



Late persistence of the Acheulian in southern Britain in an MIS 8 interstadial: evidence from Harnham, Wiltshire



M.R. Bates^{a, *}, F.F. Wenban-Smith^b, S.M. Bello^c, D.R. Bridgland^d, L.T. Buck^{c, e},
M.J. Collins^f, D.H. Keen^{g, 1}, J. Leary^h, S.A. Parfitt^{c, i}, K. Penkman^f, E. Rhodes^j, C. Ryssaert^k,
J.E. Whittaker^c

^a School of Archaeology, History and Anthropology, University of Wales Trinity St. David's, Lampeter Campus, Ceredigion SA48 7ED, Wales, UK

^b Department of Archaeology, University of Southampton, Southampton SO17 1BF, UK

^c Department of Earth Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK

^d Department of Geography, University of Durham, Science Laboratories, South Road, Durham DH1 3LE, UK

^e Centre for Research in Evolutionary and Ecological Anthropology, Whitelands College, University of Roehampton, Holybourne Avenue, London SW15 4JD, UK

^f BioArch, Biology S Block, University of York, PO Box 373, York YO10 5YW, UK

^g Institute of Archaeology and Antiquity, University of Birmingham, Birmingham B15 2TT, UK

^h Department of Archaeology, University of Reading, Whiteknights, Reading RG6 6AB, UK

ⁱ Institute of Archaeology, University College London, 3134 Gordon Square, London WC1H 0PY, UK

^j Department of Earth and Space Sciences, University of California Los Angeles, 595 Charles Young Drive East, Box 951567, Los Angeles, CA 90095-1567, USA

^k ODIN, Oude Brugsepoort 17, 9800 Deinze, Belgium

ARTICLE INFO

Article history:

Received 25 June 2013

Received in revised form

20 June 2014

Accepted 1 July 2014

Available online

Keywords:

Northwest European Lower/Middle

Palaeolithic

Acheulian

MIS 8

Middle Pleistocene environment

Vertebrates

Molluscs

Ostracods

Undisturbed occupation

Handaxes

ABSTRACT

This paper presents evidence of the discovery of a new Middle Pleistocene site in central southern England, with undisturbed evidence of hominin occupation well-dated to an interstadial towards the end of Marine Isotope Stage 8, c. 250,000 BP. The site consists of a preserved remnant of a river terrace and its alluvial floodplain overlain by chalk-rich bankside deposits, all abutting a Chalk bedrock riverbank. It preserves an area of occupation with activity focused on the riverbank, complemented by occasional activity on a palaeo-landsurface developed on the surface of the alluvial floodplain. Lithic technology at the site consists almost entirely of handaxe manufacture, allowing attribution to an Acheulian industrial tradition. Mammalian and other palaeo-environmental remains are present and associated with the occupation horizons, including large mammal bones showing signs of hominin interference. Dating was based on OSL determinations on the sediments and amino acid racemisation of molluscan remains, supported by biostratigraphic indications. Besides being a rare instance of an undisturbed Palaeolithic palaeo-landscape covering several hectares, the site contributes to wider Quaternary research concerns over the ability of Middle Pleistocene hominins to tolerate colder climatic episodes in higher latitudes, and over settlement history and changing lithic industrial traditions of northwest Europe in relation to climate change and British peninsularity. It is suggested that the Harnham evidence may represent an insular population that had persisted in southern Britain since MIS 10/9, which became locally extinct during the glacial maximum 8.2 marking the end of MIS 8.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Over the last 50 years our understanding of the British Lower/Middle Palaeolithic record has mainly been enhanced by

reinvestigation of sites first discovered and described in the 19th or early 20th century, e.g. Swanscombe (Ashton et al., 1996), Hoxne (Singer et al., 1993; Ashton et al., 2008), Barnham (Ashton et al., 1998), High Lodge (Ashton et al., 1992) and Baker's Hole, Northfleet (Wenban-Smith, 1995). However, it has been rare that entirely new sites, such as the undisturbed landscape at Boxgrove in Sussex (Roberts and Parfitt, 1999) and the evidence of very early occupation on the East Anglian coast at Pakefield and Happisburgh (Parfitt et al., 2005, 2010) are discovered and excavated. The decreased

* Corresponding author.

E-mail address: m.bates@tsd.ac.uk (M.R. Bates).

¹ Deceased.

discovery of new sites in the later 20th century is probably due to increased mechanisation of quarrying activities together with reduced collector access to active quarries. However, since the early 1990s archaeological evaluations in advance of construction have become more frequently required under the terms of British government planning policy guidance, note PPG 16 (Department of the Environment, 1990). Consequently large transects of the landscape affected by major infrastructural projects have begun to be more thoroughly investigated for threatened archaeological/Quaternary remains. As well as providing for further investigations of known sites affected by such works (e.g. at Baker's Hole, Wenban-Smith et al., in press), this has led to the discovery of entirely new sites – for instance, the Middle Pleistocene elephant butchery site in Kent, found during archaeological work in advance of High Speed 1 (Wenban-Smith, 2013), and the Late Pleistocene Neanderthal site at Lynford, Norfolk, found during routine monitoring of gravel extraction (Boismier et al., 2012).

Here we report on the discovery of a previously unknown late Middle Pleistocene occupation site at Harnham in the Avon Valley south of Salisbury, Wiltshire, UK (national grid reference SU 1520 2785) (Fig. 1). The site, found during archaeological evaluation in advance of a proposed ring road to the south of Salisbury, lies c. 500 m from a small mapped patch of river terrace gravel, but otherwise there was no prior indication, from either geological mapping or previous finds, of the nature of the deposits present or their significant archaeological content. This report reviews the discovery of the site, the geology and palaeoenvironmental remains, the age of the deposits, and provides a summary of the artefactual remains. Of particular relevance to wider Quaternary research issues are (a) the demonstration of British occupation in an interstadial within the cold stage MIS 8, (b) the abundant evidence of a technology dominated by handaxe manufacture, without any sign of Levalloisian prepared-core knapping approaches thought to be broadly coeval in other parts of the UK and north-west continental Europe, and (c) the contribution of the site to increasing understanding of the wider picture of lithic industrial variation and settlement history in Britain and north-west continental Europe in the later Middle Pleistocene.

2. Background

The site lies within the Hampshire Basin (Melville and Freshney, 1982) in a Chalk-dominated landscape on an interfluvium between the Avon and Ebble valleys (Fig. 1) between c. 70 and 75 m O.D. Pleistocene sediments were first described in the Salisbury area by

Lyell (1827) who drew attention to the fossiliferous deposits at Fisherton (see Green et al., 1983). Subsequently, the area was investigated by Reid (1903) and Sealey (1955) and most recently by the British Geological Survey (1976).

Current understanding of the Lower/Middle Palaeolithic in the Hampshire Solent Basin was synthesised by the *Southern Rivers Palaeolithic Project* (Wessex Archaeology, 1993), but the region has been relatively neglected for Palaeolithic archaeological research since the first half of the 20th century, although this is now beginning to change (Wenban-Smith and Hosfield, 2001; Westaway et al., 2006; Ashton and Hosfield, 2010). Artefact find-spots are generally abundant within the region, although concentrated in particular areas. The majority of finds come from gravel terraces associated with the main axis of the former Solent River (Fox, 1862), heading east from Dorchester, through Bournemouth and Southampton to Portsmouth. In the vicinity of Harnham, associated with the tributary valley of the Avon, there are three major sites where substantial quantities of Palaeolithic handaxes have been recovered from Pleistocene terrace gravels: Bemerton, Salisbury; Milford Hill, Salisbury; and Wood Green, north of Fordingbridge (Wessex Archaeology, 1993; Wymer, 1999). The site of Milford Hill in particular is a relevant comparator to the Harnham site, being only a few km to the north and associated with terrace deposits at a broadly similar height. The rich handaxe collections are dominated by pointed forms, including ficrons, some of which are in fresh condition suggesting contemporaneity with deposition of the terrace deposit (Roe, 1981: 213; Harding and Bridgland, 1998). There are also occasional find-spots of isolated artefacts, generally associated with mapped bodies of fluvial sand/gravel (e.g. along the courses of the Bourne and the Nadder upstream of Salisbury, and the Avon downstream), although several are associated with outcrops of Clay-with-flints or at locations with no known Pleistocene sediments (*ibid.*).

3. Site investigation

The site was discovered during archaeological evaluation in advance of a proposed new road scheme – the Harnham Relief Road – to the south of Salisbury in late 2002. Following the discovery of a cluster of handaxes on the surface of a ploughed field along the proposed road route, a fieldwork programme was developed to investigate the Palaeolithic potential of the underlying sediments by fieldwalking, trial-trenching and deep test-pitting. This work identified a buried bank of chalk-rich slope-wash/solifluction deposits – parallel with the 2002 Trench 58

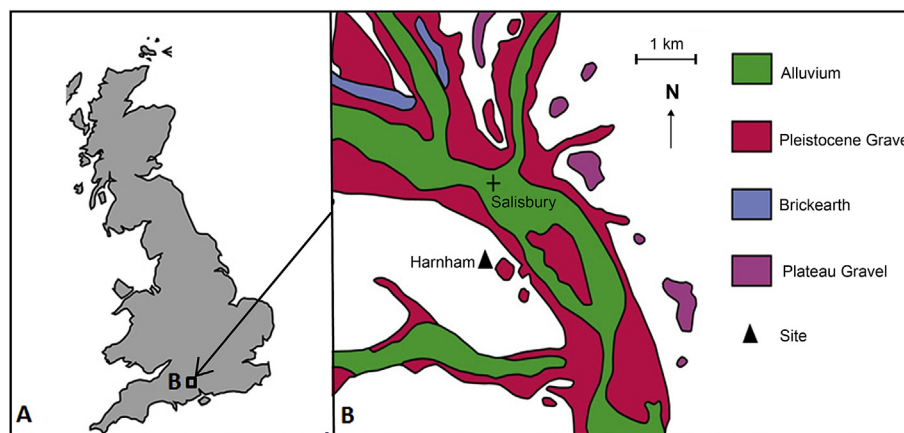


Fig. 1. Site location plan. A: location of study area in United Kingdom; B: site location plan showing superficial geology, distribution of rivers and location of site in the vicinity of Salisbury.

(Fig. 2) – as being particularly rich in Palaeolithic artefacts where ploughing was cutting into the bank and disturbing a dense artefact concentration. Seven trial trenches (Fig. 2, TR 58–63, 65) were opened to expose the sub-ploughsoil deposits. Deeper test-pitting and hand excavation in some of the trenches allowed the sub-surface deposit sequence to be examined in more detail and

sampled. The floor of Trench 59 was hand-excavated to a depth of c. 30 cm into the underlying Pleistocene deposits, and a deeper sondage (c. 1 m²) was dug for environmental sampling. A c. 1 m² test pit was excavated by hand at the south end of Trench 58 in order to assess the density and nature of the artefact concentration within the chalk-rich deposits, followed by further hand excavation

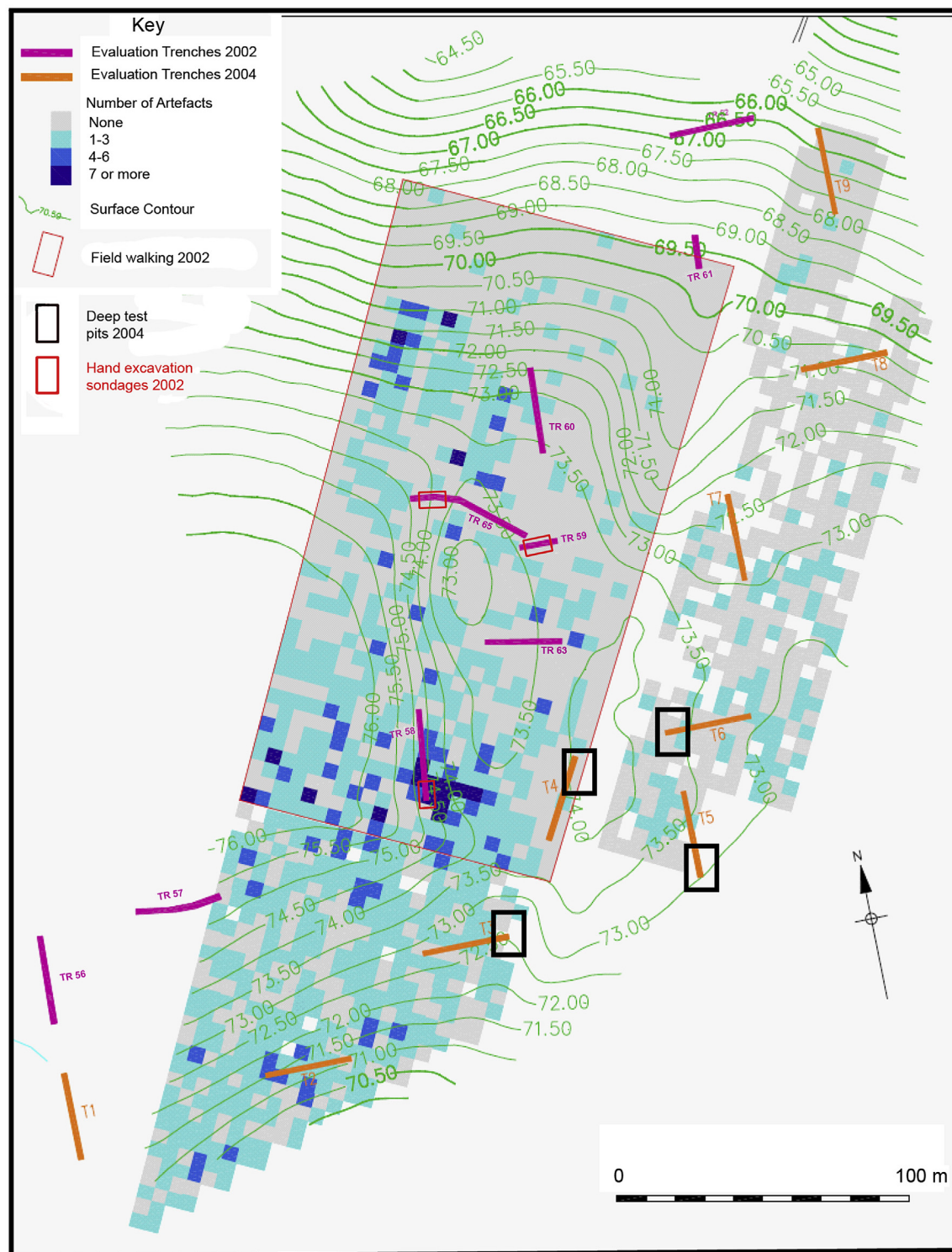


Fig. 2. Distribution of trenches from 2002 to 2004 investigations and results of the fieldwalking survey for Palaeolithic archaeology. Red boxes indicate position of hand-excavated sondages in selected 2002 trenches; black boxes indicate deeper machine-dug test pits in selected 2004 trenches. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

of an undisturbed landsurface at the west end of Trench 65. Samples were taken for dating by optically stimulated luminescence (OSL) in Trenches 59 and 60, and vertical series of samples for various types of environmental remains were taken through the upper fine-grained sequence in Trench 59.

