaviour – it is about that behaviour in a landscape in which the primary archaeological 'site' is just one node, and any information from that landscape has the potential to inform about the archaeology scattered across it. Perhaps in the near future we can hope that integration of results in the HER may include not only data on find spot distribution but also perhaps subdivision of the landscape into different zones of Palaeolithic potential (Table 2.3; Fig. 2.29; Box 2.9). This would provide curators with the tools to manage the resource in a proactive and informed fashion. If we achieve such an understanding, then the legacy of the ALSF will be cemented.

Fig. 2.28 (opposite, above) Distribution map showing mammal remains and stone tools from Lynford (from Boismier et al. *2012)*

Fig. 2.29 (opposite, below) Part of West Sussex Coastal Plain divided into zones of different Palaeolithic potential for integration with the HER (from Boismier et al. *2012)*