A second investigation was undertaken in late 2004 to refine the model of site stratigraphy and to delimit the extent of key sediment bodies more precisely. This phase of works involved nine further trial trenches (Fig. 2, T1–T9), with machine excavation of deeper test pits within four of them (Trenches 3–6). Coarse sieving for artefacts was undertaken in all trenches where gravels were encountered. Samples of 100 L at regular (c. 25 cm) intervals were taken in the gravels as excavation progressed and dry-sieved on site through a 1 cm mesh for recovery of lithic artefacts and biological evidence. When the sediment was finer or not suitable for dry sieving, excavation proceeded in shallower spits of 5 cm and the spit samples were investigated for any archaeological evidence.

4. Stratigraphy

Individual stratigraphic units and a series of events documenting site development are described in Table 1; a schematic section through the site is shown in Fig. 3B.

The lowermost deposits (phase I) consisted of a series of coarse flint gravels overlying the Chalk bedrock at about 72 m O.D. These gravels contained a variable quantity of chalk clasts, significant amounts of cobble-sized material, mainly nodular flint, but also Palaeogene flint pebbles and Greensand chert were also noted. The gravels to the west (e.g. Trenches 4, 59 and 65) (Fig. 4) were carbonate-rich but to the east (Trenches 5 and 6) the gravels were decalcified. The gravel units exhibited a crude sub-horizontal structure and sand horizons were noted in places. The basal gravels were overlain by a series of sand units (phase II) that are typically rich in carbonate material and up to 0.8 m thick (Figs. 3–6). These phase II sands (sampled in Trench 59 and Trench 4) only existed in the western part of the site and were absent to the east in Trenches 5 and 6. In places, tufa (in the form of fine-grained tufa-sand or silt) was noted in the sands. The phase II sand contained small flint and chalk clasts in places as well as abundant shells and shell fragments and rarer mammal remains. Occasional large mammal bones and flint artefacts were recovered from within, as well as resting on the surface of, the sand. A non-depositional event (phase III) has been inferred from weathering of the upper surface of the sands. This surface, when sealed by overlying chalk-rich deposits in Trench 65, appears intact and a cluster of refitting artefacts was recovered resting on the sealed surface. Where the chalk-rich deposits are absent, a truncated sand sequence is overlain by Holocene sediments.

The phase II sand was overlain across the western part of the site by the afore-mentioned “chalk-rich deposits” (phase IV), which comprised chalk gravels (angular to sub-angular chalk clasts) in a putty chalk-silt matrix with common flint inclusions – these latter including minimally-abraded whole and broken flint nodules, and sharp very angular flint artefacts of widely varying size, from tiny chips to large handaxes, and including various sets of refitting flake removals, discussed in more detail further below. These deposits are attributed to slopewash/solifluction processes, specifically collapse of the chalk riverbank and slopewash from nearby higher chalk bedrock under cooling/cold conditions. They are thick and well-developed in Trench 65 and 58 but absent in Trench 59. A thin chalk pellet gravel in Trench 4 is also attributed to this group of deposits, thought to be the tail end of the better-developed bed in Trench 58. Flint artefacts have been recovered from these chalk-rich phase IV deposits at the west end of Trench 65 and substantial numbers from the 1 m² test pit excavated at the south end of Trench

Table 1
Site phases, description of sediments, inferred environments of deposition and summary of archaeology (including numbers of artefacts recovered by phase).

Phases	Site phase description	Molluscan evidence	Ostracod evidence	Vertebrate evidence	Age estimates	Archaeology	Inferred environment of deposition
IV	Modern plough soil Chalk rubble/pebbles and flint clasts in chalky paste matrix				Modern MIS 8	High concentration of mint/fresh artefacts including handaxes and waste from handaxe production (1631)	Cool/cold climate with major mass movements during spring melt
III	Weathering horizon on surface of sands				MIS 8	Mint conditions artefacts (waste debris) with high degree of refitting (56)	Stabilised landsurface under cool climate conditions
II	Sands with occasional patches of tufa and rare flint clasts. Molluscs abundant in places	Cool, interstadial climate with species typical of environments associated with shallow streams at base of slope or sheet wash situations	Small vegetated ponds and cool springs with elements of slope wash inferred	Assemblage probably winnowed by sheet wash or fluvial activity.	MIS 8	Rare mint conditions artefacts in close proximity to mammalian remains (2)	Cool climate shallow water or base of slope with local small pools and spring seeps. Inwash of fluvial water or sheet wash down slope.
I	Flint gravels with variable chalk content. Crude horizontal bedding in places				MIS 8	Occasional abraded artefacts including 2 handaxes (12)	High energy cool to cold climate fluvial environment with input of material locally from Chalk bedrock as well as from the west from the vicinity of the Vale of Wardour.

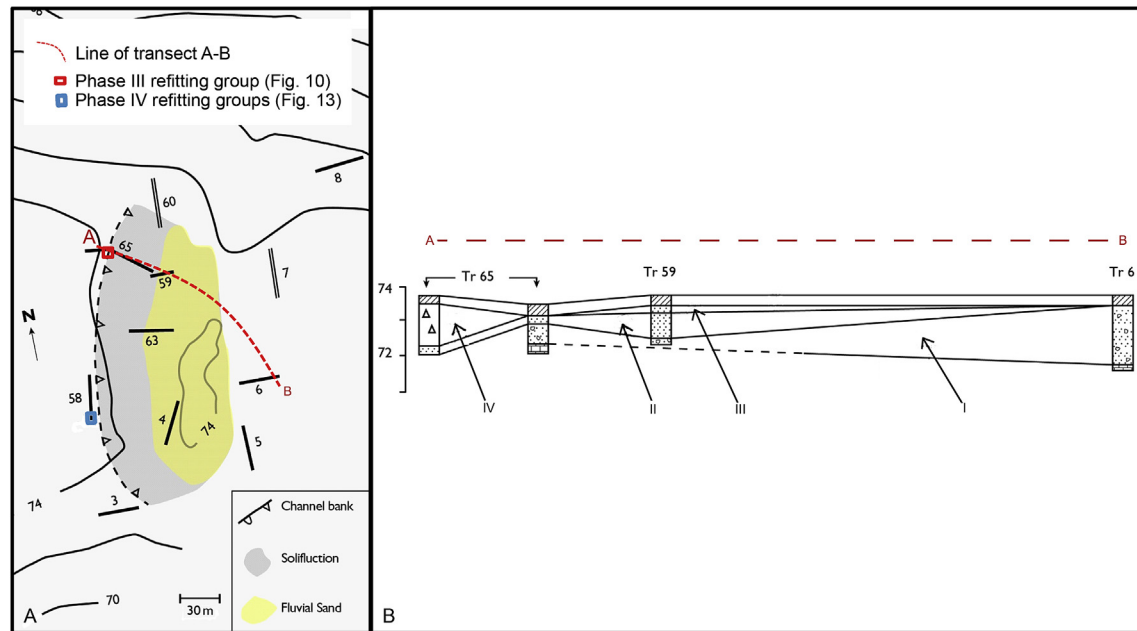


Fig. 3. A: distribution of trenches, key interventions and areas of identified superficial geology; B: schematic profile through main sedimentary phases at the site.

58 (Fig. 2). The relationship between the chalk-rich phase IV deposits and the underlying sands appears to be erosional in places; elsewhere (i.e. where *in situ* and refitting artefacts have been recovered) the relationship is likely to be more conformable.

The entire site was sealed by reddish-brown clay-silt of Holocene date that was of variable thickness and occurred as sheets of material, as well as infilling modern ditches and pits beneath the ploughsoil.

5. Palaeoenvironments

A schematic sequence of events leading to site formation is presented in Fig. 7. The basal phase I gravel sediments (lying between 72 and 74 m O.D.) appear to have accumulated under fluvial conditions. The coarse character of the gravels and their crude horizontal bedding suggests fluvial aggradation under cool to cold climate periglacial conditions within a braided channel

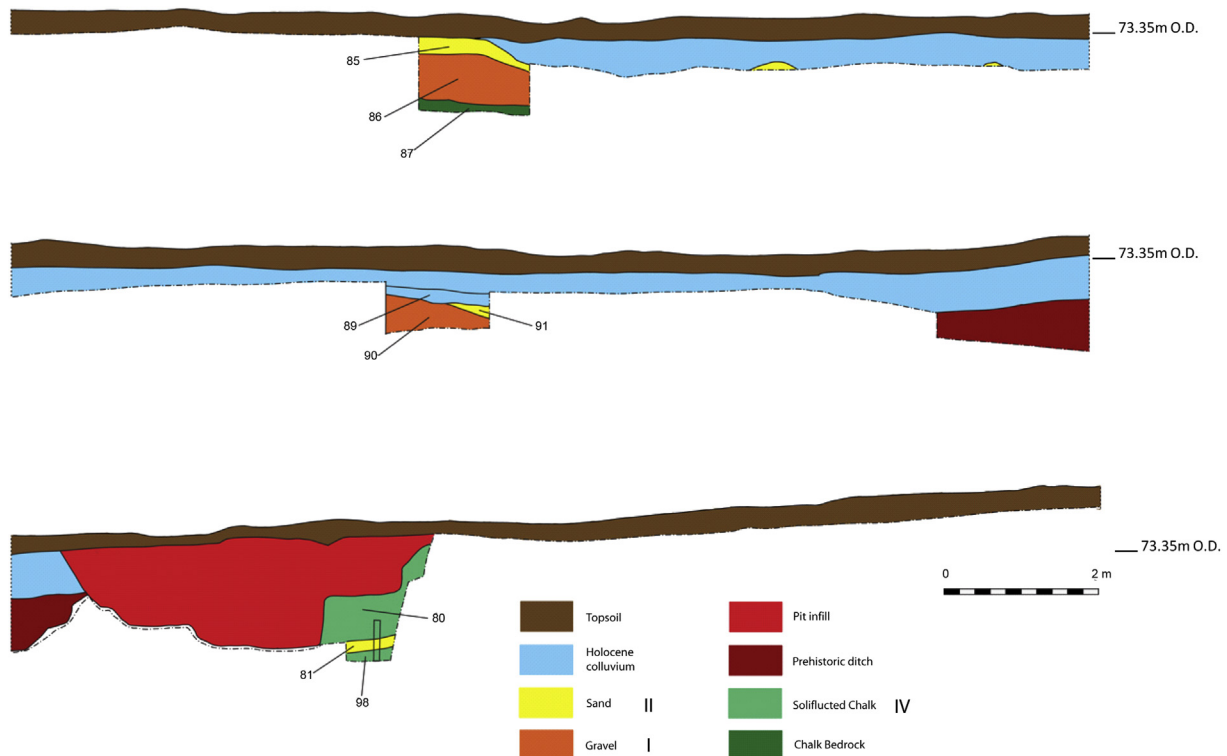


Fig. 4. Detailed section drawing of Trench 65.

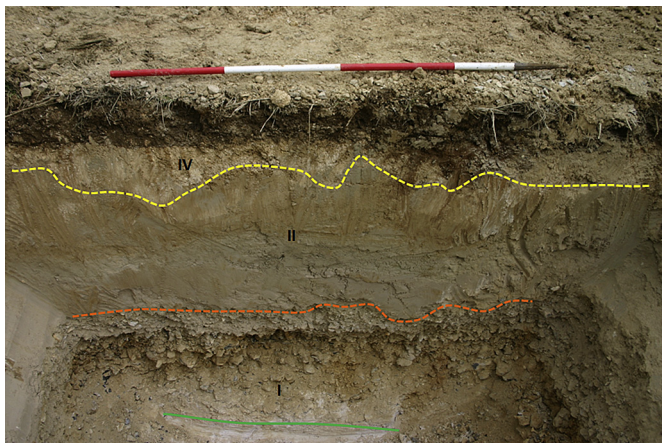


Fig. 5. Sequence of deposits present in Trench T4, from base: Phase I – flint gavels, variably chalky; Phase II – calcareous sands/silts, finer-grained in upper part; Phase IV – tail end of chalk-rich solifluction/slopewash deposits.

environment. The eastern boundary of these deposits is not currently well-mapped, and they (like the overlying Pleistocene sequence) are truncated to east, south and west by subsequent erosion. However the impression given from the local topography and the test pit exposures is that the sediments may have been laid down in a curved channel across the study area (Fig. 3A). The lithological and angularity analyses indicate local source areas, with the farthest travelled elements (excluding the two Palaeozoic cherts) derived from the older, pre-Chalk rocks exposed towards the west (in the Vale of Wardour). The limited nature of the exposures did not allow detailed observations of these gravels to be made and it remains possible that the gravels have been affected by some periglacial reworking, as solifluction material. The trend of these gravels appears to suggest that they are most likely valley-marginal sediments of a loop of the main Avon.

Sediments ascribed to phase II (the sand-rich deposits containing the majority of the mammal remains and other palaeo-environmental evidence as well as some artefactual material) overlie the basal gravel in some trenches. The evidence from the sampling carried out in Trench 59 suggests that the waters were rich in carbonate. Ostracods, although scarce, are represented by *Potamocypris zschokkei*, *Prionocypris zenkeri*, *Ilyocypris gibba* and juvenile *Candona* spp., which indicate local seepages of springs may have dominated the landscape at the edge of the floodplain. Associated charophyte oospores indicate clear (standing or slow-flowing) water, whereas earthworm granules and root-etching on some of the mammal bones indicate soil formation and vegetation on the floodplain.

Molluscan remains from the fluvial sands (Table 2) indicate mixed environments of flowing water, marshland, grassland and disturbed ground probably indicative of wet relatively open conditions with shallow water in sheet wash or ephemeral channels. The similarity between this fauna and that of the Late-glacial Interstadial at Holywell Coombe (Preece, 1998) suggests the climate was not particularly cold. The fauna consists of 23 taxa (11 from freshwater and 12 from terrestrial environments), but only four are present in high numbers and occur in all of the stratified samples. All of these are land taxa (*Pupilla muscorum*, *Trichia hispida*, *Limax* spp. and Succineidae). The complete shells of *P. muscorum* are all of the tall (3.5–4.0 mm) cylindrical form known as *P. muscorum pratensis* to European authors (Gedda, 2001). The “plates” of the slug genus *Limax* are unidentifiable to species and the Succineidae are difficult to identify to species as fossils especially when, as at Harnham, the shells are broken and juvenile specimens.

Four species of mammal are represented in samples from phase II (Table 3). Of the mammalian species the most interesting is northern vole *Microtus oeconomus*. Today the northern vole is found widely in the boreal and tundra regions of northern Eurasia, and in isolated ‘relict’ populations further south, such as coastal islands in The Netherlands, but it is no longer found in Britain. South of its present-day range, the northern vole is often common

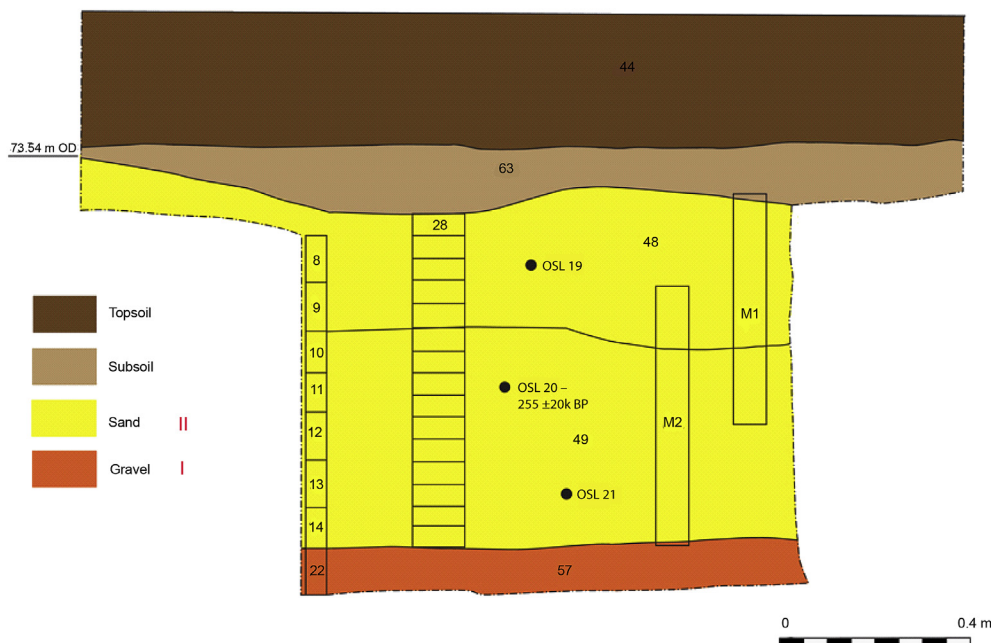


Fig. 6. Detailed section drawing of excavated pit in Trench 59 showing sampling locations. Samples 8–14 and 22 were for molluscs and small mammals, samples 28–42 for ostracods.

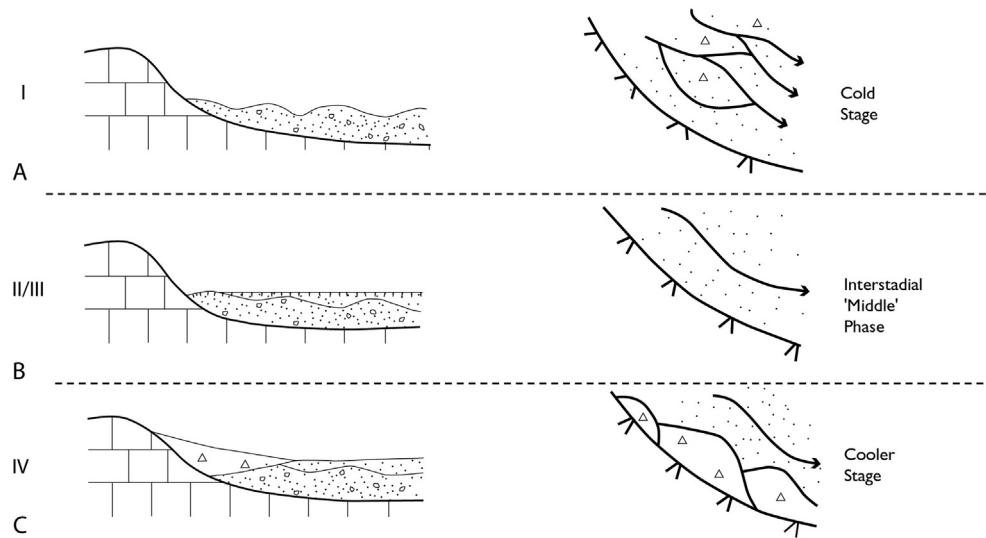


Fig. 7. Model for site development (by phase) in section (left) and plan (right).

in small mammal assemblages attributable to cold phases of the Middle and Late Pleistocene. The remaining diagnostic small mammal material consists of unrooted molar teeth of small sized microtine rodents (*Microtus* sp.), molar fragments attributable to

red-backed vole (*Clethrionomys* sp.) and water vole (*Arvicola* sp.), and the incisor of mouse (*Apodemus* sp.). In terms of ecological reconstruction, *M. oeconomus* is a very useful indicator of local environmental conditions, for its ecology is closely associated with

Table 2

Mollusc results from samples from Trenches 4 and 59 from Phase II (sands).

Trench	4	59						
Phase	II	II						
Sample number		8	9	10	11	12	13	14
Freshwater Gastropoda								
<i>Valvata piscinalis</i> (Müller, 1774)	19	1	3	2			1	14
<i>Bithynia tentaculata</i> (Linné, 1758)	5	1	7					8
Opercula								
<i>Galba truncatula</i> (Müller, 1774)	16		1					
<i>Radix balthica</i> (Müller, 1774)	18							
Lymnaeidae indet.	7							
<i>Gyraulus crista</i> (Linné, 1756)	1							
Planorbidae undet.	1							
<i>Anisus leucostoma</i> (Millet, 1813)							1	
<i>Ancylus fluviatilis</i> Müller, 1774	10	3	1	1		1		12
Bivalvia								
<i>Pisidium nitidum</i> Jenyns, 1822								1
<i>Pisidium casertanum</i> Poli, (1791)	3							
<i>Pisidium obtusale</i> (Lamarck, 1818)	5							
<i>Pisidium</i> spp.	23	2	2	1		1		3
Land Gastropoda								
<i>Carychium minimum</i> Müller, 1774							1	
<i>Carychium</i> spp.						1		
Succineidae undet.	356		11	4	1	4	1	15
<i>Cochlicopa lubrica</i> (Müller, 1774)	4	1					3	4
<i>Cochlicopa</i> spp.	24				1	2		
<i>Pupilla muscorum</i> (Linné, 1758)	33	1	7	25	10	2	14	4
<i>Vallonia</i> species undet.	5							
<i>Vallonia costata</i> (Müller, 1774)			1	1			2	
<i>Vallonia pulchella</i> (Müller, 1774)	3	3	2	12	2			
<i>Vallonia</i> spp.	12		6	7		4		1
<i>Punctum pygmaeum</i> (Draparnaud, 1801)	4			1				
<i>Vitrina pellucida</i> (Müller, 1774)	25			1			2	1
<i>Ceciloides acicula</i> (Müller, 1774)		[7]	[31]	[19]	[4]	[3]	[17]	
<i>Limax</i> spp.	418	6	20	47	2	11	2	22
<i>Helicella itala</i> (Linné, 1758)				1				
<i>Trichia hispida</i> (Linné, 1758)	597	11	13	52	25	50	128	30
<i>Arianta</i> spp.	11							1
Total	1600	29	74	155	41	76	155	116

Table 3

Small mammals remains from Trenches 59, 60 and 63 from Phase II (sands) Harnham. In British Pleistocene contexts, the presence of *Clethrionomys* and *Apodemus* is generally taken to indicate woodland. At Harnham, however, the material is too fragmentary to exclude non-native, tundra, taiga species, such as red vole *Clethrionomys rutilus*, grey-sided vole *C. rufocanus*, and steppic mice, such as the striped field mouse *Apodemus agrarius*.

Trench	4	60	59	63
Phase	II	II	II	II
Sample no.	1	7	8 9 11 12 13 14	50
<i>Clethrionomys</i> sp., red-backed vole			1	
<i>Arvicola</i> sp., water vole				1
<i>Microtus oeconomus</i> , northern vole	1			
<i>Microtus</i> sp., vole	1	1	1	1
<i>Apodemus</i> sp., mouse				1
Microtine rodent		11	4 2 1 3 2	10 6

wet grassland, bogs and the edges of rivers or lakes. Grassland on a marshy floodplain with good ground cover would accommodate all of the taxa recorded. Rare large mammal remains include five pieces of bone, of which two can be identified to taxon: horse *Equus ferus* represented by a scapula from within the sand/silts (phase II) in Trench 59 and a large bovid identified from a humerus fragment from solifluction deposits (phase IV) in Trench 58 (Table 4). The presence of these large herbivores indicates that a ready supply of high-quality forage was available throughout the year with little if any deep winter snow-cover (cf. Guthrie, 1990).

Consequently we suggest that the fine-grained sediments accumulated in an open landscape with shallow ephemeral channels at the edge of the floodplain and/or at the foot of the valley side subject to intermittent phases of sheet wash. Local springs may also have existed. Although the members of the Harnham mollusc fauna all live in the British Isles at present, the occurrence of a mollusc assemblage dominated by a small number of species of open, wet ground is typical in the later Pleistocene record of periglacial conditions in the British Isles (Keen, 1987). However, the presence of *T. hispida* as the most abundant species present suggests that the climate during deposition was not of the most extreme periglacial character, as the geographical range of this snail only just reaches north of the Arctic Circle at present in the relatively warm, maritime conditions of the Norwegian coast (Kerney and Cameron, 1979). *Carychium minimum*, although only represented by a single individual, also has a distribution in southern Scandinavia rather than in more northerly areas. As with the similar molluscan assemblage at Fisherton (Green et al., 1983) it is probable that the Harnham deposit was formed in an episode of warmer climate in a cold stage rather than the cold of a full glacial event. Several of the ostracod species live in cool (temperate) waters but this is in the very nature of springs and seepages and should not be taken as definitive evidence for a cool climate; all live in southern England today.

A weathering horizon and palaeosol (attributed to the non-depositional event, phase III) is present at the top of the sequence

Table 4

Large mammal remains from Trenches 58, 59 and 65.

Trench	Find no.	Phase	Taxon and element
59	SF.15	II	<i>Equus ferus</i> , right scapula
	SF.16	II	Large mammal, vertebra
	—	II	Large mammal, indet. bone frag.
58	SF.23	IV	Bovid, left humerus (shaft frag.)
65	SF.54	II	Large mammal, indet. bone frag.

of phase II fine-grained sediments and beneath the phase IV chalk-rich slopewash/solifluction deposits in Trench 65. Evidence of earthworm activity and root-etching on bones indicate pedogenic activity associated with this phase. Archaeological material resting on this surface probably represents undisturbed remains of activity on the palaeo-landsurface; little information exists to determine the precise local environmental conditions associated with this phase of pedogenic activity.

Deteriorating climatic conditions are inferred by the presence of thick accumulations of chalk-rich slopewash/solifluction deposits (phase IV) in Trenches 58 and 65. These can be traced to their feather edge in Trench 4, and abut the outcropping Chalk bedrock that is present in the western part of the site. These deposits contain the majority of artefactual remains recovered from the site. The mint condition of the artefacts and the high degree of refitting (discussed in more detail further below) is taken to indicate a minimum of transport and disturbance, and that they represent remains of riverbank activity broadly contemporary with, or closely following from, the more temperate event represented in phase II. Likewise, the evidence in places for a conformable junction and preserved palaeo-landsurface between phases II/III and IV suggests that the postulated cooling event associated with phase IV deposition followed the more temperate event of phase II, with a minor depositional hiatus during which the phase III palaeo-landsurface developed but without a major stratigraphic/chronological unconformity.

The final phases of sequence development are associated with Holocene colluviation and human activity involving the excavation of pits in the vicinity of Trench 3 and, most recently, ploughing of the field surface. This paper focuses upon the Pleistocene horizons and their contained Palaeolithic and palaeo-environmental evidence. The current phase of ploughing is however noteworthy, because it is cutting directly into sediments with Palaeolithic faunal and artefactual remains. These are becoming incorporated in the ploughsoil, from which a large derived lithic assemblage was recovered by field-surface collection.

6. Dating

OSL dating was applied in an attempt to directly date the sands of phase II at two locations (Table 5). Age estimates are based on sand-sized quartz grains extracted from each sample. Dose rates were calculated entirely by Neutron Activation Analysis (NAA) as the site was not visited and samples were taken by site staff. Low infrared stimulated luminescence (IRSL) values were observed, suggesting good quartz separation had been achieved. A relatively low degree of variability between aliquots was observed for one of these samples, X1362 (standard deviation of 9% was observed), while the other sample, X1364 had one aliquot lower than the majority, and one value higher. These aliquots have been excluded in the calculation, as it seems very likely that they represent the effects of incomplete zeroing or post-depositional processes. Otherwise, no signs of significant incomplete zeroing were observed.

The observed luminescence characteristics, namely good OSL sensitivity, adequate recycling values (means at 1.055 and 1.031 respectively for X1362 and X1364) and low thermal transfer values (both mean values below 1% of the natural OSL signal) strongly suggest that these age estimates are likely to be reliable; demonstrating the veracity of the method at sites of this age, and for samples with such high *De* values, is however very difficult. The OSL results from the two Harnham samples suggest a date for accumulation of the phase II sediments during the later part of the cold phase of MIS 8 or the very start of MIS 7, between c. 267,000 and 235,000 BP based on the overlapping range of the individual

Table 5

OSL dating results. Sand-sized quartz samples were measured using a SAR OSL technique (Murray and Wintle, 2000). Gamma and beta dose rate values were calculated using NAA; a value of $10 \pm 5\%$ water content was assumed for these samples.

Field code and location	Laboratory code	Depth (metres)	Phase	D_e (Gy)	Dose rate (mGy/a)	Age estimate code	Age (years before 2000A.D.)
IHRRO2 Tr 60, sample 18	X1362	1.25	II	229 ± 10	0.92 ± 0.06	OxL-1341	$248,000 \pm 19,000$
IHRRO2 Tr 59, sample 20	X1364	0.08	II	223 ± 10	0.87 ± 0.06	OxL-1342	$255,000 \pm 20,000$

dates. The very close agreement in age between the two samples from different locations reinforces their credibility.

Amino acid racemization (AAR) analyses (see Penkman, 2005 for method), were undertaken on two *Bithynia tentaculata* opercula (NEaar 1966–1967). On the basis of the relative D/L ratios and concentrations (Table 6) the amino acid data from these opercula, when compared with a control framework of values from UK sites independently dated between MIS 5a and 17 (Penkman, 2005; Penkman et al., 2011), suggest correlation for the Harnham samples with MIS 8 or early MIS 7 (Fig. 8). However, although both opercula indicate the same age correlation, the variability between them is surprisingly high compared to other studies, which typically have much more consistent results for different specimens from the same deposit, and this is likely to be due to the poor state of the material analysed.

Biostratigraphic indications from the mammalian fauna provide further insights into the age of the sediments. Among the small mammals, the presence of water vole in phase II provides a useful biostratigraphical signal. The water vole molar is unrooted and can therefore be assigned to the genus *Arvicola*, which evolved from a rooted ancestor (*Mimomys savini*) during the later part of the early Middle Pleistocene (~600,000 years ago) (Preece and Parfitt, 2012). Subsequent evolutionary trends are seen in the distribution and relative thickness of the molar enamel (Sutcliffe and Kowalski, 1976; van Kolfschoten, 1990; Parfitt et al., 1998). The enamel type observed in the Harnham molar represents an intermediate form between the living west European water vole *Arvicola terrestris* and early Middle Pleistocene *Arvicola cantianus*. This evidence, albeit meagre, suggests that the site is not as old as the Hoxnian (MIS 11) or MIS 9 (e.g. Purfleet, Cudmore Grove) and probably no younger than the Ipswichian (MIS 5e). At Harnham, the presence of horse is also significant. This species is absent from British sites correlated with MIS 5e. Furthermore, the relatively large size of the scapula would preclude a link with the Devensian and late MIS 7–early MIS 6, when British horses were relatively small (Parfitt et al., 1998).

Results from the various methods for deriving an age estimate of the site do, perhaps surprisingly for a Middle Pleistocene site, appear to be remarkably consistent. The chronometric evidence indicates a likely date for formation of the phase II sands in later MIS 8 or early MIS 7, between c. 280,000 and 230,000 BP. This is supported by the evidence from the faunal material which, although restricted, suggests a pre-Ipswichian/post-Hoxnian date. The palaeoenvironmental evidence from the molluscs and the ostracods is incompatible with deposition of the phase II sands during a fully temperate (interglacial) period. This appears to rule out the

possibility that the sequence accumulated during a temperate phase of MIS 7, the oldest stadial part of which (MIS 7d) dates to c. 225,000 BP, beyond the standard deviation of the younger OSL result. Therefore a date in the later part of the predominantly cold-climate MIS 8 is suggested for site events II, III and IV, which are associated with the most significant archaeological and faunal remains. Since the environmental evidence suggests cool interstadial conditions, and the cold peak of MIS 8.5/9a is, at c. 285,000 BP, beyond the chronometric range established for the Harnham sequence, we suggest deposition of the phase II sands in the later part of MIS 8 between the cold isotopic events 8.2 and 8.4 (Bassinot et al., 1994), followed by a climatic deterioration associated with formation of the phase IV chalk solifluction deposits.

7. Palaeolithic archaeology

Lithic artefacts were recovered by three methods: controlled fieldwalking, during excavation of trial trenches by a combination of machine and hand-digging, and from small hand-excavated sondages in Trenches 58 and 65 (Fig. 2). At the southern end of Trench 58 a small sondage (c. 1 m²) sampled the phase IV chalk-rich bank-side deposits, which were excavated in seven (10 cm-thick) spits without reaching the base of the deposits. Artefacts identified during the sondage excavation were bagged by spit. The excavated sediment (including any flint clasts and nodules not considered at the time as artefacts) from each spit was then sieved off-site through a mesh of 2 mm. This led to total recovery of artefacts above 2 mm. Sieving was particularly useful for recovery of nodular percussors and minimally worked flint nodules that otherwise might not have been recognised during fieldwork, as well as for recovery of the smaller chips and spalls. About ten metres in from the west end of Trench 65, a sloping section was exposed through the phase IV deposits where they were cut through by a large modern pit (Fig. 4). They were found to overlie a palaeo-landsurface (phase III) at their base, developed on the surface of a thin sand bed (phase II). A small, shallow sondage c. 0.6 × 1 m in plan and 25 cm deep was dug here to expose the palaeo-landsurface. Assemblages of flint artefacts were recovered from both the overlying phase IV deposits and the phase III palaeo-landsurface.

In total 2537 Palaeolithic artefacts were recovered including 36 handaxes, but excluding the thousands of smaller pieces (<2 cm) recovered by sieving for micro-debitage in the sondage at the south end of Trench 58. The great majority of artefacts came from either the Trench 58 sondage (62%) or the fieldwalking collection (33%) but smaller assemblages were recovered from a range of other

Table 6

Amino acid geochronological data.

NEaar no.	L-Asx (pmol mg ⁻¹)	D-Asx (pmol mg ⁻¹)	L-Glx (pmol mg ⁻¹)	D-Glx (pmol mg ⁻¹)	L-Ser (pmol mg ⁻¹)	D-Ser (pmol mg ⁻¹)	L-Ala (pmol mg ⁻¹)	D-Ala (pmol mg ⁻¹)	L-Val (pmol mg ⁻¹)	D-Val (pmol mg ⁻¹)
1966bF	6333	4659	1126	292	1562	1530	6365	2844	3318	780
1966bH	7394	4593	7675	1644	2288	1584	7618	2860	5761	1002
1967bF	5990	4393	1009	248	1584	1544	5806	2590	3184	721
1967bH	14065	8356	13530	3070	3421	2715	12315	4969	7769	1608

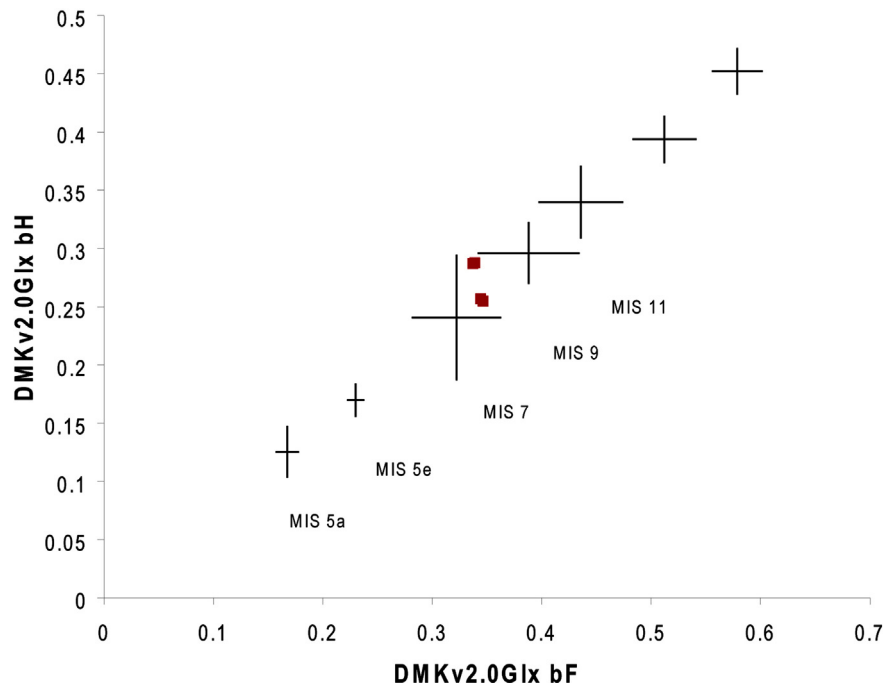


Fig. 8. Correlation between Free and Total (Hydrolysed) DMKv2.0Glx for bleached opercula from Harnham (■) compared with separation between UK Pleistocene sites. The opercula form discrete clusters (of interglacial isotope stages?). DMK values from opercula at Harnham fall within the range of MIS 7, and are therefore likely to be of early MIS 7 or MIS 8 age.

locations and deposits (Table 7). All artefacts were made of locally available nodular flint, which would have been readily accessible from the bank of the palaeo-channel where it cut into the Chalk bedrock. Artefacts were recovered from all of phases I to IV, but the most important evidence is from phases II, III and IV where they are associated with mammalian and other palaeo-environmental evidence, and where their fresh condition and (for phases III and IV) refitting evidence (Fig. 9) suggests they are relatively undisturbed and represent horizons of Palaeolithic occupation.

7.1. Phase I – gravel

The two assemblages from phase I come from medium-coarse fluvial gravel deposits in the bases of Trenches 60 and 65. Twelve artefacts were found from phase I, 10 from Trench 60 and 2 from Trench 65 (Table 7). The artefacts are all in moderately to very abraded condition with variable development of staining and patination. They probably represent a slightly mixed/transported collection resulting from activity on the braided floodplain of the

river in the vicinity of the site, or near its banks, during the period of the gravel's formation. The phase I collection includes two handaxes – one of them a pointed and thick-butted sub-cordate, and the other quite a sharply-pointed triangular form with straight sides – and one flake-tool. This latter is a moderately large flake (9 cm long) with convex working around its distal end. As such, it might commonly be characterised as a “scraper”, although it is more likely that the working is merely to facilitate comfortable handling, and the utilised part of the tool was the sharp straight edge down one side. The debitage is mostly technologically undiagnostic large primary flakes with a high proportion of cortex, although there are also smaller flakes with less cortex.

7.2. Phase II – sands/silts

The phase II sands/silts produced small assemblages from Trenches 59 and 60, comprising just 2 artefacts from the former and 4 from the latter (Table 7). Those from Trench 60 were recovered from pockets and channels of sands/silts overlying the contorted

Table 7
Overview of Palaeolithic artefact recovery by phase, then trench.

Phase	Trench	Percussors	Tested	Rough-outs	Handaxes	Flake-tools	Cores	Debitage	Total
–	Field surface	–	–	1	14	–	2	815	832
IV	4	–	–	–	–	–	–	3	3
	58	8	26	16	18	1	1	1502	1572
	65	–	–	–	1	–	2	53	56
III	65	–	–	–	–	1	–	55	56
II	59	–	–	–	–	1	–	1	2
	60	–	–	–	1	–	–	3	4
I	60	–	–	1	1	–	–	8	10
	65	–	–	–	1	1	–	–	2
Total		8	26	18	36	4	5	2440	2537

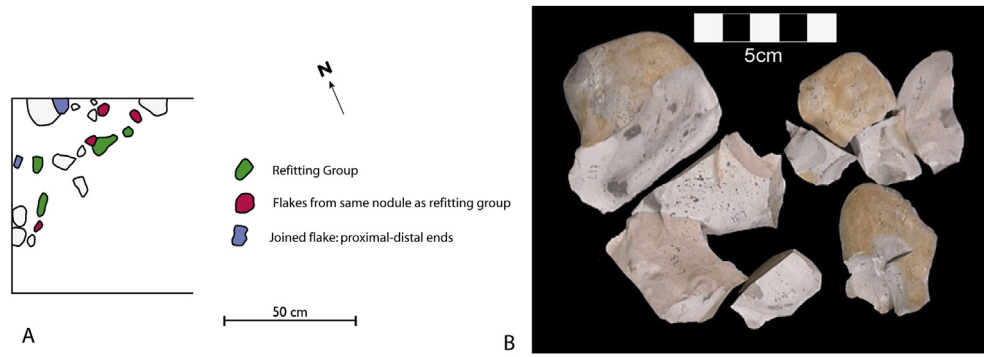


Fig. 9. A: distribution of refitting flakes from Phase III in west end of Trench 65; B: refitting assemblage group from the west end of Trench 65.

phase I gravel and have been subject to some post-depositional disturbance. Those from Trench 59 are in mint condition, and were found close to the horse scapula and the large mammal vertebra. One is a flake-tool with a convex retouched edge (Fig. 10). Rather than forming a working-edge itself, the retouching here too appears to have been aimed at blunting one edge to facilitate handling of the tool to use the adjacent sharp edge for cutting; slight nicks in this edge may represent use-damage.

7.3. Phase III – palaeo-landsurface

An assemblage of over 50 artefacts was recovered from the small area (c. 0.6 m²) of the phase III landsurface excavated towards the west end of Trench 65 (Fig. 3), on the surface of the weathered horizon at the top of the phase II sands/silts. Most artefacts were in mint or very fresh condition, and there was a high degree of refitting (Table 8; Fig. 9). The excavated area seems to represent the edge of an undisturbed flint scatter, whose main concentration continues northwest towards the palaeo-riverbank, under a trail of chalk-rich slopewash sediments. All of the artefacts recovered were waste debitage, with the exception of one flake-tool that had a single straight sharp edge with some fine unifacial scalar retouch opposed by a natural cortical edge. The assemblage provides little indication of any knapping strategies in use. No handaxes were found, and all of the debitage was technologically undiagnostic, although a few flakes appear to most likely be from handaxe shaping/thinning. However this does not rule out that all of the debitage results from manufacture of handaxes; experimental work (Wenban-Smith, 1996: 131, 2000, 2004) has established that c. 85–90% of debitage from handaxe manufacture, and 100% from early stages of reduction, is typically technologically undiagnostic.

Although full quantitative analysis has yet to be carried out, the large size and high proportion of cortex on many of the flakes suggest an early stage of reduction is represented by most of the assemblage. Therefore if it was associated with the early stages of handaxe manufacture, this would not be reflected in debitage characteristics.

7.4. Phase IV – chalk-rich bankside deposits

The greatest part of the lithic artefact collection came from the phase IV chalk-rich slopewash/solifluction deposits developed at the bank of the alluvial floodplain (Table 7). The great majority of these ($n = 1572$) came from the Trench 58 sondage, where there was a staggeringly high artefact concentration of c. 2000 per m³, discounting the even more numerous chips <2 cm. Small assemblages were also recovered from chalk-rich solifluction deposits overlying the landsurface at the west end of Trench 65 ($n = 56$), and from the tail end of the similar deposits in Trench 4 ($n = 3$). All of the artefactual material is in mint or very fresh condition, suggesting a minimum of transport or disturbance.

The collection from the phase IV deposits is dominated by waste debitage. The tool component consists almost entirely of handaxes and rough-outs, with just one secondarily worked flake (Table 7). There are also common tested nodules (with only one or two small removals) and eight small, rounded pieces of flint nodule with cortical battering marks suggesting use as knapping percussors (Fig. 11). In total 19 handaxes are present, including one made on a flake, as well as 16 rough-outs abandoned at some point in manufacture. There is hardly any evidence of non-biface manufacturing activity. The two artefacts from Trench 65 regarded as cores are both bifacially worked and could equally be

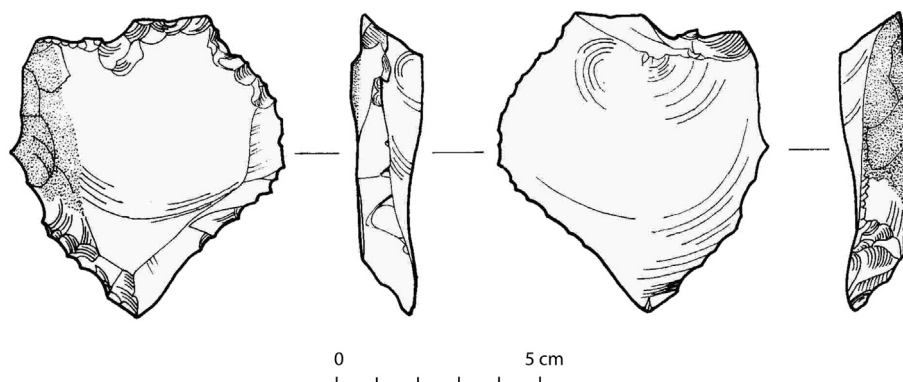


Fig. 10. Flake tool, probably a backed knife (L18, Phase II context 47/49 in Trench 59).

Table 8
Summary of refitting results.

Trench	Phase	Spit - context	Total spit assemblage size	Refitting details
58	IV	1 – context 55	361	- One joining pair of proximal and distal flake-ends - One refitting group: two sequential flake removals
		3 – context 65	110	- One refitting group: two large sequential primary cortical flakes
		4 – context 66	166	- Three refitting groups: two pairs of small flakes and one group of four sequential removals (three large flakes and one small one)
		5 – context 67	108	- Two joining pairs of proximal and distal flake-ends - Two refitting groups: one small flake to a tested nodule, one secondary flake to a flake-tool
		7 – context 74	135	- One refitting group: two sequential flake removals
65	III	Context 81	56	- One joining pair of broken proximal and distal flake-ends: L40–L32 - One refitting group: four different flakes: L44–L33–L31–L37 - Four flakes thought to be from same nodule as refitting group: L45, L38, L43, L30

interpreted as abandoned handaxe rough-outs. The “core” from Trench 58 consists of a small cylindrical nodule with a few small flakes removed at each end, and thus could easily likewise be regarded as a tested nodule or a discontinued handaxe attempt. The single flake-tool is a pointed piece of probable handaxe-manufacturing waste with at least two small notch-like removals beside each other down one side, forming a flake-tool that is uniaxially worked, although handaxe-like in plan-view. The large debitage assemblage has not yet been studied in detail, but preliminary examination shows numerous flakes that are clearly from handaxe shaping/thinning, including some that refit (Fig. 12). The relative proportions of identifiable handaxe flakes and technologically undiagnostic debitage also appear compatible with an assemblage entirely resulting from handaxe manufacture (see Wenban-Smith, 1996: 131, Fig. 3.29). The strong predominance of handaxe manufacture allows the collection to be characterised as an Acheulian industry.

Typologically, the handaxes are predominantly pointed. The assemblage includes large and well-made ficrons (Fig. 13), with a thick butt and concave sides tapering to a sharp point. One of these (Fig. 13) appears however to have had its point deliberately removed by a small flake to create a short transverse sharp edge. It also includes several more-sub-cordate forms, still with a thick butt, often partly unworked with some cortex remaining as a convenient handle, but with a rounded or transverse tip, sometimes tranchet-sharpened (Fig. 14). All the handaxes are made on fresh flint, almost certainly locally obtained from nearby exposures of Chalk bedrock or chalk-rich bankside deposits, both of which contain abundant flint nodules.

A preliminary refitting study was done on material from each spit of the Trench 58 sondage. Each spit was studied rapidly and

separately, so it is likely that further work would produce significantly enhanced refitting results, as well as establishing the vertical distribution of refitting material within the deposit. Each spit was given a separate context number to aid record keeping, although there were no apparent sedimentological boundaries within the spit sequence. This exercise produced 11 separate refitting groups from throughout the spit sequence (Table 8), including one group of four sequential removals (Fig. 12), one instance of a small flake refitting to a tested nodule, and a secondary retouching flake refitting to the above-mentioned double-notched flake-tool.

Analysis of the proportions of debitage in different size ranges throughout the sondage sequence was also carried out, and compared with evidence from experimental handaxe manufacture (Table 9). This produced a remarkably close correspondence, providing strong confirmation in combination with the refitting results and artefact condition that the lithic evidence was essentially undisturbed. It represents remains of activity from the river bank area contemporary with, or closely following from phases II–III that has been incorporated in deposits of phase IV.

Finally, evidence of human modification was observed on the humerus of large bovid with impact notches and an embedded flint chip, excavated from the top spit of the sondage in Trench 58. This humerus fragment consists of a short section of the shaft from the posterior face, close to the distal end (Fig. 15). The breaks and the entire surface of the bone are covered in a dense network of sinuous root-channels that have removed much of the external surface (SI Fig. 1). Towards the distal end of the fragment is a small

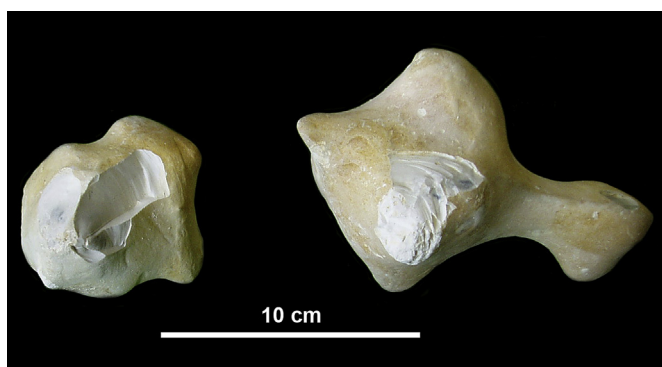


Fig. 11. Flint percussors from Phase IV sediments, Trench 58 sondage.

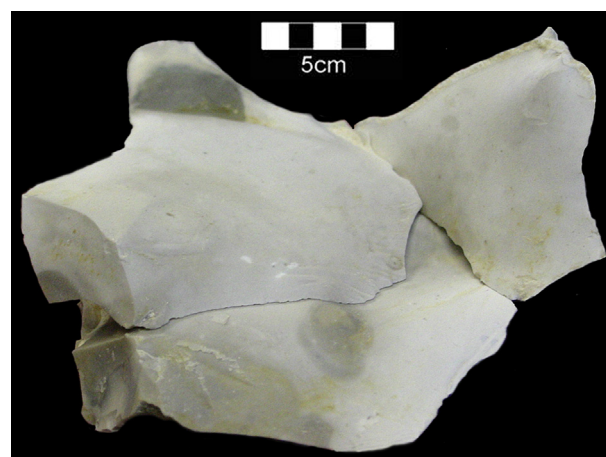


Fig. 12. Refitting handaxe thinning/shaping group from Phase IV spit 4 (context 66), Trench 58.

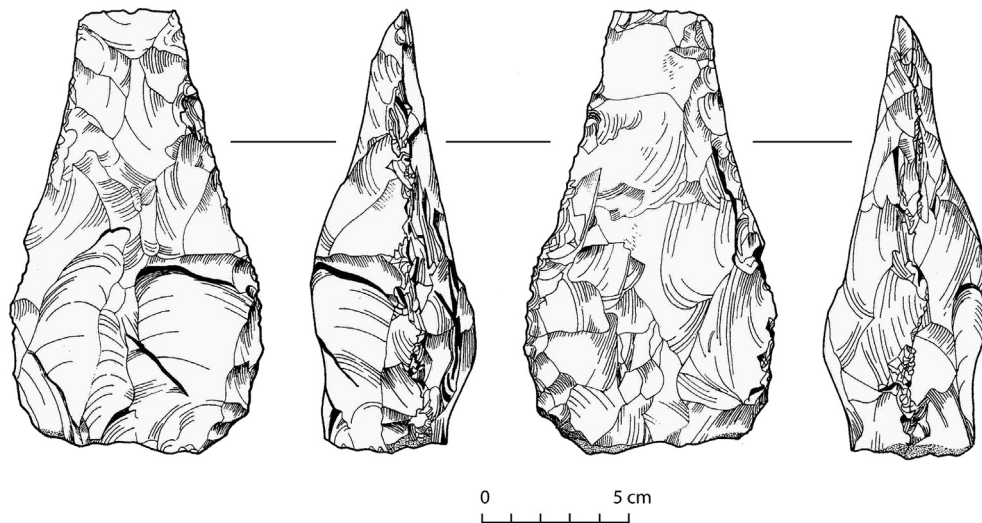


Fig. 13. Pointed ficron handaxe (L21, Phase IV spit 7 (context 74), Trench 58).

chip of flint (length 5.5 mm), which is firmly embedded in the postero-medial surface the bone (Fig. 15b). (See [Supplementary Information for analytical details](#).) The chip is cortical on one side with a flexion fracture at the distal end.

Explanations for the chip include the possibility that the flint is the tip of a projectile armature, which fractured on impact with the bone. Archaeological evidence for the hafting of lithic projectile points is first observed in late Middle Palaeolithic contexts (Shea, 1988; Rots, 2009, 2011), and includes rare examples of Levallois points embedded in bones of hunted large mammals (Boëda et al., 1999). Such an interpretation seems unlikely for the Harnham example, given the partially cortical nature of the flint chip and the absence of lithic projectile points from any Acheulian stone tool assemblage. Another possibility for this feature is that the bone was used as a knapping percussor or retoucher. However, the Harnham humerus does not display the characteristic attritional damage, as would be expected had it been used as a knapping hammer (Mallory et al., 2012; Bello et al., 2013).

A more plausible explanation is that the impacted flint chip is a piece of the percussor or anvil, which broke off and became impacted during an attempt to extract bone marrow. This interpretation is supported by the presence of opposing impact notches,

which are identified from characteristic semi-lunar flake removals that penetrate the cortical bone and associated conchoidal scars on the medullary surface (Fig. 15). Three of the notches are located on the lateral side of the bone and a less distinct (?anvil) notch, associated with the flint chip, is located medially. The configuration of the marks suggests that the humerus had been placed on an anvil-stone and struck several times on the medial face, in order to fracture the bone shaft and break into the marrow cavity (cf. Binford, 1981). Hammerstone percussion and anvil damage on bones is frequently accompanied by striae and pitting with hammerstone or anvil scratches (Blumenshine and Selvaggio, 1998). Such marks were not visible on the Harnham specimen, but any evidence for them could have been obliterated by superficial root-channelling that has removed much of the cortical surface.

7.5. Site usage and hominin behaviour

More detailed interpretation of site usage and behaviour must follow further excavation and analysis. However it is already possible to identify a number of key aspects. Firstly, based on the sample of material from the Trench 58 sondage, there is a high quantity of debitage present in relation to the number of recovered

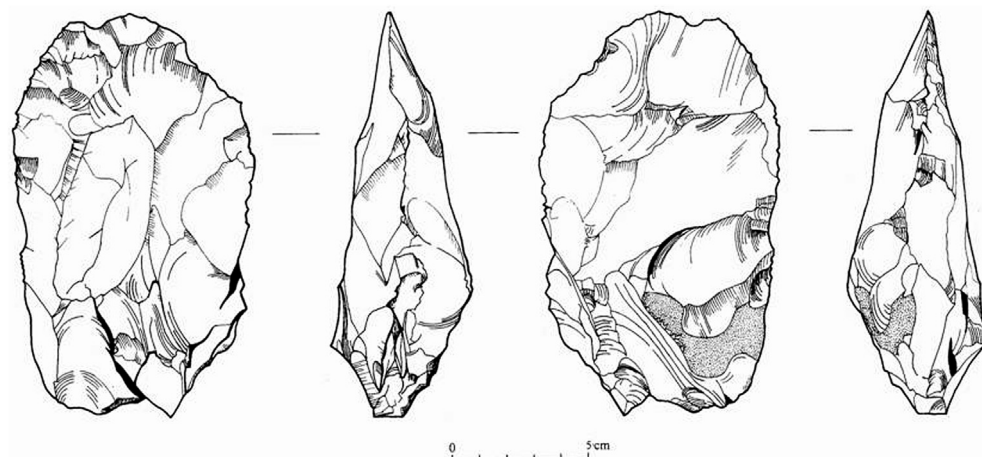


Fig. 14. Tranchet-sharpened handaxe with transverse cleaver edge at tip (L27, Phase IV context 80 in Trench 65).

Table 9

Debitage and micro-debitage size distribution (phase IV chalk-rich deposits, Trench 58 sondage), compared with experimental handaxe-manufacturing debitage (Wenban-Smith, 1996).

Spit	Context	Proportion of each size of debitage (as %)			
		2–4 mm	4–20 mm	2–5 cm	≥5 cm
1	55	43	27	20	10
2	56	54.5	25.5	14	6
3	65	59.5	28.5	10	2
4	66	67	25	6	2
5	67	63	27	7.5	2.5
6	68	59.5	30.5	7	3
7	74	60.5	27	9	3.5
Experimental		64	26	7	3

handaxes. There are also substantial numbers of tested nodules and large primary flakes. Overall, the evidence suggests a location in the landscape where good quality flint nodules were available, which therefore acted as a focus for making and tooling-up with handaxes. These, although evidently sometimes discarded nearby, were mostly removed from the site, and used and discarded elsewhere. There are also several nodular flint percussors within the Trench 58 sondage assemblage (Table 7 and Fig. 11), attesting to a process of on-site tool manufacture that was entirely served by locally available materials. There is also evidence for on-site faunal processing at the edge of the fluvial channel in the form of marrow extraction from the bovid bone. It is not possible to be sure whether the horse scapula and flake-tool in Trench 59 represent activity nearer the centre of the channel (at a time when a dry surface was

exposed), although this is a reasonable probability as the flake-tool was found only c. 1 m away from the scapula in a part of the site with few other remains. The picture is similar to the situation at Red Barns (Wenban-Smith et al., 2000), although the proportion of handaxes compared to debitage at Harnham is higher, suggesting a less strong focus at Harnham on tooling-up for activities elsewhere, and a slightly higher incidence of local activity. The local landscape would have consisted primarily of open grassland, which would have supported a high biomass of large herbivores, making Harnham, with its availability of flint raw material, nodular percussors and water, a prime focus of hominin activity.

8. Discussion

The discovery of the site at Harnham is of importance to both Quaternary scientists and Palaeolithic archaeologists. Reliably dated to an interstadial late in MIS 8 around 250,000 years ago, Harnham is the youngest well-dated example of an Acheulian industry in the UK, and one of the youngest in northwest Europe, where most Acheulian sites dating to MIS 8 or later (Tuffreau et al., 2008; Scott and Ashton, 2011) have bifaces in conjunction with significant elements of flake production strategies and flake-tools, or are less robustly dated. The suggestion (Pettitt and White, 2012) that the industry at Harnham is derived from an earlier period cannot be sustained in light of multiple complementary strands of evidence: stratigraphic sequence conformity, refitting, artefact condition and quantitative assemblage size-profile. The only comparable UK sites are Broom in the Axe Valley on the Devon/Dorset border c. 85 km to the west, and Cuxton in the

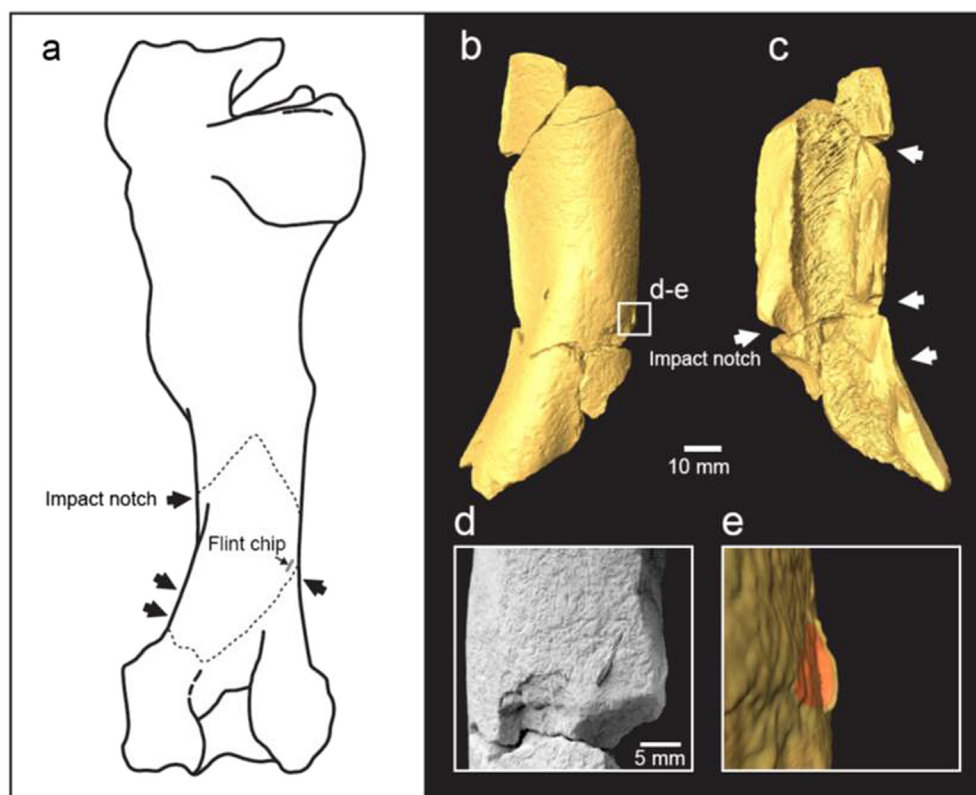


Fig. 15. a: Outline of a bovid humerus showing the anatomical position of the shaft fragment from Harnham (Trench 58, phase IV), the distribution of impact damage inflicted during marrow processing (arrows) and the embedded flint chip. b–c: Virtual micro-CT reconstruction of shaft fragment (see SI for technical details). b: cortical surface showing location of flint chip. c: View of medullary cavity with impact notches (arrows). d: Photograph of the embedded flint chip (note root-etching of the bone surface). e: CT-image showing the flint chip (highlighted in red) with the cortical bone rendered opaque. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Medway Valley, Kent, c. 150 km to the east. At Broom, OSL dating suggests an MIS 8 date for the Wadbrook Member, regarded on the basis of historical records and collecting notes as the source of the majority of Bean's substantial handaxe collection from the 1930s (Hosfield and Green, 2013). At Cuxton, recent OSL dates suggest an even younger date for the Acheulian industry, in MIS 7 (Wenban-Smith, 2006; Wenban-Smith et al., 2007), although this result is currently under more careful scrutiny (Wenban-Smith et al., in press). There are also numerous handaxe finds, at least some in fresh condition, from Milford Hill, Salisbury (Wessex Archaeology, 1993; Harding and Bridgland, 1998), a few km north of Harnham. Here, there are fluvial terrace remnants at a similar height to those at Harnham and therefore potentially of broadly similar age; however, no material has been found at Milford Hill in an independently dateable context or with any associated palaeoenvironmental indications.

The Harnham occupation belongs to a period for which relatively little is known about the Palaeolithic in England, compared to the abundance of older sites of MIS 11/10/9 age. It confirms an Acheulian presence in the central southern UK in MIS 8, broadly contemporary with Levalloisian technology being practised at sites such as Baker's Hole (Wenban-Smith, 1995; Wenban-Smith et al., in press), Creffield Road (Ashton et al., 2003) and Purfleet (Schreve et al., 2002), where Levallois is claimed to be present from MIS 8 or perhaps even earlier in late MIS 9 (*ibid.*; White and Ashton, 2003; Bridgland et al., 2013), although see the more detailed discussion of Purfleet further below. It is however, uncertain what are the precise dates of occupation of these sites and whether they overlap with the Harnham occupation. Furthermore uncertainty exists over whether we should regard handaxe-making and Levalloisian technology as mutually exclusive technological practices when there is no evidence of one or the other at a specific location, or whether apparently exclusive handaxe-makers might be practising Levalloisian technology in other parts of the landscape, and vice-versa. The flint-rich Chalk outcrop site at Harnham would have provided an ideal raw material source for Levalloisian technology, so one would have to consider why there is no evidence of it, if it was part of the technological repertoire of the Harnham knappers.

If one accepts the absence of Levalloisian technology at face-value, then it appears that the Harnham evidence (alongside that from Broom, where the minimal possible-Levalloisian evidence could be an incidental product of non-Levalloisian core reduction or handaxe shaping, and furthermore is insufficiently provenanced to tie it in firmly with MIS 8) represents the presence in MIS 8 in central southern England of a hominin population focussing entirely on handaxe manufacture, broadly contemporary with a distinct Levalloisian industrial tradition being practised in the Lower Thames basin in south-east England. The particular importance of Harnham is that this occupation is more-specifically tied in with the interstadial within the later part of MIS 8. This demonstrates the capability of hominin populations of this era to survive in this latitude even within the cool conditions of this period, refining biogeographic models of human occupation of higher European latitudes (Roebroeks et al., 1992; Roebroeks, 2006; Stewart and Stringer, 2012). This needs to be considered within the framework of British insularity-peninsularity (cf. White and Schreve et al., 2002; Ashton et al., 2011), the potential impact on hominin settlement in Britain of the cold maxima of MIS 9.2, 8.6 and 8.4, and the archaeological record of nearby continental north-west Europe for the period MIS 10/9/8/7.

Before considering the continental evidence, however, it is worth reconsidering the claims for the presence and date of Levalloisian evidence at Purfleet, which is becoming increasingly referenced (Schreve et al., 2002; White and Ashton, 2003; Bridgland et al., 2013) as an early MIS 8, and perhaps late MIS 9,

occurrence of Levallois in the UK. If there is Levalloisian evidence at Purfleet dating to MIS 9, or even persisting through MIS 8, it both highlights the contrast with its absence at the younger or contemporary sites of Broom and Harnham to the west, and is also anomalously early in relation to other well-dated occurrences of Levalloisian in south-east England. If there is Levalloisian evidence dating to the end of MIS 8, then it fits in entirely with the better-dated evidence from the Ebbsfleet Valley and West London. However, as discussed in more detail below, claims for early Levalloisian at Purfleet are undermined on at least three grounds: (1) the dubious technological recognition and great paucity of unambiguous Levalloisian material in the collections from the various Purfleet sites, (2) poor provenance of the most relevant lithic evidence, and (3) even if Levalloisian lithic material is present in the upper horizons of the Purfleet sequence as claimed, then these deposits are of uncertain date and not reliably associated with MIS 9.

First, concerning technological recognition, most of the material categorised as “Levalloisian” from the Purfleet complex of sites – Botany Pit, Esso Pit, Greenlands and Bluelands quarries – is more precisely categorised as “proto-Levalloisian”. This categorisation covers material that fails to show definitive Levalloisian characteristics such as clear pre-determination of a privileged flake by prior radial preparation of a core surface, but which appears to show some evidence of smaller, possibly-preparatory flakes of one core face prior to a larger removal from the same face. As recognised by White and Ashton (2003) this is quite distinct from true Levalloisian technology, so retention of the term “Levallois” is somewhat misleading. Furthermore, much material described as “proto-Levalloisian” by some can alternatively be regarded by others as nothing more than a series of opportunistic flakes off one surface of a core, the last one of which may be slightly larger than some earlier ones (e.g. the two proto-Levalloisian cores shown as Fig. 22 in Bridgland et al., 2013: 458). This is a highly subjective differentiation, and collections from Purfleet abound in this ambiguous proto-Levalloisian material, which is far removed from *bona fide* Levalloisian technology. So, even before considering the provenance of claimed Levalloisian elements at Purfleet, it is important to recognise that much of the reported Levalloisian material is at best proto-Levalloisian, and the quantity of unambiguous Levalloisian elements in the various Purfleet collections is tiny. None of Palmer's (1975) collection shows clear Levalloisian characteristics. Although White and Ashton (2003) do not identify any unambiguous Levalloisian elements in the collections from Purfleet, other subsequent analyses of mostly the same material (Scott, 2011: 18–33; Bridgland et al., 2013) identify small quantities of material that show more genuine Levalloisian characteristics. This material is restricted to three assemblages: a small proportion of material from Snelling's huge Botany Pit collection of the early 1960s (8% of the 300 + cores in the collection, and just three Levallois flakes, forming 0.1% of the 2500 + flakes in the collection), four Levallois flakes from Bed 8 at the Armor Road extension excavation of 1998, and a Levallois core found out-of-context in a talus heap in McKellar's Yard during the HS1 investigations in 2001.

Concerning provenance, none of Snelling's Botany Pit collection has a secure provenance to a known context. This collection was recovered from deposits 1 km to the west of the better-recorded deposits of Bluelands and Greenlands quarries. Although most of the collection probably did come from “the Botany Gravel” at Botany Pit – a current-bedded sand and gravel deposit described by Wymer (1968: 312–313) but for which there is no published primary record apart from the simplified sketch lacking heights OD in Scott (2011, p. 21), which shows a distinct basal gravel horizon under an upper bedded sand horizon – none of Snelling's collection is precisely provenanced, so no one knows which stratigraphic horizon any particular artefact came from. It is likely that at least

some, and possibly a fair proportion, of Snelling's collection did not come from the main sand/gravel deposit at Botany Pit. This deposit is reported (Wymer, 1968, 1985) as abutting a steep chalk cliff to the south. There are numerous records (including from subsequent work along the nearby southern valley-side channel bank to the east of Botany Pit: Bridgland and Allen, 1994; Oxford Archaeology, 1995; Bates et al., 1998; Bridgland et al., 2013) that show that the valley-side channel-fill stratigraphy is complex and includes numerous distinct sand/gravel and bedded sand/silt deposits, as well as chalk-rich slopewash deposits that underlie, overlie and interdigitate with the channel-fill deposits at their southern margin. All records (including Wymer's 1968 report, made nearest the time of Snelling's work) report that lithic artefacts were concentrated at the southern channel margin, where the channel-fill stratigraphy is most complex and interdigitated with chalk-rich slopewash deposits. It is therefore misleading to confidently provenance the very scarce Levalloisian elements in the Snelling collection to any particular part of the reported Botany Pit deposit sequence. It is also entirely uncertain how the date of the chalk-rich channel-margin slopewash deposits relates to the gravel abutting them. These deposits may not all be of the same date, and it is likely they include deposits younger than the gravel that have become mixed into its upper part. Since Snelling's work, numerous well-provenanced artefacts have been excavated from the Botany Pit sand/gravel or presumed equivalent deposits (see Bridgland and Allen, 1994; Schreve et al., 1998; Bridgland et al., 2013), and none of these show true Levalloisian indications. The most parsimonious explanation is therefore that the (relatively sparse, within the context of Snelling's huge collection) Levalloisian evidence from Botany Pit is not associated with the main current-bedded sand/gravel deposits of the Botany Gravel, but with the intrusion of bankside slopewash deposits into the upper part of the main Botany Pit sand/gravel deposit near its southern valley-side bank.

Other than material from Snelling's Botany Pit collection, the only *bona fide* Levalloisian material that is claimed to come from a good provenance are the Levallois flakes reported from the Botany Gravel [Bed 8 of Schreve et al., 2002] at the top of the Bluelands/Greenlands sequence (Bridgland et al., 2013: 471). Besides that there is no published primary record of these flakes' appearance and recovery, and that they have gone missing so now cannot be re-examined for further consideration on whether or not they can be regarded as truly Levalloisian, the main point is that even if they are genuinely Levalloisian there is very weak evidence to relate this gravel bed to MIS 9. It occurs at a substantially higher level than the MIS 9 interglacial horizons at Bluelands/Greenlands [Purfleet member, Beds 3–5 of Schreve et al., 2002], and is divided from them by two major stratigraphic unconformities. These include the chalk-rich slopewash deposit at the base of Bed 6, and the junction between the base of Bed 8 and the top of Bed 7. These deposits are entirely lacking in environmental indicators, and they might much more reasonably be regarded as associated with cold-climate fluvial activity and slopewash (or solifluction) deposition after MIS 9, rather than within it.

Concerning dating of Snelling's Botany Pit collection, even if the Levalloisian material from this collection did come from the main sand/gravel deposits there, it is likewise questionable whether this would allow attribution to MIS 9. It remains unknown whether these sand/gravel deposits are equivalent to Bed 6 or Bed 8 of the Greenlands/Bluelands type-sequence. All that can be said about the Botany Pit deposits is that they post-date the securely-dated MIS 9 interglacial horizons [beds 3–5, the Purfleet Member], and are divided from them by an uncertain number of major stratigraphic unconformities. However, if as is argued above, it is more likely that Levalloisian elements in Snelling's collection originate from bank-side slopewash deposits, then it is very likely that they come from

MIS 8 or later. Following Bridgland's fluvial terrace formation model (Bridgland, 2001), downcutting would occur *after* the peak of MIS 8, during warming at the onset of MIS 7e. The basal gravel bed of the Botany Gravel would most naturally be regarded as a cold climate deposit linked to the onset of MIS 8, so overlying (and interdigitating bankside) deposits could reasonably be regarded as MIS 8 or younger. The landscape through most of MIS 8 would have been formed of the chalk-rich channel bank and the Botany Gravel floodplain with braided channels, and it is during this period, or after, we suggest that any Levalloisian evidence was accumulating. As outlined below, this is a period when Britain was probably connected to the rest of the European continent. It is therefore most feasible to suggest that the appearance of genuine Levallois in Britain in MIS 8 and after could have been associated with influx of populations from northwest continental Europe, where there is better evidence of Levalloisian in MIS 9 or before.

Turning now to the Palaeolithic record in northern France and Belgium for the earlier part of this period it is characterised by industries with a dominance of core technology and varying occurrences of handaxes and Levallois technology. Although recognition of Levalloisian technology is often a contested matter between different analysts and some of the north-west European evidence has disputed provenance (cf. White and Ashton, 2003; Scott and Ashton, 2011), Levalloisian technology seems to appear earlier on the continent than in Britain, with evidence from MIS 9 or earlier claimed from, for instance, the Petit-Spiennes terrace in the Haine basin (Ryssaert, 2006; Van Balen and Ryssaert, 2011) and from Cagny-la-Garenne and Cagny La Ferme d'Épinette in the Somme Valley (Tuffreau and Antoine, 1995), where it occurs alongside a strong handaxe-making tradition. Later sites from the period MIS 8/7/6 in the eastern part of this region show varied proportions of Levalloisian, discoidal and simple flake core technologies, but they never have a strong handaxe component, for instance Mesvin IV in the Haine valley (Ryssaert, 2006), Carrière Hélin (lower level) and Rissori (Van Balen and Ryssaert, 2011). Further west, there is a stronger handaxe presence at the sites of Ranville (Cliquet, 2008), Gentelles (Tuffreau et al., 2008) and Gouzeaucourt (Sommé, 1975; Tuffreau and Bouchet, 1985; Lamotte, 2001). At Ranville, the assemblage includes two minute handaxes, a Levalloisian core and evidence of unstructured flake/core technology. At Gentelles, the main handaxe industry CLG is dated to MIS 8, contemporary with Harnham, and the younger handaxe industry, associated with horizon LBN is regarded as dating to early in MIS 6. At Gouzeaucourt, to the south of Lille in northern France, rich handaxe assemblages were found in loessic deposits sealed beneath an interglacial soil. No direct dating techniques have been applied; it has been suggested that the soil may date to MIS 7 within the context of the wider regional sequence, but this attribution remains uncertain.

It has previously been suggested (Ashton and Hosfield, 2010; Ashton et al., 2011; Scott and Ashton, 2011) that this pattern might reflect western and eastern zones for a late Lower Palaeolithic and early Middle Palaeolithic transition (defined on the basis of the appearance of Levalloisian technology), where sites with handaxes (such as Harnham, Broom, Gentelles and Ranville) are more predominant in the west, while sites dominated by Levallois are more prominent in the east such as Ebbsfleet/Baker's Hole, Creffield Road, Crayford, Oisiers, Biache and Maastricht Belvedere. This is taken as perhaps indicating different routes into Britain from the continent, although it is acknowledged that this interpretation needs further evidence to substantiate it. Here, we present the alternative suggestion that the MIS 8 south-western English evidence of handaxe manufacturing - and in particular the evidence from Harnham - may not represent colonisation from the north-western continent, but may instead represent persistence of a UK

Acheulian industrial tradition from MIS 9 through to the late MIS 8 interstadial.

It is clear from marine isotopic data and sea level modelling (Bassinot et al., 1994; Waelbroeck et al., 2002; Lisiecki and Raymo, 2005) that the cold maxima of MIS 9.2, 8.6 and 8.4 are nothing like as severe as those of MIS 12, 10 and 6, so it is possible that a population could persist in the UK from MIS 9 through to a late MIS 8 interstadial, although the cold peak of MIS 8.2 may have been too harsh for this population to persist through to MIS 7. We also regard it as questionable whether it would have been feasible for the postulated western pioneer population of MIS 8 to enter south-west Britain directly from the south, since the lower reaches of the Channel River would have presented a formidable barrier. The Harnham occupation is therefore taken as continuing an industrial tradition represented at southern UK sites that are most likely from MIS 10/9 such as Wolvercote (Bridgland, 1994), Red Barns (Wenban-Smith et al., 2000) and Priory Bay (Wenban-Smith et al., 2009). Then the apparent proliferation of Levalloisian technology in the eastern Thames Valley in late MIS 8 and early MIS 7 (for instance as best-dated in the Ebbsfleet Channel complex in the Ebbsfleet Valley, where there are undisturbed Levalloisian occupation levels attributable to MIS 7d/e, which in turn are probably younger than the classic large tortoise-core Levalloisian material from the Baker's Hole Coombe Rock – see Wenban-Smith et al., in press) may represent repopulation from the continent after the cold maximum of MIS 8.2.

It also appears, once the contested evidence from Purfleet is taken out of the discussion, that true Levalloisian industries appear later than on the north-west continental mainland, and predominantly in southeast Britain. In this context, although the isolation created by an island context does perhaps intuitively favour some kind of specialisation or different adaptive responses (White and Schreve, 2000), it has also been argued that some technological adaptations and innovations are more likely to be developed and sustained within a larger population network (Kuhn, 2012). Thus Levalloisian technologies may be more sustainable in a widespread, denser and numerically greater northwest European population, only spreading to Britain during post-MIS 8 peninsular phases. In order to assess this possibility further, it is necessary to find more sites in Britain and northwest Europe where occupation can be pinned down to a relatively tight time period, and when it can be reasonably confidently ascertained whether or not Britain was connected to the continent. As it stands, we here suggest that sites such as Harnham, Broom and Cuxton represent persistence in the UK of a handaxe-dominant adaptation through to a late MIS 8 interstadial, followed by local extinction of the British population during the cold maximum at the end of MIS 8. This is then followed by colonisation from the north-west European continent of a population with Levalloisian technology during the transition from late MIS 8 to early MIS 7 while Britain was still connected to the continent, but ameliorating climate made it habitable.

Acknowledgements

The authors would like to thank Ken Whittaker of RPS, Mark Beasley and Sean Steadman who managed the project on behalf of Gifford and Partners and Tim Carew of Pre-Construct Archaeology who supervised on-site works. The following individuals are also thanked for help: Denis Bates for help in preparing the figures for publication; Sharon Gerber-Parfitt and Su Bates for undertaking the onerous task of sorting the samples for vertebrate remains; and Gilbert Marshall for sorting micro-debitage from the sondage bulk-samples. Simon Parfitt and Silvia Bello acknowledge the support of the Ancient Human Occupation of Britain project and funding from the Leverhulme Trust and the Calleva Foundation.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.quascirev.2014.07.002>.

References

- Ashton, N.M., Cook, J., Lewis, S.G., Rose, J. (Eds.), 1992. High Lodge: Excavations by G. de G. Sieveking 1962–68 and J. Cook 1988. British Museum Press, London.
- Ashton, N., Hosfield, R.T., 2010. Mapping the human record in the British early Palaeolithic: evidence from the Solent River system. *J. Quat. Sci.* 25, 737–753.
- Ashton, N.M., Lewis, S.G., Parfitt, S.A., 1998. Excavations at Barnham 1989–94. *British Museum Occasional Paper* 125.
- Ashton, N., Jacobi, R., White, M., 2003. The dating of Levallois sites in west London. *Quat. Newsl.* 99, 25–32.
- Ashton, N.M., Lewis, S.G., Hosfield, R., 2011. Mapping the human record: population change in Britain during the later Middle Pleistocene. In: Ashton, et al. (Eds.), *The Ancient Human Occupation of Britain*. Elsevier, Amsterdam, pp. 39–51.
- Ashton, N., Lewis, S.G., Parfitt, S.A., Penkman, K.E.H., Coope, G.R., 2008. New evidence for complex climate change in MIS 11 from Hoxne, Suffolk, UK. *Quat. Sci. Rev.* 27, 652–668.
- Bates, M.R., Lambrick, G., Welsh, K., White, M., Scaife, R., 1998. Evaluation of Palaeolithic deposits at Purfleet, Essex. *Lithics* 19, 72–86.
- Bello, S.M., Parfitt, S.A., De Groot, I., Kennaway, G., 2013. Investigating experimental knapping damage on an antler hammer: a pilot-study using high-resolution imaging and analytical techniques. *J. Archaeol. Sci.* 40, 4528–4537.
- Bassinot, F.C., Labeyrie, L.D., Vincent, E., Quidelleur, X., Shackleton, N.J., Lancelot, Y., 1994. The astronomical theory of climate and age of the Brunhes-Matuyama magnetic reversal. *Earth Planet. Sci. Lett.* 126, 91–108.
- Binford, L.R., 1981. *Bones: Ancient Men and Modern Myths*. Academic Press, New York.
- Blumenshine, R.J., Selvaggio, M.M., 1998. Percussion marks on bone surfaces as a new diagnostic of hominin behaviour. *Nature* 333, 763–765.
- Boëda, É., Geneste, J.-M., Griggo, C., Mercier, N., Muhesen, S., Reyss, J.L., Taha, A., Valladas, H., 1999. A Levallois point embedded in the vertebra of a wild ass (*Equus africanus*): hafting, projectiles and Mousterian hunting weapons. *Antiquity* 73, 394–402.
- Boismier, W.A., Gamble, C.S., Coward, F., 2012. Neanderthals among Mammoths: Excavations at Lynford Quarry, Norfolk. *English Heritage, Swindon*.
- Bridgland, D.R., 1994. Quaternary of the Thames. Chapman & Hall, London.
- Bridgland, D.R., 2001. The Pleistocene evolution and Palaeolithic occupation of the Solent River. In: Wenban-Smith, F.F., Hosfield, R.T. (Eds.), *Palaeolithic Archaeology of the Solent River*, pp. 15–25. *Lithic Studies Society Occasional Paper* 7.
- Bridgland, D.R., Allen, P., 1994. Land off Stonehouse Lane, Purfleet, Essex: Archaeological Evaluation, Trial Trenching. Unpublished client report by Essex County Council Field Archaeology Group [Planning Application THU 581/93].
- Bridgland, D.R., Harding, P., Allen, P., Candy, I., Cherry, C., George, W., Horne, D.J., Keen, D.H., Penkman, K.E.H., Preece, R.C., Rhodes, E.J., Scaife, R., Schreve, D.C., Schwenninger, J., Slipper, I., Ward, G.R., White, M.J., White, T.S., Whittaker, J.E., 2013. An enhanced record of MIS 9 environments, geochronology and geoarchaeology: data from construction of the High Speed 1 (London–Channel Tunnel) rail-link and other recent investigations at Purfleet, Essex, UK. *Proc. Geol. Assoc.* 124, 417–476.
- British Geological Survey, 1976. Sheet 298. Salisbury. Drift Edition. 1:50 000 Series. British Geological Survey, Keyworth.
- Cliquet, D. (Ed.), 2008. Le site Pléistocène Moyen Récent de Ranville (Calvados – France) dans son contexte environnemental. ERAUL 119, Liege.
- Department of the Environment, 1990. *Planning Policy Guidance: Archaeology and Planning*. PPG 16. HMSO, London.
- Fox, W.D., 1862. When and how was the Isle of Wight separated from the mainland? *Geologist* 5, 452.
- Gedda, B., 2001. Environmental and Climatic Aspects of the Early to Mid Holocene Calcareous Tufa and Land Mollusc Fauna in Southern Sweden. *LundQua Thesis* 45, PhD thesis. University of Lund.
- Green, C.P., Keen, D.H., McGregor, D.F.M., Robinson, J.E., Williams, R.B.G., 1983. Stratigraphy and environmental significance of Pleistocene deposits at Fisherton, near Salisbury, Wiltshire. *Proc. Geol. Assoc.* 94, 17–22.
- Guthrie, R.D., 1990. *Frozen Fauna of the Mammoth Steppe*. University of Chicago Press, Chicago.
- Harding, P.A., Bridgland, D.R., 1998. Pleistocene deposits and Palaeolithic implements at Godolphin School, Milford Hill, Salisbury. *Wilts. Archaeol. Nat. Hist. Mag.* 91, 1–10.
- Hosfield, R.T., Green, C.P. (Eds.), 2013. *Quaternary History and Palaeolithic Archaeology in the Axe Valley at Broom, South West England*. Oxbow Books, Oxford.
- Keen, D.H., 1987. Non-marine molluscan faunas of periglacial deposits in Britain. In: Boardman, J. (Ed.), *Periglacial Processes and Land-forms in Britain and Ireland*. Cambridge University Press, Cambridge, pp. 257–263.
- Kerney, M.P., Cameron, R.A.D., 1979. *A Field Guide to the Land Snails of Britain and North-west Europe*. Collins, London.
- Kuhn, S., 2012. Emergent patterns of creativity and innovation in early technologies. In: Elias, S. (Ed.), *Origins of Human Innovation and Creativity*. Elsevier, Amsterdam, pp. 69–87.

- Lamotte, A., 2001. Les industries à bifaces de l'Europe du Nord-Ouest au Pléistocène moyen: l'apport des données des gisements du bassin de la Somme, de l'Escaut et de la Baie de St-Brieuc. In: *British Archaeological Reports: International Series*, vol. 932 (Oxford).
- Lisiecki, L.E., Raymo, M.E., 2005. A Plio-Pleistocene stack of 57 globally distributed benthic $\delta^{18}O$ records. *Paleoceanography* 20. <http://dx.doi.org/10.1029/2004PA001071>. PA1003.
- Lyell, C., 1827. On some fossil bones of the elephant and other animals, found near Salisbury. *Proc. Geol. Soc. Lond.* 1, 25–26.
- Mallye, J.-P., Thiébaud, C., Mourre, V., Costamagno, S., Claud, É., Weisbecker, P., 2012. The Mousterian bone retouchers of Noisetier Cave: experimentation and identification of marks. *J. Archaeol. Sci.* 39, 1131–1142.
- Melville, R.V., Freshney, E.C., 1982. The Hampshire Basin and adjoining Areas. *British Regional Geology*. HMSO, London.
- Murray, A.S., Wintle, A.G., 2000. Luminescence dating of quartz using an improved single-aliquot regeneration protocol. *Radiat. Measur.* 32, 57–73.
- Oxford Archaeology, 1995. Purfleet, Thurrock, Essex: Archaeological Evaluation Report. Unpublished report prepared by OAU for Union Railways Limited [reference TIS 192/84-10411].
- Palmer, S., 1975. A Palaeolithic site at North Road, Purfleet, Essex. *Trans. Essex Archaeol. Soc.* 7, 1–13.
- Parfitt, S.A., Barendregt, R.W., Breda, M., Candy, I., Collins, M.J., Coope, R.G., Durbridge, P., Field, M.H., Lee, J.R., Lister, A.M., Mutch, R., Penkman, K., Preece, R.C., Rose, J., Stringer, C.B., Symmons, R., Whittaker, J.E., Wymer, J.J., Stuart, A.J., 2005. The earliest record of human activity in Northern Europe. *Nature* 438, 1008–1012.
- Parfitt, S.A., Ashton, N.M., Lewis, S.G., Abel, R.L., Coope, G.R., Field, M.H., Gale, R., Hoare, P.G., Larkin, N.R., Lewis, M.D., Karloukovski, V., Maher, B.A., Peglar, S.M., Preece, R.C., Whittaker, J.E., Stringer, C.B., 2010. Early Pleistocene human occupation at the edge of the boreal forest zone in northwest Europe. *Nature* 466, 229–233.
- Parfitt, S.A., Owen, F., Keen, D.H., 1998. Pleistocene stratigraphy, vertebrates and Mollusca; Black Rock, Brighton. In: *Murton, J.B., Whiteman, C.A., Bates, M.R., Bridgland, D.R., Long, A.J., Roberts, M.B., Waller, M.B. (Eds.), The Quaternary of Kent and Sussex. Field Guide. Quaternary Research Association, London*, pp. 146–150.
- Penkman, K.E.H., 2005. Amino Acid Geochronology: a Closed System Approach to Test and Refine the UK Model. Unpublished PhD thesis. University of Newcastle.
- Penkman, K.E.H., Preece, R.C., Bridgland, D.R., Keen, D.H., Meijer, T., Parfitt, S.A., White, T.S., Collins, M.J., 2011. A chronological framework for the British Quaternary based on *Bithynia* opercula. *Nature* 476, 446–449.
- Pettitt, P., White, M., 2012. *The British Palaeolithic*. Routledge, London and New York.
- Preece, R.C., 1998. Mollusca. In: *Preece, R.C., Bridgland, D.R. (Eds.), Late Quaternary Environmental Change in North-west Europe. Excavations at Holywell Coombe, South-east England. Chapman and Hall, Norwell*, pp. 158–161.
- Preece, R.C., Parfitt, S.A., 2012. The Early and early Middle Pleistocene context of human occupation and lowland glaciation in Britain and northern Europe. *Quat. Int.* 271, 6–28.
- Reid, C., 1903. *The geology of the Country around Salisbury. Memoir of the Geological Survey of Great Britain*.
- Roberts, M.B., Parfitt, S.A., 1999. Boxgrove. A Middle Pleistocene Hominid Site at Eartham Quarry, Boxgrove, West Sussex. *English Heritage Archaeological Report 17*. English Heritage, London.
- Roe, D.A., 1981. *The Lower and Middle Palaeolithic Periods in Britain*. Routledge & Kegan Paul, London.
- Roebroeks, W., 2006. The human colonisation of Europe: where are we? *J. Quat. Sci.* 21, 425–435.
- Roebroeks, W., Conard, N., van Kolfschoten, T., 1992. Dense forests, cold steppes and the palaeolithic settlement of northern Europe. *Curr. Anthropol.* 33, 551–586.
- Rots, V., 2009. The functional analysis of the Mousterian and Micoquian assemblages of Sesselfelsgrötte, Germany: aspects of tool use and hafting in the European late Middle Palaeolithic. *Quartär* 56, 37–66.
- Rots, V., 2011. Tool use and hafting in the western European Middle Palaeolithic. *Le Paléolithique Moyen en Belgique. Mélanges Marguerite Ulrix-Closset. ERAUL* 128, 277–287.
- Ryssaert, C., 2006. Some new insights in an old collection: lithic technology at Mesvin IV. *Notae Praehist.* 26, 91–99.
- Schreve, D.C., Allen, P., White, M.J., Haggart, B.A., Bridgland, D.R., 1998. *Armor Road Extension, Excavations at Bluelands and Greenlands Quarries, Purfleet, Essex: Evaluation Report*. Unpublished client report for Essex County Council Field Archaeology Unit [February 1998, Planning Application THU/0479/94].
- Schreve, D.C., Bridgland, D.R., Allen, P., Blackford, J.J., Gleed-Owen, C.P., Griffiths, H.I., Keen, D.H., White, M.J., 2002. Sedimentology, palaeontology and archaeology of late Middle Pleistocene River Thames terrace deposits at Purfleet, Essex, UK. *Quat. Sci. Rev.* 21, 1423–1464.
- Scott, B., 2011. *Becoming Neanderthals: the Earlier British Middle Palaeolithic*. Oxbow Books, Oxford.
- Scott, B., Ashton, N.M., 2011. The Middle Palaeolithic: the European context. In: *Ashton, et al. (Eds.), The Ancient Human Occupation of Britain*. Elsevier, Amsterdam, pp. 67–89.
- Sealey, K.R., 1955. The terraces of the Salisbury Avon. *Geogr. J.* 121, 350–356.
- Shea, J.J., 1988. Spear points from the Middle Palaeolithic of the Levant. *J. Field Archaeol.* 15, 823–846.
- Singer, R., Gladfelter, B.G., Wymer, J.J., 1993. *The Lower Palaeolithic site at Hoxne, England*. The University of Chicago Press, Chicago and London.
- Somme, J., 1975. *Les Plaines de la Nord de la France et leur bordure, étude géomorphologique* (Unpublished PhD Thesis, Paris).
- Stewart, J.R., Stringer, C.B., 2012. Human evolution out of Africa: the role of Ice Age refugia and long term climate change. *Science* 335, 1317–1321.
- Sutcliffe, A.J., Kowalski, K., 1976. Pleistocene Rodents of the British Isles. *Bull. Br. Mus. (Nat. Hist.) Geol.* 27 (2).
- Tuffreau, A., Antoine, P., 1995. The earliest occupation of Europe: continental northwestern Europe. In: *Roebroeks, W., van Kolfschoten, T. (Eds.), The Earliest Occupation of Europe*. University of Leiden, Leiden, pp. 147–164.
- Tuffreau, A., Bouchet, J.P., 1985. Le gisement acheuléen de la Vallée du Muid a Gouzaucourt (Nord). *Bull. Soc. Préhist. Française* 82, 291–306.
- Tuffreau, A., Lamotte, A., Govaal, E., 2008. Les Industries acheuléennes de la France septentrionale. *L'Anthropologie*, 112, 104–112, 139.
- Van Balen, A., Ryssaert, C., 2011. The early Middle Palaeolithic in Belgium. *Le Paléolithique Moyen en Belgique. Mélanges Marguerite Ulrix-Closset. ERAUL* 128, 197–212.
- van Kolfschoten, T., 1990. The evolution of the mammal fauna in the Netherlands and the middle Rhine area (Western Germany) during the late Middle Pleistocene. *Mémoires de la Société Géologique des Pays-Bas* 43 (3), 1–69.
- Waelbroeck, C., Labeyrie, L., Michel, E., Duplessy, J.C., McManus, J.F., Lambeck, K., Balbon, E., Labracherie, M., 2002. Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records. *Quat. Sci. Rev.* 21, 295–305.
- Wenban-Smith, F.F., 1995. The Ebbsfleet Valley, Northfleet (Baker's Hole). In: *Bridgland, D.R., Allen, P., Haggart, B.A. (Eds.), The Quaternary of the Lower Reaches of the Thames: Field Guide. Quaternary Research Association, Durham*, pp. 147–164.
- Wenban-Smith, F.F., 1996. *The Palaeolithic Archaeology of Baker's Hole: a Case Study for Focus in Lithic Analysis*. Unpublished PhD thesis. Department of Archaeology, University of Southampton.
- Wenban-Smith, F.F., 2000a. Lithic artefacts. In: *Wenban-Smith, F.F., Gamble, C.S., ApSimon, A.M. (Eds.), The Lower Palaeolithic Site at Red Barns, Portchester, Hampshire: Bifacial Technology, Raw Material Quality and the Organisation of Archaic Behaviour. Proceedings of the Prehistoric Society, vol. 66*, pp. 209–255.
- Wenban-Smith, F.F., 2004. Bringing behaviour into focus: Archaic landscapes and lithic technology. In: *Walker, E.A., Wenban-Smith, F.F., Healy, F. (Eds.), Lithics in Action: Proceedings of the Lithic Studies Society Conference held in Cardiff, September 2000*. Oxbow Books, Oxford, pp. 48–56. *Lithic Studies Society Occasional Paper No. 8*.
- Wenban-Smith, F.F., 2006. Handaxe typology and Lower Palaeolithic cultural development: flicrons, cleavers and two giant handaxes from Cuxton. In: *Pope, M., Cramp, K. (Eds.), Lithics 25 (Papers in Honour of R.J. MacRae)*, pp. 11–21.
- Wenban-Smith, F.F. (Ed.), 2013. *The Ebbsfleet Elephant: Excavations at Southfleet Road, Swanscombe in Advance of High Speed 1, 2003–4*. Monograph in Oxford Archaeology CTRL Series.
- Lithic Studies Society Occasional Paper 7. In: *Wenban-Smith, F.F., Hosfield, R.T. (Eds.), Palaeolithic Archaeology of the Solent River. Lithic Studies Society, London*.
- Wenban-Smith, F.F., Bates, M.R., Bridgland, D.R., Marshall, G., Schwenninger, J.-L., 2009. The Pleistocene sequence at Priory Bay, Isle of Wight (SZ 635 900). In: *Brian, R.M., Bates, M.R., Hosfield, R.T., Wenban-Smith, F.F. (Eds.), The Quaternary of the Solent Basin and West Sussex Raised Beaches: Field Guide. Quaternary Research Association, London*, pp. 123–137.
- Wenban-Smith, F.F., Bates, M.R., Marshall, G., 2007. *Medway Valley Palaeolithic Project Final Report: the Palaeolithic Resource in the Medway Gravels (Kent)* (Unpublished report submitted to English Heritage).
- Wenban-Smith, F.F., Gamble, C.S., ApSimon, A.M., 2000. The Lower Palaeolithic site at Red Barns, Portchester, Hampshire: bifacial technology, raw material quality and the organisation of Archaic behaviour. *Proc. Prehist. Soc.* 66, 209–255.
- Wenban-Smith, F.F., Schwenninger, J.-L., Bates, M.R., Marshall, G., 2014a. *New Work at the Late Middle Pleistocene Handaxe Site at Cuxton, Kent (UK): Single-grain OSL Dating, Post-depositional Sediment Disturbance and Giant Handaxe Finds* (in press).
- Wenban-Smith, F.F., Stafford, E., Bates, M.R. (Eds.), 2014b. *Prehistoric Ebbsfleet: Excavations and Research in Advance of High Speed 1 and STDR 4*. Monograph in Oxford/Wessex Archaeology CTRL Series (in press).
- Wessex Archaeology, 1993. *Southern Rivers Palaeolithic Project, Report 1: Region 3 (The Upper Thames Valley, the Kennet Valley) and Region 5 (The Solent Drainage System)*. Wessex Archaeology, Salisbury.
- Westaway, R., Bridgland, D.R., White, M., 2006. The Quaternary uplift history of central southern England: evidence from the terraces of the Solent river system and nearby raised beaches. *Quat. Sci. Rev.* 25, 2212–2250.
- White, M.J., Ashton, N.M., 2003. Lower Palaeolithic core technology and the origins of the Levallois method in NW Europe. *Curr. Anthropol.* 44, 598–609.
- White, M.J., Schreve, D.C., 2000. Island Britain-Peninsula Britain: palaeogeography, colonisation and the Lower Palaeolithic settlement of the British Isles. *Proc. Prehist. Soc.* 66, 1–28.
- Wymer, J.J., 1968. *Lower Palaeolithic Archaeology in Britain as Represented by the Thames Valley*. John Baker, London.
- Wymer, J.J., 1985. *The Palaeolithic Sites of East Anglia*. Geo Books, Norwich.
- Wymer, J.J., 1999. *The Palaeolithic Occupation of Britain*. Wessex Archaeology, Salisbury.